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Giving Hope and Seeing Hope
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Letter from the Editor

What does ageing mean?

Of course to each of us, ageing mean many different things, we come from different homes, spring from different circumstances and arrive at different platforms after many years at work. When we see a patient who is ageing – do we stop for a moment to think about what it means to him? What is in his psyche? Perhaps the hardest to deal with in ageing is not just the frailty of the body, but rather it is the decay of the mind and the spirit.

I have excerpted two verses from a poem below:

Ageing
"Now that I’m really old
there seems little left to say.
Pointless to bewail
the decline, bodily and mental;
undignified; boring
not to me only but everyone,"
…
"When I saw that young girl on her blades,
wind in her hair, sun on her face,
like a magazine illustration
from childhood days, racing
her boyfriend along the pavement:
– then I understood ageing."


These two verses show two states of the mind. The former seems to be of a disgruntled defeated grumpy old chap; and the latter a more reflective man with some measure of wisdom, more enlightened, but who would love to still have a spot of active living.

How should we treat these two patients? Will they respond differently to our treatment plans? Should we offer them the same treatment plan? Should we do more work to understand the former state of mind? I am sure we would all want to understand the patient’s state of mind better during treatment planning.

Almost as insidiously as we have aged, the Singapore population has aged. As the proportion of the elderly increases among us, the nature of practice will also change. As spending habits of patients who now become elderly change, will the types of treatment adopted change? How it will be for dental practice in Singapore as a whole, nobody can foretell. But change will surely come. How should dentists prepare for these changes? Are there additional skill-sets which are required to make practicing with elderly patients more meaningful, for them as well as for us – the professionals? Are there new medico-legal issues that would crop up with a more elderly patient? What attitudes should we adopt when dealing with a difficult elderly patient? Indeed issues that should be considered, during a professional disciplinary inquiry, might well have to change if the patient involved was an elderly patient.

Continuing medical education programmes have thus far, as far as I have been made aware, done scanty little to address the issues of dealing with an elderly patient. Although much needed, such as special devices to clean teeth with wider inter-radicular spaces; few companies have dental supplies or materials dealing strictly with elderly patients. It is not “glamorous” to talk about the elderly. However, to this end, we are pleased to inform you that the World Congress 2015 – Dental care and oral health for healthy longevity in an aging society – is scheduled to be held over the three days of March 13 (Friday) to March 15 (Sunday), 2015. This congress will be held at the Tokyo International Forum co-hosted by the World Health Organization (WHO) and supported by the FDI World Dental Federation. The Japanese Dental Association has made the theme for the FDI 2015 (Tokyo ) – Ageing!

Whilst much of the buildings around Singapore are gearing up for the so called “silver tsunami”, I wonder how prepared our profession is with our population ageing at such an alarming rate. To help the profession come to terms with the impending arrival of the “silver tide”, several articles have been invited from renowned authors in their fields. These deal with patient management and treatment planning issues, medico-legal issues among others. We hope these will be useful for you to “train” yourselves to be ready. Whilst it was possible to beg, on your behalf, for a few authors to write about ageing and the physiological changes as they apply to dentistry, it was not possible to find one to write about the mind of the elderly, how an older person may appreciate dental treatment needs, something that we think should be very instructive.

The editorial board is always on the look-out for ways of keeping our members informed and up-to date. If you have any suggestions please do not hesitate to write to us at sdj@sda.com.sg.

Many Happy returns in the New Year.

Editor
Sum Chee Peng

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An ageing population poses dental challenges

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Abstract

In this narrative review paper, we summarise what is known about the oral health of older people, with a specific focus on the most common oral conditions in that age group. After that, the implications for older people’s oral care are considered, along with ways of developing and maintaining a gerodontologically capable and responsive workforce and oral care delivery system.

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The oral health of older people

A feature of industrialised societies over the last century or so has been their steady ageing. Falling birth rates have combined with increases in longevity, with the result that older people make up an increasing proportion of the population [1]. The most striking example of this phenomenon is Japan, where people aged 65+ currently make up 23% of the population and are expected to reach 38% by 2050 [2]. Similar trends are evident (but not be as marked) in other developed countries. In North America, the equivalent estimates are 13% and 22%; in Europe, they are 16% and 27%; and in China, they are 8% and 23%. In New Zealand, where those estimates are 14% and 25%, people aged 80 or more currently comprise about 25% of those aged 65+, but that will rise to 40% by 2050. Singapore is no exception to this phenomenon, with the median age having virtually doubled since 1970; in the same period, the total fertility rate more than halved, and life expectancy at birth increased by just over 16 years [3]. The 11% of the population who were aged 65 or over remains relatively low by international standards (for example, it is currently 14% in New Zealand and expected to rise to 25% by 2050), but it is important to consider that it has been increasing steadily: the key trend is the same.

Alongside the inexorable increase in the proportion of older people, a “dental transition” has been occurring, whereby the proportion of that group who are edentulous has also been steadily falling. This is likely to have been more marked...
in countries where edentulism has been a widespread sociocultural phenomenon, such as New Zealand, Australia and Scotland [4], but there is a lack of comparative data from other countries. Nevertheless, it can safely be assumed that retention into old age of at least part of the natural dentition is increasing in developed countries.

The most common oral conditions among older people are tooth loss, dental caries, periodontitis, dry mouth and oral precancer/cancer [5]. These all can compromise older people’s quality of life. Each of these issues is briefly discussed below.

Edentulism is the state of having lost all of the natural teeth; it should be distinguished conceptually and practically from the more common loss of teeth which tends to occur incremental throughout adult life. Becoming edentulous requires the patient and dentist to collude in the decision to remove the remaining dentition, usually in a single operation. Edentulism comes about because of both disease-related and societal influences [6]. It is now far less common than incremental tooth loss, irrespective of age. Indeed, it can be argued that the unplanned, crisis-driven and incremental loss of teeth as we age presents more of a problem for the profession and the public, because the piecemeal loss of teeth can result in the drifting of adjacent teeth and the over-eruption of opposing units, thus complicating prostodontic rehabilitation at a later date. Reports from cohort studies of older adults confirm the phenomenon of incremental tooth loss in people aged 65 or older [7–13].

Dental caries is perhaps the major oral problem among older people. Reports from prospective cohort studies of population-based samples of community-dwelling older people [10,14–16] have shown that dental caries is remarkably active among older people, with a mean increment of about 1 surface per year [17,18]. That rate is no different from the increment observed among adolescents and younger adults [19]. Somewhat surprisingly for most dentists, the greater contribution to that increment among older people is made by coronal caries rather than root surface caries (respectively comprising 60% and 40% of the increment). South Australian research by the late Dr Jane Chalmers demonstrated that the annual dental caries increment among older people residing in nursing homes is more than double that observed among their community-dwelling counterparts; among those with dementia, it is more than twice as high again [20]. These longitudinal study data lend credibility to anecdotal reports of dentitions being ravaged relatively quickly after admission to a nursing home.

Periodontitis is not a highly prevalent condition among older people. A review in Periodontology 2000 summarised knowledge of the occurrence of periodontitis in older populations at that time [21], and concluded that periodontitis is a disease of ageing; that is, ageing is a risk factor for loss of periodontal attachment (other factors being equal). Essentially, most older people have had some periodontitis, with moderate levels of attachment loss. Advanced attachment loss (affecting relatively few sites) is apparent in a small proportion, and a substantial minority experience ongoing attachment loss, mainly in the form of increases in gingival recession rather than in probing depth. Research published in the years since that authoritative review by Locker and colleagues has not materially changed those conclusions [22].

Chronic dry mouth occurs in a substantial proportion of older people, affecting their speaking, enjoyment and ingestion of food, and denture wearing [23,24]. About one in five older people suffers from dry mouth [25,26], and they are likely to be at higher risk of dental caries, whether because of their compromised salivary buffering or the efforts they go to to relieve their symptoms (such as by sucking sweets). Higher rates of dry mouth are seen in those taking medications such as antidepressants, respiratory agents, opiate-containing analgesics, or some cardiac or antihypertensive drugs [27–29]. Whether older people taking particular medications are at greater risk of caries is not supported by the available epidemiological evidence [16], but dry mouth is an important oral condition among older populations because of its effects on sufferers’ quality of life.

Oral mucosal lesions are more common among older people. The term “oral precancer” generally refers to leukoplakia, lichen planus and erythroplakia, conditions with recognised potential (especially the latter) for malignant transformation. By contrast, the term “oral cancer” usually refers to oral squamous cell carcinoma [30]. Although epidemiological data on the occurrence of oral precancer and cancer in representative samples are hard to find, most cases of oral cancer occur among older people, and they occur less commonly in developed countries than less developed ones [5]. Clinicians should always be aware of the possibility of such lesions being present.

All of the above conditions can affect older people’s oral-health-related quality of life (OHRQoL). Given the cumulative nature of those conditions, it might be expected that the OHRQoL of older people is far poorer than that of younger adults, but that is not the case. In an interesting analysis of Australian national oral health survey data, Slade and Sanders [31] recently pointed out the paradox of apparently better OHRQoL among older adults, with scale scores being lowest among the oldest Australians. They stressed that it should not be assumed that older people are necessarily disabled by their accumulated burden of clinical oral disorders (such as tooth loss, dental caries, periodontal attachment loss and dry mouth); instead, it appears that their age-associated stoicism, adaptability, capacity for coping and ongoing reappraisal of what is actually important mean that most manage reasonably well from day to day. Notwithstanding that phenomenon, however, the epidemiological literature shows that OHRQoL tends to be poorer among seniors who wear dentures, have higher numbers of missing teeth or decayed teeth, have dry mouth, or have difficulty in eating because of—or alongside—those states. In other words, adaptation and stoicism enable most older people to cope despite difficulties in chewing.

**What do these data mean for the oral care of older people?**

An increasing number of dentate older adults will place great demands on the resources and skills of the dental workforce, because of not only their having more teeth, active dental caries and ongoing incremental tooth loss, but also because they are more sophisticated in their demands on the oral
health care system. Functional dependency among older people has been reported to be a major barrier to service utilisation [32]. The relationship between frailty and oral health is not fully understood, but it is likely to be a two-way phenomenon. Poor oral health can contribute to frailty (a) by leading to chronic undernutrition (and eventually sarcopenia, or muscle wasting), and (b) through periodontitis-associated increases in inflammatory markers creating systemic perturbations which themselves increase the risk of frailty [33]. The seminal longitudinal work of Chalmers and colleagues [20] has highlighted the contribution of frailty and dependency to higher dental caries rates among older people.

In New Zealand, at least half of the older population will end up in a residential aged-care facility at some stage, and only a small proportion of those will return to their own homes [34]; most will end their days in a care facility. Aged residential care for the approximately 32,000 individuals in such care currently costs the New Zealand taxpayer about $800 million per year [35]. There are challenges in maintaining oral health among (and providing care for) older people who are in care [36]. Many agencies and professional groups are involved. There are workforce issues (not only with the various dental personnel but also with care facility staff), along with problems in monitoring oral health and determining need, and with the funding of any preventive or palliative care which may be involved. Important complicating factors include the ever-increasing proportion of dentate residents, and in New Zealand, at least the trend seen in recent decades for dependency levels upon admission to have increased over time [37]. Those entering care facilities have more teeth but are less able to take care of themselves; their needs are more diverse. Recent attention has been focused on developing a more systematic, evidence-based approach to assessing and delivering care to older dental patients, using dental care pathways which are specific to particular levels of dependency [38]. Their use should improve the likelihood of consistent and predictable care because evidence-based and standardised levels of care are provided, but it is too early to be able to evaluate their effectiveness.

US work by Kiyak et al. [39] found that dental practitioners held many negative stereotypes about older adults and that they had only limited knowledge of geriatric dentistry. A subsequent exploration of New Zealand dentists’ knowledge of older people’s oral health found that it was generally sound, but that most were not involved in providing ongoing care to residents of nursing homes [40]. Most were unwilling to get involved in such care because of the inconvenience of leaving their practices to do so.

Shaping a gerodontologically capable and responsive workforce

Meeting the oral health needs of the burgeoning older population will require a diverse and capable dental workforce. A two-pronged approach is required, focusing on both (a) new entrants to the profession via Dental Schools, and (b) existing dentists. The latter will be through continuing professional development for the majority of dentists, but there will also be a greater need for postgraduate-level education and training. Previous commentators have highlighted the need for geriatric dentistry to be incorporated into both the undergraduate and postgraduate dental curricula [5,41]. The need for a recognised dental specialty in gerodontology has also been raised recently [42], and there is merit in such a consideration. However, considering that dentistry is already a specialised health sciences field with several existing sub-specialities, it could be argued that specialists in the fields where the older population already constitutes a large proportion of the patient pool could be trained further in order to meet those gerodontological requirements. Prosthodontics and special needs dentistry are two such dental specialties where older patients and people who are medically compromised are already routinely seen. The International College of Prosthodontists recently asserted that dental geriatrics should be included as one of the major courses in the postgraduate prosthodontic programme curriculum [43]. Conversely, it could be argued that prosthodontists might not want to spend a lot of their clinical time dealing with relatively low-level problems, and that there is indeed scope (and room) for the specialist gerodontologist. The scarcity of special needs dentistry specialists complicates the issue: they would be ideally placed to provide care to the geriatric population, but there are too few of them at present. There is, of course, scope for the further deployment of dental hygienists (or the relatively recent dual-qualified therapist-hygienists) in the sector alongside the dentists and dental specialists.

Turning to the dental curriculum, the topics taught in gerodontology need to be broad, ranging from ageing theories, older persons’ nutrition, and the neuromuscular function of aged individuals to more dentally oriented subjects such as the management of root surface caries and changes to tissues in the denture space. Prior to treating older patients, it is necessary for students to have sound knowledge about variations in biological ageing and for them to be able to differentiate between normal ageing-associated changes and the pathological effects of diseases [44]. Effective clinical education programmes need to go beyond merely minimum exposure to various older people to intensive and stimulating clinical experiences in an environment that provides the oversight and guidance which allow students to develop a greater degree of comfort in treating older people and provides the foundations for caring for those populations in dental practice rather than always in an institutional setting [45].

Currently, there is considerable room for improvement in the education and training of dentists. For example, a substantial proportion of graduating dental students across the US felt insufficiently trained in treating older people and were therefore less willing to manage those patients [46]. This perception is also reflected in dentists’ general reluctance to treat (and low interest in treating) older people residing in long-term care facilities [40,47]. Dental professionals regard providing such a service as a minimal financial gain and this lack of competence, confidence and interest must be addressed by adequate training in the area of gerodontology so that the older population in need can be served [48]. Undergraduate education is the seedbed for conscientious professionals [49], and it is therefore important to place
appropriate emphasis on oral health care for older patients in the undergraduate curriculum [50–53]. There is some evidence that undergraduate clinical exposure to gerodontology results in a higher likelihood of dentists subsequently providing comprehensive care in nursing homes, because they are exposed to a different group of older people during those crucial undergraduate years [54,55]. Similarly, extramural activities involving older people contribute to the formation of positive attitudes and a willingness to work with older patients upon qualification [49].

The skills necessary for treating older patients can differ according to the dependency level of the individual concerned. A proportion of the older population would have received extensive dental treatment requiring comprehensive and sophisticated designs. However, as the patients become more debilitated or faced with restricted financial circumstances, the ongoing maintenance issues need to be dealt with in a timely and simple manner. The clinician needs to adjust from a “treat everything” philosophy to treating and restoring what is necessary for patients to function comfortably [56]. There is also the need to “plan for failure”, so that the proportion of the dentition affected by the failure of a component or unit is minimised and the patient is not disadvantaged any more than absolutely necessary. That failure can result from biological complications—such as dental caries and periodontitis—or patient-related failure, where the individual is no longer able to sustain the meticulous self-care which is required to maintain complex restorations such as implant-supported bridges or overdentures. It is crucial that the initial treatment provided can be modified in the future to allow easier maintenance. For example, an implant fixed bridge should be designed in such a way that it can be converted to either a removable implant prosthesis (to improve oral hygiene access for patients who struggle with their manual dexterity) or even more traditional conventional dentures for those who may develop severe dementia or difficulty in maintaining adequate self-care. While oral implants have shown to improve quality of life for older edentulous patients [57], they can also rapidly become a burden to those who are unable to receive satisfactory maintenance [58].

It is important that clinicians are clinically competent and experienced in a wide range of dental procedures, so that the treatment can be delivered in the most effective and efficient manner. The cost of dental treatment can be high; it can be invasive and require multiple visits, and many older patients may opt for “easier” (or indeed cheaper) options at the cost of their longer-term oral health.

The fall in the prevalence of edentulism has led to a gradual withdrawal from complete denture prosthetics in dental education. It has been pointed out that many recent graduates in the UK are not confident or competent in treating edentulous patients. The removable prosthetics curriculum has been reduced to a bare minimum [59]. As pointed out in respect of New Zealand, an ongoing absolute fall in the number of edentulous people has led to a de facto abandoning of complete denture prosthodontics and its relegation to clinical dental technicians [60]. The over-representation of low-income adults among the edentulous population has further hastened the dental profession’s general abandoning of that area of practice. Earlier commentators have already suggested the possibility of teaching complete dentures through the approach of duplicating patients’ existing dentures or modifying these duplicate dentures according to patients’ needs [59,61]. This could enable simplification of the removable prosthodontic curriculum, but dentists are the ones who must diagnose, treat and plan for any future oral health needs of our older patients. Without an ongoing, comprehensive understanding of removable prosthodontics, the profession’s ability to meet the ongoing needs of edentulous (or even partially dentate) older patients would be compromised.

Conclusions

Steady increases in both the absolute and relative numbers of older people—together with increases in tooth retention into old age—pose particular challenges for the oral care system. Although the other oral conditions are important, dental caries remains by far the greatest clinical challenge faced by those treating older people. The dental profession will have to be equipped to meet the dual challenges of treating and preventing the disease in a group which is usually hard to reach and which has not enjoyed much attention from policy-makers to date, at least where oral health is concerned. There is a need to identify, develop and test innovative approaches to catering for older people’s oral health needs.

References


Scientific article

Oral health status and complete denture status of independent-living Singaporean elderly residing in a community home

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A B S T R A C T

Aim: Past studies have examined the oral health status of elderly Singaporean adults residing in long term care facilities and living in residential housing but no oral health research has been conducted on elderly Singaporeans residing in community homes. The aim of this paper is to report on the oral health status and complete denture status of a group of free living (community dwelling) elderly in Singapore from the AWWA Community Home for Senior Citizens, and investigate the relation between the clinical findings and demographic data.

Materials and methods: This research used a cross-sectional design and was conducted in the month of December 2011. Consenting residents of the AWWA home who were over the age of 60 participated in this study. Sampling strategy was census. Two calibrated interviewers collected demographic information from the participants and four calibrated dentists conducted extra-oral and intra-oral soft tissue examinations along with assessment of dentition, periodontal and denture status.

Statistical analysis: All data were input into Microsoft Excel 2010™ and analysed in SPSS 21.0™. Descriptive analysis and bivariate analysis were performed on the demographic factors and other variables of interest. The Spearman’s test, Mann–Whitney U and Chi-Square test were used to examine the correlation between the clinical findings and age, gender and education level respectively.

Results: Among the 70 participants, two subjects (2.9%) had complete dentition, 34 (48.6%) were partially dentate, and 34 (48.6%) had no teeth. The mean number of teeth among the partially dentate participants was 11.28 while the mean number of anterior, posterior and total occlusal contacts were 1.61, 2.17 and 3.78 respectively. The mean number of decayed teeth (DT) and filled teeth (FT) were 2.81 and 0.25, giving a mean DFT score of 3.06. The mean Root Caries Index was 0.13. Periodontal examination revealed that only 5 (13.9%) individuals had healthy periodontal tissues, while 2 (5.6%) had the highest score of 1, 9 (25.0%) had the highest score of 2, 11 (30.6%) had the highest score of 3 and 7 (19.4%) had
the highest score of 4. Amongst the partially dentate, 14 had dentures and 20 had none. There were 34 edentulous participants and 23 had at least one denture while 11 did not have any complete dentures. The most frequent unsatisfactory finding for complete dentures was inadequate retention of the mandibular dentures. When the dentures were grouped into those that were satisfactory and those that had at least one unsatisfactory factor, 11 of the 26 maxillary dentures and 17 of the 23 mandibular dentures fell to the latter category. Analysis revealed that there was a correlation between age and the number of teeth with a correlation coefficient of $-0.43$ ($p=0.01$) and age with the mean DFT, $-0.33$ ($p=0.05$).

Conclusion: The findings of this study revealed a high treatment need for this group of elderly.

Introduction

Singapore has one of the world’s fastest ageing populations, with the proportion of elderly adults rising from 10.5% of the total population in 2013 to almost 20% of the total population by 2030 [1]. By 2030, it is estimated that the number of seniors above 65 in Singapore will increase to almost one million. One of the challenges with an ageing population is ensuring that the needs of the elderly, including their oral health needs are well provided for. Studies have shown that oral health can have a significant impact on the general health and quality of life of individuals; therefore, public health policies need to take into consideration the oral health status and needs of the elderly population [2,3]. This will encourage active and healthy ageing amongst the elderly population.

Peer-reviewed reports on the oral health of the elderly in Singapore date back to the 1990s. Soh et al. examined the status of the dentition, soft tissue and periodontium of 479 institutionalized elderly living in long-term care facilities and found that the mean DMFT for the cohort was 27.0 [4]. Fifty-six percent of the elderly were edentulous and 78.8% were without dentures. They also found that 52.2% of the subjects presented without a dental condition that required immediate care. Loh et al. studied the oral health of 891 elderly residential residing adults and found that the percentage of edentulous individuals was 27.3% and there was a significant difference in the percentage of edentulous individuals in the different age groups [5]. The mean DMFT of the elderly in their study group was 53.4 and showed an upward trend with each increasing age cohort. Thean et al. studied the treatment needs of 184 nursing home residents to be high [6]. More than half the complete dentures examined were unsatisfactory and untreated decay and retained roots were prevalent.

Currently, there is not any information on the oral health status of elderly Singaporeans residing in community homes. In 2011, about 97 per cent of the elderly population resided in residential housing, while the remaining were living in institutions such as community and nursing homes [7]. Community homes, also known as sheltered homes, provide residential care for ambulant destitute or low-income elderly who are without family support and can live independently while nursing homes provide care for the elderly with medical conditions who need nursing care. This paper reports on the oral health status and complete denture status of a group of elderly Singaporeans residing in the AWWA Community Home for Senior Citizens, and investigates the relation between the clinical findings and demographic data.

Materials and methods

This research used a cross-sectional design and was conducted in the month of December 2011. The participants of this study were free-living residents of the Asian Women’s Welfare Association (AWWA) Community Home for Senior Citizens. Sampling strategy was census, as all the residents over the age of 60 years were invited to participate. The study was explained to the residents and written consent was obtained from all volunteer participants. Those unable to answer the questionnaire were excluded from the study. The participants were given an oral care kit as a token of gratitude for their participation. Ethical approval to conduct this research was received from the National University of Singapore Institutional Review Board, Reference Code 10-155.

Two calibrated interviewers collected demographic information and four calibrated dentists performed the clinical examinations on the participants. Demographic data collected included information regarding age, gender, level of education, number of years in Singapore, and monthly income. Clinical examinations were carried out on location using portable headlamps, mouth mirrors, CPI probe with 0.5 mm ball end, magnifying loops (Heine HR 2.5 x S frame), with the participants reclining on portable dental chairs. Clinical examination included extra-oral and intra-oral soft tissue examination along with assessment of dentition, periodontal and denture status.

Dentition status included the presence of natural teeth, the number of posterior and anterior occlusal contacts and presence of caries. The number of occlusal contacts was observed by asking the participant to bite in maximum intercuspsation. The number of posterior contacts counted the presence of contacts on mandibular premolars and molars while the number of anterior tooth contacts was counted by observing the number of contacts achieved on the mandibular anterior teeth. Dental caries was assessed using criteria described in ICDAS-2 with mouth mirrors, CPI
probes with a 0.5 mm ball tip, and headlamps [8]. ICDAS Caries codes 0 and 1 were not differentiated, as compressed air was not used for the examinations, but the rest of the codes and criteria were applied. Both coronal and exposed root surfaces were scored for the presence of caries and restorations. For this report, the scores were converted to decayed and filled surfaces, while missing surfaces are not reported due to recall error by the participants. For root surfaces, the findings are reported using the Root Caries Index [9].

Periodontal status was assessed using the Community Periodontal Index (CPI) according to the WHO methodology using a CPI probe with a 0.5 mm ball tip [10]. The scoring system is shown in Table 1. The mouth was divided into six sextants defined by teeth numbers 18–14, 13–23 24–28, 38–34, 33–43, and 44–48 and a sextant was examined only if there were two or more teeth present and not indicated for extraction. The two molars in each posterior sextant are paired for recording, and if one is missing, there is no replacement. If no index tooth was present in a sextant qualifying for examination, all the remaining teeth in that sextant were examined.

Complete dentures were assessed for retention, stability, defects and occlusion. Retention of maxillary dentures was assessed with the examiner placing his index finger and thumb in the premolar areas and exerting a gentle downward pressure while for the mandibular dentures the index finger and thumb of one hand were used to grip either side of the central incisors and a gentle upward force was exerted [4]. Stability was assessed with the examiner placing their index fingers and thumbs on either side of the premolars and applying rotatory and lateral forces on the complete denture. Occlusal relationship was recorded by asking the patient to bite down from his resting position, with the examiner gently supporting the lower denture with his index fingers. The relationship was recorded as inadequate if there was a slide of greater than one quarter cusp length into intercuspal position from first contact, if first contact was uneven, leading to displacement of the dentures on further closure or if first contact was clearly uneven between right and left or where all contact was on the anterior teeth, even in the absence of significant displacement. Defects in the form of broken teeth, missing teeth, fractured base and deficient base were noted for both maxillary and mandibular complete dentures. A score of 0 was given for each of the items if the item assessed was satisfactory and a score of 1 was given if the examination showed unsatisfactory findings. The scores were then tabulated to reflect the denture status and higher scores were associated with more problems with the complete dentures. Partial dentures were examined for the Kennedy classification, type of support, and retention. However, due to the variability of partial dentures, the status of partial dentures is not reported in this paper.

### Data analyses

All data were input into Microsoft Excel 2010™ and analysed in SPSS 21.0™. Descriptive analysis and bivariate analysis were carried out for the demographic factors and other variables of interest. The Spearman’s test, Mann–Whitney U and Chi-Square test were used to examine the correlation between the clinical findings and age, gender and education level respectively.

### Results

#### Demographic distribution

Seventy participants were recruited in this study (47 (67%) males; 23 (33%) females). The demographic distribution of the study population is shown in Table 2. The mean age of the participants was 74.4, with the oldest being 91 years of age. Sixty-four (91%) were Chinese, 5 (7%) were Malays and there was 1 (1%) Indian participant. Whilst 19 (27%) of the participants had no formal education, 32 (46%) had up to primary

---

### Table 1 – CPI scoring system.

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Healthy</td>
</tr>
<tr>
<td>1</td>
<td>Bleeding observed, directly or by using mouth mirror, after sensing</td>
</tr>
<tr>
<td>2</td>
<td>Calculus felt during probing but all the black area of the of probe is visible</td>
</tr>
<tr>
<td>3</td>
<td>Pocket 4 or 5 mm (gingival margin situated on black area of probe)</td>
</tr>
<tr>
<td>4</td>
<td>Pocket &gt; 6 mm (black area of probe not visible)</td>
</tr>
<tr>
<td>X</td>
<td>Excluded sextant</td>
</tr>
<tr>
<td>9</td>
<td>Not recorded</td>
</tr>
</tbody>
</table>

---

### Table 2 – Distribution of some socio-demographical characteristics of elderly subjects (n=70).

<table>
<thead>
<tr>
<th>Demographic variables</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>47 (67.1)</td>
</tr>
<tr>
<td>Female</td>
<td>23 (32.9)</td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>60–69</td>
<td>15 (21.4)</td>
</tr>
<tr>
<td>70–79</td>
<td>34 (48.6)</td>
</tr>
<tr>
<td>80 and above</td>
<td>21 (30.0)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
</tr>
<tr>
<td>Chinese</td>
<td>64 (91.4)</td>
</tr>
<tr>
<td>Malay</td>
<td>5 (7.1)</td>
</tr>
<tr>
<td>Indian</td>
<td>1 (1.4)</td>
</tr>
<tr>
<td>Education level</td>
<td></td>
</tr>
<tr>
<td>No formal qualification</td>
<td>19 (27.1)</td>
</tr>
<tr>
<td>Primary school education</td>
<td>32 (45.7)</td>
</tr>
<tr>
<td>Secondary school education</td>
<td>18 (25.8)</td>
</tr>
<tr>
<td>Professional qualification</td>
<td>1 (1.4)</td>
</tr>
<tr>
<td>Marital</td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>54 (77.1)</td>
</tr>
<tr>
<td>Married</td>
<td>12 (17.1)</td>
</tr>
<tr>
<td>Divorced</td>
<td>4 (5.7)</td>
</tr>
<tr>
<td>Monthly income</td>
<td></td>
</tr>
<tr>
<td>No income</td>
<td>9 (12.9)</td>
</tr>
<tr>
<td>Up to $999</td>
<td>61 (87.1)</td>
</tr>
</tbody>
</table>
school education, 18 (26%) had up to secondary school education, and only 1 had a professional qualification. Fifty-four (77%) of the participants were single, 12 (17%) were married, and 4 (6%) were divorced. The majority of the participants, 61 (87%) were engaged in the work force and only 9 (13%) were not.

**Prevalence of edentulism and denture usage**

Amongst the participants, 4 (5.7%) had all maxillary teeth present (with the exception of the third molars) and 2 (2.9%) had intact mandibular dentition. Twenty-five (36%) were partially edentulous on the maxillary arch and 12 of them had partial dentures. For the mandibular arch, 32 (46%) were partially edentulous and 7 had partial dentures. Forty-one (56%) of the participants were edentulous on the maxillary arch and 26 had complete denture prosthesis. On the mandibular arch, 36 (51%) were edentulous and 23 had complete denture prosthesis. Two subjects (2.9%) had complete dentition, 34 (48.6%) were partially dentate, and 34 (48.6%) were edentulous. Amongst the partially dentate, 14 had dentures and 20 had none. Amongst the edentulous participants, 23 had at least one denture and 11 did not have any complete dentures. Table 3 summarises the data on prevalence of edentulism and denture usage.

**Dentition status**

Of the 70 participants, 34 were edentulous; thus, only 36 were included in the examination and analysis of dentition status. The mean number of teeth was 11.28. The mean number of anterior, posterior and total occlusal contacts were 1.61, 2.17 and 3.78 respectively. The mean number of decayed teeth (DT) was 2.81 while that of filled teeth (FT) was 0.25, giving a mean decayed and filled teeth (DFT) score of 3.06. The mean RCI index was 0.13. Table 4 shows the dentition status of the 36 dentate participants. There was a correlation between age and the number of teeth with a correlation coefficient of $-0.43 \,(p=0.01)$ and age with the mean DFT, $-0.33 \,(p=0.05)$. There was no correlation noted between age, gender and education level with the other factors considered in dentition status. The intra-class correlation for inter-examiner reliability was 0.94 for DT.

**Periodontal status**

Table 5 shows the periodontal status of the participants according to CPI. Only 5 (13.9%) individuals had healthy periodontal tissues, while 2 (5.6%) had the highest score of 3, and 7 (19.4%) had the highest score of 4. There were no significant correlations noted between the highest CPI score and age, gender and education level.

**Status of complete dentures and its relationship with demographic factors**

The results for complete denture status are shown in Table 6. For maxillary complete dentures, 18 (69%) had satisfactory retention and the remaining 8 were deemed unsatisfactory.

### Table 3 – Prevalence of edentulism and denture usage according to arch.

<table>
<thead>
<tr>
<th></th>
<th>Maxillary arch n (%)</th>
<th>Mandibular arch n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All teeth present (except 8s)</td>
<td>4 (5.7)</td>
<td>2 (2.9)</td>
</tr>
<tr>
<td>Partially dentate with denture</td>
<td>12 (17.0)</td>
<td>7 (10.0)</td>
</tr>
<tr>
<td>Partially dentate without denture</td>
<td>13 (18.6)</td>
<td>25 (35.7)</td>
</tr>
<tr>
<td>Complete edentulism with denture</td>
<td>26 (37.1)</td>
<td>23 (32.6)</td>
</tr>
<tr>
<td>Complete edentulism without denture</td>
<td>15 (21.4)</td>
<td>13 (18.6)</td>
</tr>
<tr>
<td>Total</td>
<td>70 (100)</td>
<td>70 (100)</td>
</tr>
</tbody>
</table>

### Table 4 – Dentition status among the 36 dentate participants.

<table>
<thead>
<tr>
<th></th>
<th>Male (n=25)</th>
<th>Female (n=11)</th>
<th>Total (n=36)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of natural teeth</td>
<td>10.6 (6.98–14.30)</td>
<td>12.7 (7.46–18.00)</td>
<td>11.28 (8.40–14.16)</td>
</tr>
<tr>
<td>Number of anterior occlusal contacts</td>
<td>1.6 (0.69–2.51)</td>
<td>1.63 (0.39–2.89)</td>
<td>1.61 (0.91–2.31)</td>
</tr>
<tr>
<td>Number of posterior contacts</td>
<td>2 (0.46–3.54)</td>
<td>2.55 (–0.45–5.54)</td>
<td>2.17 (0.84–3.49)</td>
</tr>
<tr>
<td>Total occlusal contacts</td>
<td>3.6 (1.25–5.95)</td>
<td>4.18 (1.00–7.36)</td>
<td>3.78 (1.97–5.59)</td>
</tr>
<tr>
<td>DT</td>
<td>3.32 (1.87–4.77)</td>
<td>1.64 (0.13–3.15)</td>
<td>2.81 (1.71–3.90)</td>
</tr>
<tr>
<td>FT</td>
<td>0.12 (–0.13–0.37)</td>
<td>0.55 (–0.15–1.24)</td>
<td>0.25 (–0.01–0.51)</td>
</tr>
<tr>
<td>DFT</td>
<td>3.44 (2.02–4.86)</td>
<td>2.18 (0.69–3.68)</td>
<td>3.06 (1.99–4.12)</td>
</tr>
<tr>
<td>No. of root surfaces with decay</td>
<td>0.68 (–0.35–1.71)</td>
<td>1.36 (–0.66–3.39)</td>
<td>0.89 (0.00–1.78)</td>
</tr>
<tr>
<td>No. of root surfaces with permanent fillings</td>
<td>3.12 (0.37–6.20)</td>
<td>2.55 (0.14–4.96)</td>
<td>2.94 (0.75–5.14)</td>
</tr>
<tr>
<td>No. of sound root surfaces</td>
<td>23.08 (16.04–30.11)</td>
<td>31.27 (17.69–44.86)</td>
<td>25.58 (19.44–31.73)</td>
</tr>
<tr>
<td>Root Caries Index</td>
<td>0.13 (0.06–0.21)</td>
<td>0.12 (0.03–0.20)</td>
<td>0.13 (0.07–0.19)</td>
</tr>
</tbody>
</table>
In terms of stability, 22 (85%) of the maxillary complete dentures were satisfactory while 4 (15%) were unsatisfactory. For mandibular complete dentures, only 6 (26%) had satisfactory retention, 14 (61%) had satisfactory stability, in contrast to the 17 (74%) and 9 (39%) which had inadequate retention and inadequate stability, respectively. Eleven out of the 49 complete dentures examined had defects. Seventeen (65%) of the 26 dentures had satisfactory occlusion with the opposing arch. When the dentures were grouped into those which were satisfactory and those which had at least one unsatisfactory factor, 11 of the 26 maxillary dentures and 17 of the 23 mandibular dentures fell to the latter category. The status of complete dentures was not related to age, gender or educational level.

**Discussion**

This is the first study in Singapore reporting on the oral health of independent residents of a community home. Unlike residents of nursing homes, these elderly were ambulant and active and studies have shown that active elderly tend to have better oral health than dependent elderly [11]. However, residents of community homes have limited financial income and as shown in Table 2, 72.8% of the participants in this study attained only primary school education and 61 (87.1%) reported monthly income up to $999 while 9 (12.9%) reported no income. Low income and education level have been associated with poor oral health in the elderly, who tend to be underserved with regards to oral care [12]. In this study, no attempt was made to determine the correlation between clinical findings and income level, since the participants had no or limited income. It is important to note that the findings of this study describe the oral health status of this unique group of elderly and should not be generalised to the general elderly population in Singapore. It does, however, reveal the need for oral health care amongst this group of elderly.

A high percentage of the participants (48.6%) in this study were edentulous and among those partially dentate, the mean number of natural teeth was 11.28 and the mean number of occluding contacts was 3.78 (Table 4). While it has been noted that globally the elderly are living longer and retaining more teeth, this trend might not be the case for elderly who are of low economic status [13]. Amongst the partially dentate, 20 (58.9%) of the partially dentate participants did not have any partial dentures and 23 (32.4%) of the edentulous participants had no complete dentures. This proportion was lower than the 94% of the partially dentate participants and 78.8% of the edentate participants who could benefit from prosthetic treatment in the study by Soh et al. [4]. The necessity of dentures may be questioned for partially dentate individuals, since the presence of dentures may increase the incidence of caries, periodontal problems and denture stomatitis in the absence of proper oral care. It has also been suggested that there was sufficient adaptive capacity in subjects with at least four occlusal units and that it was not necessary to restore an individual to complete dentition of 28 teeth [14]. On the other hand, dentures may aid in masticatory function, especially in subjects who have fewer than 3 occluding pairs of teeth, and help to improve aesthetics and thus self-esteem [15]. In this study population, given that the mean number of natural teeth and occluding contacts were low, participants may be able to benefit from the provision of partial dentures. The presence of complete dentures may also be beneficial for edentate individuals since the absence of complete dentures has been linked to the risk of malnutrition in edentate subjects [16].

A global survey by the World Health Organisation revealed a huge unmet need for denture treatment and restorative dental care amongst older people [12]. However, the provision of dental care based on normative treatment need alone might not be sufficient to determine if prosthetic treatment should be provided since the impact of missing teeth might not affect the functioning, social and psychological well-being of these individuals. Using the sociodental approach might provide a more relevant estimation of treatment need in the provision of dentures in the elderly population [17]. This approach involves identifying both normative needs and socio-dental factors, such as perceived impacts and oral health-related behaviours, and should be utilised in subsequent studies.
Complete denture examination showed that 17 out of the 23 mandibular prostheses had unsatisfactory retention. This is similar to the findings of the study by Thean et al. which showed that almost 50% of the complete dentures had inadequate retention [6]. The study by Soh et al. revealed that 20% of the complete dentures needed replacement due to inadequate retention or stability [4]. Elderly adults may be satisfied with the function of their poor fitting dentures since there may be a lack of association between clinicians’ evaluation of dentures and patients’ satisfaction [18]. In cases where it is difficult to achieve retention for mandibular complete dentures, it has been suggested that implant retained mandibular overdentures be considered and studies have shown that such an intervention can help to improve the quality of life of the elderly [19]. However, the increased cost and greater need of maintenance for implant-retained overdentures may deter the elderly from seeking this modality of treatment.

This study omitted the reporting of the mean number of missing teeth due to caries (MT) since it was difficult for the elderly to recall accurately the reasons for the extraction of their teeth; hence only mean DFT was reported. The study by Loh et al. on community-dwelling elderly found that the mean DT and the FT was 1.2 and 2.0 respectively [5]. The DT of 2.21 was higher in this study but the FT of 0.25 was much lower than the study by Loh et al. [5]. However, our values for DT and DFT correspond closely with those found in India and China [20,21]. The DT for a study amongst the elderly in India (n=300) was 2.5 and another study in China (n=23452) found the DFT to be 2.5. The mean DT of 2.81 and mean decayed root surface of 0.89 reflect a high treatment need for this group of independent living elderly. The low FT of 0.25 and high DT could be due to a preference for tooth extraction in older people or may reflect an underutilisation of restorative care due to various reasons. The use of professional dental services has been shown to be low amongst elderly adults, particularly among the socio-economically disadvantaged [22]. Dental caries is a major public health problem in older people and it is closely linked to social and behavioural factors such as irregular dental attendance and lack of proper oral hygiene habits [13]. This study also showed that the number of teeth and mean DFT were significantly correlated with age (p=0.01 and 0.05 respectively), similar to findings in other studies [23,24].

The prevalence of subjects with the highest CPI score 2 and 3 has been noted in other countries as was the case for this study, where 61% of the participants had the highest CPI score 2 and 3, reflecting poor oral hygiene, while 19.4% had CPI-4, an indication of severe periodontal disease [12]. A study in Hong Kong among low-income middle-aged to elderly participants had results similar to this study, where 64.1% of the participants had the highest CPI score 2 and 3 while 35.9% had CPI-4 [25]. While age was not associated with the incidence of periodontal disease, earlier studies have shown that females and those with a higher level of education had better periodontal health [26,27]. However, this was not the case in our sample population and could possibly be due to the small sample size, resulting in a Type II error. The promotion of good oral self care and regular visits to dentists throughout the adult lifespan might be beneficial in improving the oral health status of the elderly population. Oral hygiene education programmes targeting the elderly have been shown to improve self-care skills and may ultimately impact positively on the oral health status of the elderly [28]. This may result in the retention of more natural teeth, which has been associated with better oral-health quality of life of individuals [3].

6. Conclusion

The results from this study showed there is a great normative need for dental care in this group of elderly. There is also a significant correlation between age and the number of natural teeth and DFT (p=0.01 and 0.05 respectively).

Acknowledgement

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References

Factors contributing to tooth loss among the elderly: A cross sectional study

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\textbf{ABSTRACT}

Background: The present study evaluates the influence of several demographic, health, personal, and clinical factors on the number of missing teeth in old age sample.

\textbf{Methods}: The number of patients included was 259; they received a full mouth examination and answered a questionnaire provided by one examiner. All the variables related to teeth loss based on the literature were included. These variables focused on age, gender, race, marital status, clinical attachment level, pocket depth, year of smoking, number of cigarettes smoked per day, number of medications, root decay, coronal decay, health status, and year of education. Statistical analysis involved stepwise multivariate linear regression.

\textbf{Results}: Teeth loss was statistically associated with clinical attachment level (CAL) ($p$ value 0.0001), pocket depth (PD) (0.0007) and education level (0.0048). When smoking was included in the model, age was significantly associated with teeth loss (0.0037). At least one of these four factors was also related to teeth loss in several specific groups such as diabetes mellitus, male, and White. The multiple linear regressions for all the proposed variables showed that they contributed to teeth loss by about 23%.

\textbf{Conclusions}: It can be concluded that less education or increased clinical attachment level loss may increase number of missing teeth. Additionally, age may cause teeth loss in the presence of smoking.

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Contribute to tooth loss or extractions include un-repairable teeth (either from fractures or caries) (27%), or periapical lesions (12%), however 35.6% of the teeth extracted had an endodontic treatment [6]. Anand et al. reported on extraction trends in India, caries was observed as the main etiologic factor for extraction at 44%, periodontal breakdown at 33%, Orthodontic reasons at 11%, impactions and prosthodontics purposes were at 2% [7]. Reports from previous studies stated that periodontitis is associated with coronary heart disease [8] and diabetes mellitus [9,10].

Genco et al. [11] found an association between various markers of periodontitis and cardiovascular disease (CVD). A good oral hygiene is needed to reduce the mortality risk among elderly population. It was reported that people who maintain good oral hygiene, and visit the dentist at least once a year, had a lower mortality risk when compared with people who did not have good oral hygiene maintenance [12,13]. However, elderly patients with periodontal disease need to have a more aggressive therapy than what is commonly practiced [14].

Rosén et al. found that, patients who did not visit their dentists at least once annually were more susceptible to periodontal progression [15]. Other studies found that, the use of dentures had a relationship with reduction of mortality rates for older patients, who are missing teeth; this can be explained by the reduction of teeth that can harbor specific ecology group of micro-organisms that might have an association with systemic conditions [16–18].

Bachwald et al. examined the relationship between individual income status, and chronic systemic inflammation, to assess the progression of periodontal disease and tooth loss in Pomerania, Germany, 2566 participants had a 5 year follow up. They concluded that there was an association between individual income status and periodontitis, as the income decreased the progression of periodontitis was more evident [19].

Linden et al. reported that age was found to be associated with tooth loss, due to the progressive loss of attachment level [20]. Renvert et al. in 2013 found that, prevalence of probing depth more than, or equal to 5 mm with radiographic bone loss more than 5 mm increased with age, regardless of frequent dental visits [21].

Chen et al. 2012 found that coronal root caries, and removable dentures had a synergistic effect on tooth loss in the old population; patients who wore dentures had multiple carious areas, when the areas were treated they had the highest risk of tooth loss [22].

Tooth loss is associated with a lower quality of life due to more bacterial accumulation around the sulcus of the teeth, and/or the dentures [23]. Chronic inflammation contributes to the formation of diseases like coronary disease, stroke, hypertension, diabetes mellitus, and chronic obstructive pulmonary disease [24].

There are limited studies that report on tooth loss with different variables such as education level, race, age, smoking, coronal caries, and number of medications. In the Linden et al. study [20], the final outcome reported was mortality; in contrast to what is being researched in the current study, which is tooth loss. Previously mentioned studies [19–24] reported on one or two of the following variables: education level, race, age, smoking, coronal caries, and number of medications; however, there was no study that combined all of those variables as a multi-variable interaction.

Teeth maintenance in elderly population deserves some attention as it increases the quality of life, which requires a stable dentition to aid in food digestion [25], having tooth loss might decrease the quality of life for the patient.

The aim of our current study is to evaluate if there is an association between, tooth loss and several other variables like coronal root caries, smoking, patient education level, race, diabetes, medication use, and age.

Materials and methods

The volunteers recruited for this study came from either Tufts Geriatric Outreach program (57% of participants) or Tufts dental clinics (43%). The Tufts Geriatric Outreach program performs dental screening, nutritional screening, and educational sessions for elderly people and is conducted at 30 different locations in the greater Boston area.

Selection criteria for enrollment in the study included being a community dwelling resident, having six or more teeth, being free from wasting illness (endocrine disease that would affect nutrition; recent unexplained weight loss; and active alcoholism), and being willing and able to complete a 3-d food diary in a predetermined manner. Each participant signed a consent form agreeing to participate in the study. The study was approved by the Human Investigation Review Committee of Tufts University.

Clinical oral examinations were conducted at Tufts University School of Dental Medicine by one examiner using artificial light, explorer, mirror, and air syringe. The teeth were dried before examination to assess the dental decay. The coronal and root caries and periodontal measurements were made on all subjects according to the diagnostic criteria used in the US adult survey [26]. Third molars were excluded from examination. Training and calibration sessions to standardize caries and periodontal measurements based on the diagnostic criteria used in the US adult survey [26] were held semi-annually. Intraclass correlation coefficients for clinical attachment level and probing depth were 0.92 and 0.88, respectively. Self-administered questionnaires on general and health knowledge, attitudes and behavior, and medication history were also administered.

Sample size

We expected to have 95% power based on squared multiple correlation ρ^{2} of 0.1, effect size of 0.11 and 10 predictors, a sample size of 195, and α=0.05. We expect about 20% drop out due to age of the participants. So, the total sample size was at least 245. The sample size was calculated using G*power software, version 3.1 (University Kiel, Germany).

Statistical analysis

Descriptive statistics were expressed as mean ± SD or N (%). Univariate analysis and the stepwise model selection technique determined the significant variables that are more commonly associated with actual number of teeth loss.
Multiple linear regressions were used to assess potential associations of actual number of teeth loss and several variables. The multicollinearity was checked. The adjustment and adequation of the final model was checked by the $C_p$ and $R^2$ adjusted. Analyses were performed using SAS 9.3 (SAS Institute, Cary NC).

### Results

Table 1 shows the demographic features of the study, the prevalent population was female, white, married, completed 13 years of education, and is about 72 years old. The population had deeper clinical attachment level ($\geq 3$ mm) and shallower pocket depth ($<3$ mm).

**Variables associated with actual number of teeth loss**

Actual number of teeth loss was statistically associated with clinical attachment level ($p$ value 0.0001), pocket depth (0.0007) and education (0.0048) (Table 2). Number of teeth loss increased with more recession, less pocket depth, and less education. When smoking was included in the model, age was significant and positively associated with teeth loss (0.0037). At least one of these four factors was also related to number of teeth loss in several specific groups such as diabetes mellitus, male, and White.

**Full model associated with actual number of teeth loss**

In further analyses, multiple linear regression with smoking excluded due to number of missing, the variables clinical attachment level, pocket depth and education were significant (Table 3). Other variables indicated that tooth loss was higher with increased number of medications and root caries. Single, African American, females that had diabetes or cardiovascular disease, were more likely to demonstrate increased tooth loss. Adding smoking to the model which reduced the total subject to 146 due to case wise deletion characteristic of multiple linear regression, showed the same result, except more teeth loss was observed with increased coronal caries and among married population (Table 4). Both models found that these variables together explained about 23% of factors associated with teeth loss.

**Discussion**

This study had a population of (44%) males compared to females (56%), most of the population was white (90%), and almost half of the population was married (52%).

---

**Table 1 – Descriptive statistics of the study sample.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>$N = 259$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean ± SD)</td>
<td>72.41 ± 15.43</td>
</tr>
<tr>
<td>Gender, n (%)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>108(44.08)</td>
</tr>
<tr>
<td>Female</td>
<td>137(55.92)</td>
</tr>
<tr>
<td>Race, n (%)</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>218(89.71)</td>
</tr>
<tr>
<td>African American</td>
<td>25(10.29)</td>
</tr>
<tr>
<td>Marital status, n (%)</td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>55(22.63)</td>
</tr>
<tr>
<td>Married</td>
<td>126(51.85)</td>
</tr>
<tr>
<td>Others</td>
<td>62(25.51)</td>
</tr>
<tr>
<td>Clinical attachment level (CAL) (mean ± SD)</td>
<td>3.33 ± 1.02</td>
</tr>
<tr>
<td>Clinical attachment level (CAL) n (%)</td>
<td></td>
</tr>
<tr>
<td>$\geq 3$ mm</td>
<td>107(41.31)</td>
</tr>
<tr>
<td>$&lt;3$ mm</td>
<td>152(58.69)</td>
</tr>
<tr>
<td>Pocket depth (mean ± SD)</td>
<td>2.01 ± 0.43</td>
</tr>
<tr>
<td>Pocket depth, n (%)</td>
<td></td>
</tr>
<tr>
<td>$\geq 3$ mm</td>
<td>252(97.30)</td>
</tr>
<tr>
<td>$&lt;3$ mm</td>
<td>7(2.70)</td>
</tr>
<tr>
<td>Years of smoking (mean ± SD)</td>
<td>4.92 ± 12.53</td>
</tr>
<tr>
<td>Number of cigarette per day</td>
<td>85420.90 ± 137382.52</td>
</tr>
<tr>
<td>Number of medications</td>
<td>0.72 ± 1.57</td>
</tr>
<tr>
<td>Missing teeth</td>
<td>8.73 ± 7.00</td>
</tr>
<tr>
<td>Root decay</td>
<td>0.39 ± 1.12</td>
</tr>
<tr>
<td>Coronal decay</td>
<td>0.64 ± 2.35</td>
</tr>
<tr>
<td>Total decay (root+coronal)</td>
<td>1.02 ± 2.81</td>
</tr>
<tr>
<td>Disease, n (%)</td>
<td></td>
</tr>
<tr>
<td>CVD</td>
<td>63(24.32)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>47(18.15)</td>
</tr>
<tr>
<td>Medical stable</td>
<td>149(57.53)</td>
</tr>
<tr>
<td>Years of education (mean ± SD)</td>
<td>13.96 ± 2.46</td>
</tr>
</tbody>
</table>

**Table 2 – Simple linear regression (univariate) analysis for all groups when teeth loss was associated with several demographic, health, personal and clinical factors.**

<table>
<thead>
<tr>
<th>Group and variable</th>
<th>$P$ value</th>
<th>estimate</th>
<th>SE</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>All: excluding smoking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean CAL</td>
<td>0.0001*</td>
<td>1.73290</td>
<td>0.44054</td>
<td>0.066</td>
</tr>
<tr>
<td>Mean PD</td>
<td>0.0007*</td>
<td>-3.84605</td>
<td>1.11906</td>
<td>0.115</td>
</tr>
<tr>
<td>Education</td>
<td>0.0048*</td>
<td>-0.54821</td>
<td>0.19254</td>
<td>0.147</td>
</tr>
<tr>
<td>All: including smoking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.0037*</td>
<td>0.17869</td>
<td>0.06035</td>
<td>0.071</td>
</tr>
<tr>
<td>CVD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>DM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean CAL</td>
<td>&lt;0.0001*</td>
<td>5.54010</td>
<td>1.13992</td>
<td>0.396</td>
</tr>
<tr>
<td>Medically stable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean CAL</td>
<td>&lt;0.0001*</td>
<td>2.57647</td>
<td>0.58867</td>
<td>0.164</td>
</tr>
<tr>
<td>Mean PD</td>
<td>0.0006*</td>
<td>-5.33759</td>
<td>1.49555</td>
<td>0.261</td>
</tr>
<tr>
<td>Age</td>
<td>0.0075*</td>
<td>0.11748</td>
<td>0.04303</td>
<td>0.314</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean CAL</td>
<td>0.0002*</td>
<td>1.71620</td>
<td>0.45805</td>
<td>0.067</td>
</tr>
<tr>
<td>Mean PD</td>
<td>0.0010*</td>
<td>-4.39621</td>
<td>1.31887</td>
<td>0.117</td>
</tr>
<tr>
<td>African American</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

* $P$ value $<0.05$.
It was found that tooth loss was associated with (a) increased clinical attachment level (CAL), (b) decreased probing depth (PD), and (c) less education level. When a tooth has increased CAL, it is less associated with the bone structure, PDL, and connective tissue, this increases its mobility and susceptibility to infection from bacteria due to the exposed dental tubules and apical migration, as the CAL progresses it causes the probing depth to decrease, hence we get shallower pocket depth.

Patient education was statically significant with tooth loss, when the population was more educated they had more teeth present, in contrast to the population with lower education that tended to have more teeth loss, our findings in patient education agreed with the findings from Buchwald et al. that reported Low education levels and low individual income were associated with higher chances of tooth loss [19].

Smoking and age were found to have a significant effect on tooth loss; hence if an individual was smoking and aging, he will have a higher chance of losing teeth compared to non-smokers. Ando et al. found that smoking, low education level, and poor nutritional status, had an association with tooth loss among middle-aged and elderly Japanese population [27], this agrees with our findings in the current study.

De Marchi et al. reported on a combination of factors that might influence tooth loss such as being old, male, married, living in the countryside, with less education, and was not satisfied with methods to obtain health services. All of the previous factors were associated with tooth loss [28].

Another study that has a different result, regarding smoking and age affecting tooth loss, is a study by Jiang et al., who studied the adult population in Rhode Island, and found
individuals that smoked had a high chance of losing teeth, and age was not related to tooth loss [29].

Being a white, male, and smoking increased the risk of tooth loss with increased CAL, decreased PD, and increased age. Diabetes mellitus (DM) was positively correlated to tooth loss with smoking, Meisel et al. in Germany found C-reactive protein (CRP), and other inflammatory mediators were elevated due to chronic inflammation, which affects the bone hemostasis and results in bone resorption around areas that involve the tooth structure [30].

Increasing the number of medications taken daily was also significant (without the smoking variable) to tooth loss incidence. Taking too many medications has a negative effect on the salivary glands, it reduces its function, and it favors more bacterial accumulation. Locker et al. reported that xerostomia has an important influence on the quality of life of the population [31].

When caries activity is associated with the root dentine, it produced a positive relation to tooth loss, as restoring these teeth becomes more challenging than restoring caries in the enamel surface, the main reason for tooth loss was the persistence of periodontal disease, followed by smoking, however when root caries was involved, it had an additional cause to tooth loss [32].

Caries in the crown area has less association with tooth loss. Both variables were not significant (p=0.746 root, p=0.862 crown caries) but it showed positive and negative correlations respectively to tooth loss. Imazato et al. reported on root caries among elderly population and concluded that root caries was more prevalent with patients that are taking increased number of medications, which induces xerostomia [33].

When we combine multiple variables like Married (M) vs. Single (S) there was a negative correlation to tooth loss, being single has a positive relation to tooth loss. African American (AM) vs. white had a positive relation to tooth loss. DM or CVD had positive relation to tooth loss.

When smoking variable was excluded in Table 3, it was found that CAL, PD, and EL variables were still statistically significant to tooth loss, however the PD had a negative relation because, as the tooth losses more bone support the distance from the gingival margin to the apex of the root decreases, hence the decrease in PD, this gives the negative relation right before the tooth is lost. The remaining variables in the table were not significant alone; however, when all are combined it can give a significant positive correlation to tooth loss. When we add smoking to the variables S, AM, and DM/CVD, it will enhance the positive correlation to tooth loss (up to 23%).

There are some limitations to the current study, (a) small sample size, (b) sample not representative as we got a convenient sample, and (c) lack of other studies that have the same study design with similar variables to compare the results.

We found that it might be beneficial to increase awareness and education, as this would help in encouraging the dwelling community to take a better care of their oral cavity. A regular dental visit helps to further maintain the teeth. Senior citizens that smoke are at an increased risk from losing their dentition. There should be a consideration when taking many medications as it can lead to a decrease in the salivary flow, which might induce more caries formation on the tooth and root. It is important to try and maintain teeth at a healthy state to have a good quality of life, especially in elderly population. A good masticatory performance or dietary intake is associated with good oral health status [34]. This study enables us to understand how different individual variables can interact with each other to result in an outcome of tooth loss.

Conclusion

It can be concluded that less education or more clinical attachment level loss may increase number of missing teeth. Additionally, age may cause teeth loss in the presence of smoking. Other variables indicated tooth loss was higher with increased number of medications, root decreased coronal caries. Also it was found that Single African American females, that had diabetes or cardiovascular disease were more likely to demonstrate increased tooth loss. It is important to maintain teeth in a healthy status, to increase the quality of life among elderly population. However, we need a bigger sample size to further investigate this relationship.

Conflict of interest

None declared.

REFERENCES


Review

Challenges in anaesthesia for elderly

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A R T I C L E  I N F O

Keywords:
Anaesthesia
Postoperative delirium
Postoperative cognitive dysfunction
Elderly

A B S T R A C T

The segment of elderly individuals comprises a growing proportion of the global population. Health care systems and health care providers worldwide need to understand the specific challenges related to treatment of this heterogeneous patient population. The process of ageing is complex and under constant influence by numerous factors, for which reason the way human age is extremely individual.

It is important to understand and acknowledge how elderly differ from younger adults, and how management needs to be modified and tailored to the individual patient in order to improve outcomes. The goal of treatment of an elderly patient is not necessarily to increase human longevity regardless of the consequences, but to increase active longevity free from disability and functional dependence. For older people, deterioration in function can be devastating and is often precipitated by a stressful event such as an acute episode of illness or injury. Therefore a mainstay of treatment of the aged is prevention of functional decline.

In this review, we will outline the extreme variability in the aging process, and its implications for tailoring the perioperative care for the elderly. We will provide an overview of the challenges, when dealing with the aged surgical population with emphasis on postoperative cognitive changes.

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Introduction

In recent years a growing interest has revolved around the impact of surgery and anaesthesia on the elderly. As life expectancy increases with more elderly patients undergoing surgery [1], it is imperative that knowledge on this important topic is disseminated for health care systems and providers to understand why elderly are different and how management needs to be modified to improve outcome.

Especially postoperative cognitive decline is much more common in the elderly and this has been associated with higher morbidity and mortality among elderly, which challenges the benefits of surgery in this population. In this review, we will provide an overview of the problems when dealing with the aged, with emphasis on postoperative cognitive changes.

Ageing and the aged patient population

Ageing is a physiological process, where the structure and functional capacity of organs and tissue progressively degenerates over time. The ageing process is extra-ordinarily complex, and is constantly influenced by numerous factors; such as life style choices, environment, genetics, social network and chronic diseases [2]. The geriatric population has a higher prevalence of numerous medical conditions and comorbidity; including atherosclerosis, heart failure, diabetes, chronic obstructive lung disease, kidney impairment, and dementia. Often patients receive several drugs for their chronic diseases, which may have negative connotations. Polypharmacy can be associated with increased risk of adverse drug reactions, problematic drug interactions, and medication errors [3].

Humans age differently, for which reason the elderly patient population is health-wise extremely diverse. A large proportion of elderly is functionally independent; they are healthy or have well treated milder chronic diseases. However, a significant proportion of elderly are particularly frail; they have severe chronic diseases, high level of co-morbidity, and may have low functional capacity.

The human body has the capability to compensate for the age related changes to some extent, but elderly, healthy or sick, have a limited physiological reserve that can become evident upon application of stressors [4,5]. The increased frailty renders the elderly patient at risk of transient disabilities. This can potentially push the elderly into a vicious cycle that ultimately may lead to permanent loss of daily functions, loss of self-care capacity, dependence on supportive care or institutionalization [6]. Clinicians should be particularly aware of tailoring care and support to the individual patient’s needs, and for the elderly this may include careful considerations on how to prevent functional decline and disabilities.

Important aspects of perioperative care of the aged

A preoperative consultation is essential to evaluate the perioperative risks and plan preventive perioperative actions. It is important to address all the aspects of the elderly patient, which include changes induced by the process of aging, the cumulative impact of co-existing diseases, presence of polypharmacy, difficulties in communication and comprehension (reduced hearing or vision), compromised cognitive function, and a consideration whether the patient can provide informed consent [7]. It should always be considered, where a certain procedure for the individual patient could be best carried out. Certain patients should only be treated in places where supportive care and increased monitoring are available, for example elderly patients with bleeding disorders, or significant heart disease going through more invasive procedures. Relevant specialists e.g. a geriatrician should be consulted whenever in doubt how to provide best practice of care.

Generally, adjustment of drug selection and dosage is required for the elderly. Elderly patients are generally more sensitive to analgesics and sedatives. As polypharmacy is frequent, one should be aware of potential interactions. The variability in pharmacodynamics and kinetics is high; usually, smaller doses are needed for clinical effect compared to the adult population, and the duration of action is prolonged. Therefore dosing should be carefully titrated by the principle: “start low – go slow” [8]. Using local anaesthetics for elderly is usually safe. Not different from other adults, clinicians should be aware of allergies, decreased liver and kidney function, and pay attention to correct dosing of local anaesthetics to prevent toxic reactions [9].

It is essential to avoid inadequate pain relief; particular awareness should be given to the patients lacking communication abilities, as they may not be able to express if they experience pain (for an example a patient with severe dementia, or a patient suffering from a severe stroke). The use of multimodal analgesia is usually beneficial. This includes a combination of different analgesics and adjuvants. Anti-inflammatory drugs should be used cautiously, especially because of the risk of gastric bleeding, and renal impairment [10].

Sedation should be carried out with extreme caution since elderly are more susceptible to drugs acting on the central nervous system. Premedication with anxiolytics with weak sedative effects may be feasible with no further monitoring [11]; however deeper sedation should be carried out under continuous monitoring of vital functions (oxygen saturation, respiratory rate, heart rate, blood pressure, and electrocardiogram). General anaesthesia can be performed with either intravenous or inhaled anaesthetics. Selection of anaesthesia has to be individualized and influenced not only by the condition, but also by the anaesthesiologist’s skill and expertise.

Elderly are at higher risks for complications postoperatively. The immune system is not as effective as in the younger population, why elderly are more prone to hospital...
acquired and surgical infections. Other common complications include thromboembolic events, dehydration, insufficient nutrition intake, and insufficient pain treatment [12].

In past years, a growing interest has revolved around a significant part of elderly patients that experience cognitive decline after an operation. It has been proposed, that anesthetics could induce cognitive alterations.

**Syndromes of postoperative cognitive deterioration in the elderly**

Postoperative cognitive impairment can potentially affect patients of all ages, but is predominantly seen in the elderly.

Postoperative delirium (POD) and postoperative cognitive dysfunction (POCD) are the most common syndromes of neurobehavioral disturbances presenting after surgery; it is an on-going discussion whether these syndromes are part of a continuum or separate entities [1,13,14].

**Postoperative delirium**

Two types of delirium can be present in the postoperative phase; emergence delirium (ED) and postoperative delirium (POD). ED is benign temporal cognitive disorientation, that can occur during the transition from anaesthesia to wakefulness and resolves within minutes or hours [15,16], whilst (POD) is an acute organic brain syndrome that usually develops within the first few postoperative days [13,16].

POD is a common condition; approximately 15% of elderly patients experience POD after elective procedures, with a pronounced higher incidence rate (30–70%) for elderly undergoing emergency or major surgery [17,18]. A key feature of POD is the sudden onset of symptoms that tend to fluctuate during the course of the day. Following a lucid interval after surgery, patients characteristically debut with a disturbance in consciousness (reduced clarity of awareness, reduced ability to focus or sustain attention, reduced awareness of the surrounding environment). This is accompanied by cognitive changes (memory deficit, disorientation, language disturbances) or/and perceptual disturbances such as vivid hallucinations [18,19]. The severity of symptoms varies tremendously, which has been acknowledged by implementation of sub-diagnoses of POD based upon the patient’s psychomotor behaviour. The psychomotor types of delirium can range from hypoactive states e.g. the patient is sluggish or lethargic to hyperactive states, where the patient may be restless, agitated or even aggressive or violent [16]. Hypoactive forms of POD may be under-diagnosed due to a relatively non-disturbing behaviour, or misdiagnosed as symptomatic manifestations of dementia or depression [20]. However, clinicians should be particularly aware of signs of psychomotoric inhibition in elderly patients (to the point of stupor), as patients that develop a hypoactive form of POD seem to have a relatively increased mortality [20].

The pathophysiology of POD is still poorly understood. It may be related to disturbances in the production, release, or inactivation of neurotransmitters [21]. Another suspected culprit of POD is modulation of the inflammatory signalling system. This hypothesis suggests recruitment and activation of inflammatory substances in response to the surgical stress and anaesthesia may trigger neuroinflammation, thus contributing to POD [22–26].

Despite the underlying mechanism is still poorly understood, several predisposing and eliciting factors have been recognized. Predisposing factors include advanced age, preoperative cognitive impairment such as dementia, pre-existing medical disease burden, and genetic factors, for an example patients with a high-risk gene identified in Alzheimer’s disease (apolipoprotein E4 phenotype) have higher incidence and longer duration of POD [27].

Eliciting factors have been identified to include infection/inflammation, metabolite disturbances, substance withdrawal, medications, discomfort, environmental disturbances including sleep disruption, and severe pain with inadequate analgesia [28]. The risk factor for developing POD is additive, therefore recognizing the presence of one or more of the factors should render clinicians particularly aware of cognitive changes in the postoperative phase. Treatment of POD requires a multicomponent strategy aimed at both optimizing preventative measures in addition to eliminating eliciting triggers, if this does not reverse the symptoms, pharmacologic intervention with haloperidol may be required after excluding modifiable causes [29].

POD is an acute disorder, but has been associated with a wide range of negative long-term outcomes for the elderly, despite that patients may initially recover completely [28,30]. POD is associated with reduced function and independence, increased short- and long-term mortality, and prolonged cognitive impairment in survivors [28]. It has been suggested, that POD could induce dementia, but the association is not confirmed. There seems to be a significantly higher proportion of patients who experience POD that eventually will be given a diagnosis of dementia [31], but this may reflect that patients with pre-existing cognitive impairment may be more frail thus developing cognitive problems more easily.

**Postoperative cognitive dysfunction**

Opposed to POD, postoperative cognitive dysfunction (POCD) is more subtle. POCD can affect a wide spectrum of neuropsychological domains such as memory, psychomotor speed, information processing, and executive functions. The patient experiences, or their relatives observe, a subtle deterioration of daily cognitive performance that typically last for weeks or months postoperatively [31,32]. The majority of patients experiencing POCD debut with minor decrement of cognitive function such as discrete memory problems, mild personality changes, or the experience that formerly uncomplicated daily tasks suddenly are somewhat difficult to execute; for an example patients report that they cannot concentrate sufficiently to read the newspaper, or have forgotten how to brew coffee. Profound changes with significant loss of memory, intellectual abilities, or executive functions can be seen. Most patients return to their preoperative function after a shorter period of time, but whether POCD can precede a permanent deterioration of a patient’s cognitive trajectory is still debated and not entirely clear [13,30].

Approximately 10% of elderly undergoing surgery will develop POCD [33]. The true incidence is probably
underestimated, since many studies have excluded patients with pre-existing cognitive impairment or dementia at baseline [32,33].

The pathogenic mechanism leading to POCD is not well understood. Loss of cognitive reserve, cumulative effect of chronic disease, altered response to anaesthetics, and toxic effects of anaesthetics have been suggested, but not been proven to be responsible for postoperative cognitive decline in the elderly [34–36]. Similar to POD, the incidence rate of POCD varies with higher incidence in the subpopulation of elderly undergoing major surgery suggesting that a profound systemic inflammatory response may induce alteration of neurotransmitter function, neuroendocrine or immunomodulatory pathways [37–40], which eventually can lead to cognitive dysfunction.

Predisposing factors for POCD have been identified, which are quite similar to POD. These include advanced age, prior cognitive impairment, post- and perioperative complications (infection, second operation), and lower levels of education [1,41,42]. However, the evidence is slightly divergent, as some studies support while others cannot confirm correlations between these factors and POCD [36].

The development of POCD may adversely influence long health term outcome; it is associated with impairments of daily functioning, premature departure from the labour market and dependency on financial and personal support from government or family after hospital discharge, and most disturbingly is POCD associated with increased mortality [1,42,43].

**Diagnosing postoperative cognitive impairment**

To detect a postoperative cognitive decline, the clinician must foremost be aware of the patient’s habitual cognitive status to make a reasonable evaluation of changes from their individual baseline status. Various studies of both POCD and POD indicate that new onset of cerebral dysfunction in elderly is readily overlooked due to an incorrect assumption of pre-existing cognitive dysfunction.

The diagnosis of POD is based on detection of symptoms, where POCD encompass more subtle cognitive changes of one or more cognitive domains, which is why detection requires repeatedly neuropsychological testing.

Delirium is well defined in international disease classification systems, which relies on various compositions of diagnostic criteria [44,45]. Nevertheless, rapid bed-side assessment tools are more clinically appropriate for discovering delirium for the individual patient. Numerous suggestions of user-friendly diagnostic tools such as The Confusion Assessment Method (CAM), Nursing Delirium Symptom Checklist (NuDESC) have been developed. The Confusion Assessment Method for the Intensive Care Unit (CAM-ICU) have been validated in non-postoperative settings [46,47]. However, there are shortcomings of these tools; they have failed to stratify severity of delirium [48], and studies have questioned their specificity when used in postoperative settings [46]. Invention of an easy and exact clinically applicable delirium tool validated in postoperative settings is still demanded. Full-scale hyperactive delirium is usually easy to detect; however when suspicion of milder and fluctuating neuropsychological changes arises, repeatedly testing to capture the presence of POD should be initiated.

POCD has been vigorously studied since it first was described in scientific literature half a century ago; however the understanding of POCD is still evolving, thus no international classification system has formulated diagnostic criteria for POCD. A general consensus in scientific literature has formed, that POCD reflects affection of numerous neuropsychological domains, implying that detection relies on pre- and postoperative repeated testing of cognitive function by a battery of comprehensive neuropsychological tests [49]. Still core issues remain to be clarified; what determinate a clinical relevant decline in cognitive function, what are the optimal tests for measuring POCD, what are the timeframe in which a cognitive decline could merely be attributed to the perioperative trajectory instead of normal changes related to the ageing process of the human brain, what is the optimal timing for testing cognitive function before and after surgery? Adjustment for anxiety through inclusion of mood and anxiety scores may also be incorporated, because performance may be negatively affected by surgery-associated anxiety [50,51].

The difficulties of understanding and establishing diagnostic criteria for POCD may be ascribed to large diversity and methodological limitations among previous studies; lack of appropriate control groups, lack of baseline data on cognitive function, variation in definition on the magnitude of cognitive change attributed to cognitive dysfunction, missing validation of observations, inconsistent timing of testing, variation in test selection, or use of insensitive test batteries e.g. tests that do not address the patient’s affected cognitive domains, or tests that are insufficient to detect changes in cognitive function over time [49–51].

**Anaesthetic management**

At this point, no evidence supports the choice of one anaesthetic over another. The same applies for anaesthetic technique. In the early days of studying patients’ postoperative cognitive trajectories, an association between the anaesthetic technique and POCD was proposed, contemplating that general anaesthesia led to higher incidences of POCD and POD. However, a growing amount of evidence shows that the choice of general versus regional anaesthesia does not appear to influence on the occurrence or magnitude of POD or POCD [42,52,53].

As the pathogenesis of postoperative changes has been associated with inflammatory mediators, intra-operatively use of intravenous lidocaine was believed to provide neuro-protection by modulation of the inflammatory response, however no current evidence supports this theory [54].

Sedation may be employed in elderly in conjunction with regional anaesthesia, but careful age-related dose reduction is needed, and the feasibility of sedation is not quite elucidated [53,55]. In one trial, patient-controlled sedation was administered in elective ophthalmologic day-surgery with a
high level of patient satisfaction and no adverse effects on cognitive function [56], but the technique has not yet been validated in other studies. Perioperative sedation by dexmedetomidine infusion may be superior to other sedatives in reducing the incidence of POD [57,58], the effect on POCD is yet not elucidated.

Intraoperative close monitoring is believed to be essential to sustain physiologic homeostasis (e.g. continuous measuring by arterial gasses including status of electrolytes, temperature, urinary output, saturation, cardiac output, depth of sedation, brain oxygenation). However, the impact of extended monitoring and goal directed therapy on postoperative cognitive changes is not entirely clear. Carefully titrating anaesthesia using perioperative brain monitoring has been a research area of great interest [59]; cerebral oxygen oximetery can be measured by intra-operative near-infrared spectroscopy (NIRS), and depth of anaesthesia can be guided by continuous recordings of electroencephalograms processed by a bispectral index (BIS) monitor or auditory evoked potentials [32,55,59–64].

The evidence on effectiveness of minimizing cerebral oxygen desaturation and depth of sleep has been divergent [32,55,59–66], but there is mounting evidence from several randomised, controlled trials that anaesthetic administration guided by BIS-protocols can decrease POD [62]. However, future research with larger trials is needed to draw conclusions.

Currently there is no good evidence for the efficacy of any specific intervention to decrease POCD and POD. Distinct patient-related risk factors may be of greater aetiological importance than perioperative surgical or anaesthetic management [49,51,67]. From the patient’s hospital admission to discharge, emphases to maintain homeostasis and restore daily physical function may be most important.

Conclusion

Postoperative cognitive complications are often transitory, but can be associated with devastating outcomes in elderly patients. Understanding the causality concerning both POD and POCD is pending, but seems to be multifactorial.

To further substantiate the optimal management of these patients, future trials should be carefully designed, and employ administration of valid pre- and postoperative tests, that are easily applicable in clinical practice.

To this point, careful patient-centred management is essential to provide elderly patients their best chance of returning to their previous level of function.

Competing interest

No external funding and no competing interests declared.

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A.M. MacLullich, B.T. Edelshain, R.J. Hall, et al., Cerebrospinal fluid interleukin-8 levels are higher in people with hip fracture than in controls, J. Am. Geriatr. Soc. 59 (2011) 1151–1153.


W.A. van Gool, D. van de Beek, P. Eikelenboom, Systemic fluid interleukin-8 levels are higher in people with hip fracture than in controls, J. Am. Geriatr. Soc. 59 (2011) 1151–1153.


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Review

Clinical issues in occlusion – Part I

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A R T I C L E   I N F O

Keywords:
Occlusion
Occlusal trauma
Parafunction
Fremitus

A B S T R A C T

Good occlusal practise provides an important cornerstone to optimal patient care. Occlusal problems can manifest in different areas of dentistry but these are more apparent when there are restorative aspects to the patient’s problem. This review highlights areas of restorative dentistry where the appreciation of occlusal aspects can optimise diagnosis and follow up care.

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Introduction

The Glossary of Prosthodontic Terms defines Occlusion as ‘the act or process of closure or of being closed or shut off’ or ‘the static relationship between the incising or masticating surfaces of the maxillary or mandibular teeth or tooth analogues’ [1].

However, it is both static and dynamic relationships between different components of the masticatory system that are usually considered simultaneously when occlusion is examined or recorded. In essence, this describes the relationship between the opposing masticating surfaces of teeth and the movements of the mandible dictated by way of the temporomandibular joint and associated orofacial musculature. Therefore, occlusion represents a spectrum of anatomical and physiological principles varying in their complexity and intricacies. These principles can lack robust evidence to advocate their usage and as such,

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confusion and uncertainty can result. Recreating the occlusal relationships inaccurately outside of the mouth can result in frustration for the dentist, technician and most importantly the patient. In contrast there maybe situations (with appropriate planning) where restorations maybe cemented at an increased vertical dimension which may otherwise be considered unconventional.

The awareness of occlusal aspects when examining a patient as well as associating these with signs and symptoms provides information for optimal management. This ethos should be considered on a backdrop of changes in patient demographics, social pressures and increased patient expectations. The first part in this series will look at specific occlusal problems and their aetiology and diagnosis. The second part will illustrate occlusal registration techniques and subsequent management.

**Occlusion and tooth surface loss (TSL)**

Attrition results from tooth-to-tooth contact resulting in well-defined wear facets on the occluding surfaces of teeth which correspond between the maxilla and the mandible (Fig. 1). Physiological tooth wear is expected to a certain level when taking into account the age of the patient. Pathological toothwear (where the rate is greater than that expected physiologically) as a result of parafunctional activity results in the accelerated loss of tooth tissue, threatens pulp health and can result in axial tooth movement that will make future restorative management difficult due to changes in interocclusal relationships, potential differential tooth movement and loss of interocclusal space. In its mildest form faceting within enamel may provide early signs of attrition. In the latter stages tooth tissue may become significantly damaged resulting in difficulties in restoration and pulpal involvement (Table 1). The key in these situations is to identify patients with parafunctional activity, recognising this at the planning stages of any procedure and protecting tooth structure and restorations by way of individual design characteristics or considerations for long term appliance therapy. If such parafunctional activity is allowed to progress the prognosis for survival of teeth and their associated restorations is likely to diminish (Table 2).

One notable risk factor for parafunctional activity is psychological stress [2]. Current research shows that psychological stress is increasing in the general population and this is more often than not associated with vocation related pressures [3]. In such cases a thorough social history is likely to inform the treatment planning process and aide delivery of care. Other much cited risk factors include occlusal relationships such as the retruded contact-, intercuspal position slide and lateral guidance pathways such as canine or group function [4,5]. There is no evidence to suggest that any occlusal relationship will result in a greater likelihood of parafunction or indeed temporomandibular dysfunction [4,5].

General conservative management of attrition type TSL would be the provision of a stabilisation splint in the first instance in order to prevent further hard tissue surface loss. Parafuction against the splint would lead to favourable attrition of the acrylic splint material [6]. A upper soft bite guard could be made in acute cases as a quick urgent way of relief.

**Occlusion and restoring/increasing the occlusal vertical dimension (OVD)**

In cases of severe TSL due to a combination of attritive or erosive processes there may be extensive loss of the dental hard tissues, and commonly the teeth appear to look grossly shorter in clinical crown height from gingival aspect to the incisal edge or occlusal surface. It could appear that there is a loss of OVD here, however in most cases in dentate patients this is not the case due to physiological dentoalveolar compensation that occurs [7]. The compensatory mechanism is noticeable due to the varied position of the gingival zeniths of the anterior segment (Fig. 1). If the rate of tooth destruction occurs at a faster rate than compensation, an open bite can occur.

In cases where compensation has occurred there is a loss of interocclusal space, increasing the existing OVD is a treatment strategy that may be considered. Other more drastic treatment methods have been proposed such as elective extraction, surgical crown lengthening and orthodontic intrusion. These techniques vary in their invasiveness and as such irreversible damage. Although considered invasive and damaging to sound tooth tissue and supporting structures these techniques can still be considered with appropriate care and planning. A technique routinely utilised in the UK is increasing the OVD using a method modelled on a concept first illustrated by Dahl [8]. Dahl and colleagues were the first to discover this phenomenon in the 1970s by utilising a removable cobalt chromium intrusion appliance with a bite platform anteriorly. This concept was developed further in the 1990s in the UK by utilising composite resin to restore worn teeth (Fig. 2). This involves the placement of composite restorations at an increased OVD on anterior teeth leaving posterior teeth with no occlusal contacts. A period of occlusal adaptation results with a combination of intrusion of the anterior teeth and vertical migration of posterior teeth resulting in the relinquishing of contacts over time.

This treatment modality shows good short to medium term results although the requirement for maintenance maybe high [9]. Despite this, the advent of placement of
## Table 1 - Smith & Knight TSL Index

<table>
<thead>
<tr>
<th>Score</th>
<th>Surface</th>
<th>Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>BLOI C</td>
<td>No loss of enamel surface characteristics  No change of contour</td>
</tr>
<tr>
<td>1</td>
<td>BLOI C</td>
<td>Loss of enamel surface characteristics  Minimal loss of contour</td>
</tr>
<tr>
<td>2</td>
<td>BLO I C</td>
<td>Enamel loss just exposing dentine &lt; 1/3 of the surface  Enamel loss just exposing dentine  Defect less than 1 mm deep</td>
</tr>
<tr>
<td>3</td>
<td>BLO I C</td>
<td>Enamel loss just exposing dentine &gt; 1/3 of the surface  Enamel loss and substantial dentine loss but no pulp exposure  Defect 1-2 mm deep</td>
</tr>
<tr>
<td>4</td>
<td>BLO I C</td>
<td>Complete enamel loss or pulp exposure or secondary dentine exposure  Pulp exposure or secondary dentine exposure  Defect more than 2 mm deep, or pulp exposure or secondary dentine exposure</td>
</tr>
</tbody>
</table>

Each surface of each tooth is given a score between 0 and 4 according to its appearance.
B=buccal or labial, L=lingual or palatal, O=occlusal, I=incisal, C=cervical.

## Table 2

<table>
<thead>
<tr>
<th>Occlusal Problem</th>
<th>Clinical presentation</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tooth surface loss</td>
<td>Shortened teeth  Wear faceting  Dentine sensitivity</td>
<td>Preventive  ● Splint therapy  ● Patient education  Invasive  ● Provision of composite restorations at an increased occlusal vertical dimension</td>
</tr>
<tr>
<td>Restoration of teeth with limited interocclusal space and tooth surface loss</td>
<td>The need to create space for restorations that will be functional and aesthetic</td>
<td>● Dahl technique  ● Surgical crown lengthening  ● Orthodontic intrusion  ● Elective extraction</td>
</tr>
<tr>
<td>Crack/fracturing of teeth</td>
<td>Teeth with large restorations which restore marginal ridges or those with decay resulting in poor support of remaining tooth tissue</td>
<td>● Provision of cuspal coverage restoration such as an overlaid plastic restoration or an extra-coronal restoration such as a crown or onlay</td>
</tr>
<tr>
<td>Protecting non-vital teeth</td>
<td>The reduction in tooth tissue as above coupled with the presence of an access cavity for endodontics results in significant weakening of the remaining crown</td>
<td>● Provision of a copper band or an orthodontic band during endodontic therapy  ● Provision of an extra-coronal restoration on completion of root canal treatment</td>
</tr>
<tr>
<td>Occlusal trauma and periodontal disease</td>
<td>Periodontal disease may be exacerbated by the presence of occlusal trauma. The evidence for occlusal factors causing periodontal inflammation is very weak</td>
<td>Management of periodontal disease as per required without the instigation of occlusal adjustment/ modification</td>
</tr>
<tr>
<td>Occlusion and TMJD</td>
<td>● Pain associated with the muscles of mastication and the TMJ  ● Signs of wear or faceting  ● Clicking of TMJ  ● Locking of TMJ</td>
<td>● Conservative management involving patient education on risk factors for TMJD and how to minimise these  ● The reduction of stress, avoidance of habitual chewing such as nail biting, avoidance of a poor posture, and the prescription of TMJ joint exercises should always be the first line of treatment When deciding the occlusal scheme it maybe more advisable to maintain certain aspects such as the OVD from previous prostheses for purposes of adaptability. There is weak evidence advocating one occlusal scheme such as bilateral balanced over others when considering functionality of the prostheses</td>
</tr>
<tr>
<td>Occlusion and the ageing population</td>
<td>These cohort of patients are likely to have increased needs for complete denture prosthetics and maintenance of these prostheses</td>
<td></td>
</tr>
</tbody>
</table>
composite restorations at an increased OVD is biologically the kindest treatment modality when directly comparing to crowns, surgical crown lengthening or orthodontic intrusion.

**Occlusion and mechanical failure of teeth**

The cracking or fracture of teeth is a problem that is increasing and is notoriously difficult to diagnose in the early stages especially when the clinical picture does not always consistently correlate with the symptoms of the patient [10]. More often than not patients may present with parafunctional tendencies that are likely to stress and strain teeth prior to inception of a crack or fracture (Fig. 3). Other patients may give a history of trauma related to biting into something very hard at the inception of symptoms or fairly specific symptoms associated with pain on release, biting certain foods or biting in a certain way [9]. Cracks and fractures of teeth are significantly associated with large restorations and also mandibular molars [11,12]. The prevalence increases in patients forty years or older with women being more affected than men [13]. The incidence of complete fractures is approximately 5% in the adult population with the overwhelming majority being posterior teeth [13]. Of the 5% of complete fractures 15% result in pulp involvement or extraction [13]. Aetiological factors associated with fractured teeth are numerous. These can be split into local and general factors. General factors are likely to be associated with parafunctional activity or attrition placing teeth under significant loads for long periods. Local factors include morphology and the tooth's restorative status. Teeth with steep cuspal inclines may be naturally more prone to cracking when put under stress or strain [14]. This is in part associated with the wedging effect of the cusp fossa relationship putting teeth under tensile and internal shearing stresses [14]. Further to this teeth with large restorations and cusps that are poorly supported with an absence of underlying tooth tissue [15]. As tooth bulk decreases so does the remaining tissues ability to resist force and prevent fracture [15]. This is best illustrated by mesial occlusal distal (MOD) restorations on premolar teeth. Vale and colleagues discovered that with increased width of restoration isthmus a decreased resistance resulted. Where unsupported cusps are involved in non-working side interferences this is likely to compound the risk of fracture [16]. Despite the effect of reduction of tooth tissue a recent study found that the split between restored and unrestored teeth that suffered with cracks was approximately 50% [17] (Figs. 4 and 5).

Cuspal coverage of teeth with reduced tooth tissue provides a means to reduce the likelihood of fracturing or cracking. Cuspal coverage has been shown to provide greater resistance to fracture than non-cuspal coverage restorations and unrestored teeth [16]. These results were echoed by Salis and colleagues who found that MOD restorations weakened teeth when lacking an overlaying [18] (Fig. 6). Further aspects that may make teeth prone to fracture include the position within the arch. Frequently first molars have been cited due to their close proximity to the muscles of mastication and the temporomandibular joint making the forces exerted upon them greater than teeth further away [17]. Indeed the decision to provide cuspal coverage can be difficult to make. Where an extra-coronal restoration maybe indicated the removal of more tooth tissue, hence making the tooth even weaker, will be required prior to the provision of a

**Fig. 2** – Direct composite restorations placed on the upper and lower anteriors at an increased occlusal vertical dimension.

**Fig. 3** – Lower right 6 with a fractured lingual cusp. The tooth was still responsive to sensibility testing. The fracture was investigated and found to be subgingival but within normal limits of restorability. This tooth was restored with an onlay restoration.

**Fig. 4** – This patient complained of pain on release and on eating certain types of granary bread. Utilisation of disclosing solution on the upper left 5 revealed a crack that ran from mesial to the distal portion of the tooth.
crown. As yet there seems to be no objective consensus as to when to provide cuspal coverage to protect the remaining tooth tissue in vital teeth. This of course needs to be weighed against the greater probability of irreversible pulpal damage by the preparation [19]. In comparison the literature for cuspal coverage of non-vital teeth is more robust [20].

The need to protect non-vital teeth

Non-vital teeth have a significantly decreased ability to withstand occlusal loads when compared to vital teeth [21]. The pulp is likely to provide proprioceptive feedback that allows the masticatory system to avoid overloading and thus catastrophic fracture. This was illustrated in a classical study by Randow and Glantz where cantilevered loads were applied to vital and non-vital teeth. Pain perception by the patient manifested with occlusal loads that were twice as high for non-vital than vital teeth [22]. These differences were not present when the teeth were anaesthetised. This study illustrated the likelihood of mechanoreceptor function of the pulp and detection of occlusal loads. Once loss of vitality is established and root canal treatment is required the presence of an endodontic access cavity weakens teeth and so affects structural integrity [23]. The relative stiffness of a tooth reduces with an occlusal access cavity which increases significantly if marginal integrity is broken [23]. Reeh and co-workers found that an MOD cavity preparation reduced tooth stiffness by 63%. The defining factor in resisting occlusal loads of both vital and non-vital teeth seems to be the amount of remaining tooth tissue and as such minimising tissue removal during access cavity preparation is advised. Further to this chemo-mechanical endodontic procedures weaken teeth. The utilisation of hypochlorite and EDTA significantly weakened teeth and increased tooth surface strain [24,25]. These biomechanical factors need to be considered in tandem with the need for optimal coronal seal as lack of tooth tissue will not only make teeth susceptible to fracture but also compromise post root canal treatment failure due to re-infection [20].

Occlusion and the periodontium

Occlusal trauma is defined as ‘trauma to the periodontium from functional or parafunctional forces causing damage to the attachment apparatus of the periodontium by exceeding its adaptive and reparative capacities. It may be self-limiting or progressive’ [2] (Figs. 7 and 8). What seems clear within the literature and in practice is the need to distinguish between association and causation [26]. Periodontitis may be associated with a multitude of local, general or patient based factors ranging from overhanging restorations to inflammatory systematic diseases manifesting in the periodontium [26].

Few clinical studies have identified a link between trauma from occlusion and inflammatory periodontitis in man [27]. Although both processes cause destruction of the apparatus in different ways the exact mechanisms and whether there is true synergy between the two pathological processes is yet to be realised. It may be fair to say that occlusal trauma may exacerbate already present periodontal inflammation whereas orthodontic force is unlikely to exacerbate periodontal tissue loss. Where frank plaque induced periodontitis and occlusal trauma is present gradual widening of the periodontal ligament space with mobility and angular bone loss can be observed.
expected. In the absence of periodontitis occlusal trauma does not result in attachment loss but does result in tooth mobility which is reversed once the trauma is removed.

The utilisation of occlusal adjustment to reduce non-axial loading of teeth in an attempt to prevent occlusal trauma and so periodontal disease is controversial with poor or limited evidence to support it. The removal of sound tooth tissue to aide what is an inflammatory process fuelled by the presence of bacteria is difficult to recommend. In a randomised controlled trial two groups of patients underwent periodontal therapy with and without occlusal adjustment. There was no effect of occlusal adjustment on changes in pocket depth [28]. These findings were later confirmed by way of a Cochrane systematic review [29].

**Occlusion and temporomandibular joint dysfunction (TMJD)**

The role of occlusion in the development of TMJD is controversial as the majority of reasoning behind causation is based upon anecdotal rather than scientific evidence. Weak evidence between occlusal scheme and TMJD development has been identified [30,31]. In a series of studies by Seligman and Pullinger an overjet of greater than 5 mm, unilateral posterior crossbite and retruded contact position intercuspal position slides of greater than 1.75 mm were associated with TMJD although this was statistically weak. The fact that this was an association and not implication also requires some thought. Further to these findings Clark and colleagues in a systematic review found that the introduction of occlusal interferences did not result in significant evidence for development of TMJD [32]. Aetiology based on occlusal scheme does not stand up to scrutiny when considering fibromyalgic patients – 75% of which may present with TMJD regardless of occlusal scheme [33]. Indeed there is limited evidence for either occlusal splint therapy or occlusal adjustment in the treatment of TMJD [34]. In a systematic review examining both modalities the benefit of occlusal splint therapy was unclear, and none of the twenty studies included in the analysis could provide beneficial evidence for occlusal adjustment [35].

Due to the above findings it seems unsurprising that the authors recommend a conservative approach to TMJD treatment that are reversible and do not remove sound tooth tissue. The provision of an occlusal stabilisation splint, although reversible, does not provide significant benefit over ultra-conservative treatment [35]. In a randomised controlled trial comparing splint therapy to patient education and muscle exercise there was no detectable benefit of splint provision [35]. The emerging evidence shows that patient education coupled with jaw exercises provide patients with measurable improvements especially in patient centred outcome studies [36,37].

The current evidence is too weak to advocate occlusal adjustment and relatively ambiguous to advocate routine stabilisation splint therapy prescription. Conservative modalities such as patient education and muscle exercises seem to be the assured way of treatment at the current time [38].

**Occlusion and the ageing patient**

Our patients are living longer. As we age our adaptive capacity to changes decreases and this maybe the case with
occclusal modifications. Where complete dentures require replacement the adaptive capacity of the patient may need consideration when deciding on provision of a conventional prosthesis or simply copying the current dentures and modifying where required (Fig. 9). Other aspects include the loss of interocclusal space in isolated areas due to the overeruption of opposing teeth making prosthetic rehabilitation difficult to achieve. In such situations localised intrusion devices maybe utilised to recreate space for future restorations (Fig. 10).

When considering the prescription of occlusal scheme for complete dentures the evidence seems unequivocal. When examining the true advantage of bilateral balanced tooth set up there was no detectable advantage functionally in the majority of studies examined in a systematic review [39].

Summary

Some may argue that occlusion plays an integral part in many situations. The presence of occlusal problems may not be readily apparent when examining clinically and as such further analysis maybe required (Table 2). The mounting of models to aide in diagnosis and treatment planning is invaluable especially where multiple restorations are planned. Virtual planning on models by way of adjustments in wax-ups provides the clinician with foresight as to the achievability and predictability of a chosen plan. These techniques will be described in further detail in Part II of this series.

References


Review

Diagnosis of oral pigmentations and malignant transformations

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ARTICLE INFO

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- Pigmentation
- Melanin
- Oral
- Diagnosis

ABSTRACT

Background: Oral pigmentation is a common finding in the mouth. Pigmentation can be either normal or abnormal discoloration of oral mucous membrane. The purpose of this review mainly focuses on the main oral pigmented lesions, in order to help the clinicians establish a better approach towards the patients with pigmented oral lesions and to provide thorough knowledge regarding such lesions for patient reassurance, early definitive diagnosis and prompt treatment.

Methods: Relevant data concerning oral pigmented lesions, clinical features and the possibility of malignant transformation of such lesions were reviewed thoroughly from pubmed literature published in English. Pigmented lesions affecting the skin were not included in our review.

Results: Few pigmented lesions have been identified and their tendency to become malignant has been reported in the literature. The oral lesions showing malignant transformation reported were mostly case series. Unfortunately, due to lack of long-term studies, follow ups and randomized controlled studies in this respect it was difficult to draw a statistical analysis. This information is quite crucial for general dental practitioners to improve their understanding regarding oral lesions and to differentiate between normal and diseased conditions, so that they can master the skill of differential diagnosis, definitive diagnosis and prompt treatment.

Conclusion: Oral pigmentation may present as focal, multifocal or diffused macular or tumefactive lesions. They may greatly vary in color as blue, purple, brown, gray or black depending on the quantity and site of melanin in the tissues [1]. Etiology of pigmentation can be multifactorial. Mostly pigmentation is physiologic but at times it can be a precursor of severe diseases.

Lesions may be caused by localized harmless accumulations of melanin, hemosiderin or exogenous metals or they may be a sign of underlying systemic or genetic disease. A few lesions may be associated with life-threatening medical conditions that require immediate intervention. The differential diagnosis for any pigmented lesion is extensive, as it includes examples of endogenous and exogenous pigmentations. Although biopsy is a helpful and necessary aid in...
Introduction

Pigmented lesions of the oral mucosa

Oral mucosa is not uniformly colored. The color varies in different physiological and pathological conditions [1–6]. Physiological pigmentation is frequent in Asians, Africans and Mediterranean people [3]. The color change of the oral mucosa could be due to accumulation of one or more pigments in tissues. Pigments associated with mucosal discoloration could be classified as endogenous (e.g. melanin and blood-related pigments) and exogenous (e.g. metals and drug-related pigments). Melanin-associated lesions are most common pigmentations. They may present as benign melanocytic nevi or extremely aggressive neoplasm as mucosal melanoma [1–7]. Benign melanin-associated pigmentations of the oral mucosa includes racial pigmentations, melanotic macules, oral melanocytic nevi (OMNs), melanocanthoma, post-inflammatory pigmentations and so-called smoker’s melanosis [1–6]. Several systemic diseases such as Peutz–Jeghers, Laugier–Hunziker syndromes as well as the Addison’s disease are also characterized by the presence of benign melanin-associated lesions of the oral and perioral tissues. Non-melanin associated pigmentations may be caused by blood-related entities (bilirubin and biliverdin, iron-containing ferritin and hemosiderin) and metal pigments (e.g. silver, gold, lead and mercury) [1–6]. Among these, the most frequent is amalgam pigmentation (amalgam tattoo). Several drugs have been reported to induce mucosal discoloration through direct deposition on oral surfaces, local accumulation after systemic absorption, stimulation of melanin-related pathways and bacterial metabolism [1–6].

It is important to have a thorough checkup of all the systems of the body and to study the previous medical and surgical history to determine the presence of any atypical, unstable or malignant skin lesions. Similarly a positive family history of oral pigmentation or hereditary systemic diseases is crucial in the overall evaluation of the patient. For clinical assessment good lighting and a mouth mirror or magnifying glass should be used. Examination of the mouth should begin with the evaluation of focal pigmented lesions, with diffuse pigmentation lesions require a thorough dental and medical history and laboratory investigations.

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Classification of oral pigmentation

Kauzman et al. [8] proposed a classification based on the distribution of the pigmentation.

Diffuse and bilateral
Early onset: physiological pigmentation, Peutzjegher’s syndrome.
Predominantly adult onset.
With systemic signs and symptoms.
Addison’s disease, heavy metal pigmentation, Kaposi’s sarcoma.
No systemic signs and symptoms.
Drug induced pigmentation, post-inflammatory.
Smoker’s melanosis.
Focal
Red, blue, and purple.
Blanching: hemangioma, varix.
Nonblanching: thrombosis, hematoma.
Blue-gray: amalgam tattoo, other foreign body tattoo, blue nevus.
Brown: melanotic macule, pigmented nevus, melanocanthoma, melanomas.
The clinical features and presentation of most commonly found pigmented lesions in the oral cavity are as follows:

Physiologic Melanotic Lesions.

Physiologic Pigmentation (Racial).
Racial pigmentation of oral mucosa is the most common cause of oral pigmentation; however it is not directly related to the color of the skin [9–11]. The pigmentation is symmetrically distributed, especially on the gingival [Fig. 1] and buccal mucosa, on the hard palate, lips and tongue may also be seen as brown patches with well-defined borders. Gaeta et al. [3] stated that it is more common in African, Asian and Mediterranean populations. This increase in pigmentation is due to increase in melanocyte activity and not due to greater number of melanocytes. The degree of gingival pigmentation is directly related to skin pigmentation. In light skinned individuals gingiva is mostly non-pigmented but in dark skinned people the chance of having pigmented gingiva is extremely high [4]. It is seen during the first two decades of life but may not come to the patient’s attention until later. The color ranges from light to dark brown. The attached gingiva is the most common site, where it appears as a bilateral, well-demarcated, ribbon-like, dark brown band that usually spares the marginal gingiva [1]. The pigmentation is asymptomatic therefore no treatment is required. Since these lesions are considered physiological so there are no chances of malignant transformation, having said this, it is critical to differentiate between normal and premalignant lesions.

Ephelides

Ephelides are common small, brown macules (5 mm) [8,9]. They appear on sun-exposed areas of the perioral skin and lips. These lesions darken after sun light exposure. It is a self limiting condition depending on the amount of exposure to the sun. There have been no reports on malignant transformation.

Melanotic macules

Weathers et al. [12] stated that the labial melanotic macule is a benign pigmented lesion that is common on the lower lip, and the oral melanotic macule is the same lesion seen inside the oral cavity, most commonly on the gingiva, buccal mucosa and palate. It is caused by increased melanin production without increase in the number of melanocytes. Melanotic macules are usually smaller than 1 cm in diameter and show a well-demarcated smooth border. They usually occur as single lesions, but multiple lesions are sometimes seen. The color is homogenous light or dark brown. Melanotic macules are more common in women and young adults [13]. Melanotic macules are benign and hardly ever transform into melanoma. For any melanotic macules seen on the palate that has been reported by the patient to increase in size, a biopsy should be performed. This was because is usually required to establish the diagnosis and to rule out melanoma, especially for lesions involving the palate, where malignant melanoma is most prevalent and malignant transformation of melanotic macules is rare [14]. No further treatment is required once the diagnosis has been established.

Heavy metal pigmentation

Increase in heavy metal (e.g. lead, bismuth, mercury, silver, arsenic and gold) levels in the blood leads to oral mucosal discoloration. It is mostly seen in individuals exposed to heavy metal vapors (occupational) or patients taking drugs containing heavy metals such as arsenic, previously used for the treatment of syphilis. Use of water or paints containing lead and drugs containing mercury or silver can also cause mucosal discoloration [8]. The pigmentation appears as a blue-black line along the gingival margin and seems to be proportional to the amount of gingival inflammation as stated by Esen et al. [15,16]. Other oral mucosal sites may also be involved [Fig. 2]. A variety of systemic signs and symptoms may be seen depending on the type of heavy metal exposure [15]. Malignant transformation of oral pigmentation due to heavy metal pigmentation has not been reported. Yet care should be taken regarding severe systemic toxicity.
Kaposi’s sarcoma

Kaposi’s sarcoma (KS) is a multifocal vascular malignancy seen predominantly in HIV-infected individuals. The development of this tumor is considered diagnostic of AIDS progression. A human herpes virus (HHV-8, also called Kaposi’s sarcoma-associated herpes virus) has been implicated as the cause. KS in the oral mucosa most commonly affects the hard palate, gingiva and tongue. It appears as a bilateral flat or slightly elevated brown to purple colored lesion in early stages. Advanced lesions may appear as dark red to purple plaques or nodules that may exhibit ulceration, bleeding and necrosis. A definitive diagnosis requires biopsy, which shows the proliferation of spindle-shaped cells, surrounded by poorly formed vascular spaces or slits with numerous extravasated red blood cells [15,16]. With new treatments for AIDS, KS has become less common in the United States, and it now occurs at a rate of about 6 cases per million people each year. In the United States, KS is much more common in men than in women, and it is rarely seen in children. It is also more common in African Americans than in whites in the United States.

Transplant recipients are another group that gets KS. About 1 in 200 transplant patients in the United States gets KS. Most people who develop Kaposi’s sarcoma have been infected with the virus prior to organ transplantation. The drugs taken to suppress the immune system of the patient after transplantation is done, allows KS to develop. In areas of the world (such as Africa) where KSHV and HIV infection rates are high, both endemic and HIV-associated KS are seen, and KS occurs in men, women, and children. Early detection of HIV thorough investigations and management of the immune modulation will turn down further complications associated with HIV.

Post-inflammatory pigmentation

Long-standing inflammatory mucosal diseases, particularly lichen planus, can cause mucosal pigmentation [2]. This is seen more frequently in dark-skinned individuals. Clinically, multiple brown-black pigmented areas are noted adjacent to reticular or erosive lesions of lichen planus. Halder et al. mentioned that the pathogenesis of post-inflammatory pigmentation remains unclear [17]. Histologically, there is increased production of melanin by the melanocytes and accumulation of melanin laden macrophages in the superficial connective tissue. There is no literature on hand about its transformation into malignancy.

Chemically induced melanosis

Smoker’s melanosis

Hedin et al. stated that smoking may cause oral pigmentation in light-skinned individuals and accentuate the pigmentation of dark skinned patients [18]. There is increased production of melanin, which may provide a biologic defense against the noxious agents present in tobacco smoke [19]. Smoker’s melanosis occurs in up to 21.5% of smokers [20]. It is proved that the intensity of the pigmentation is related to the duration and amount of smoking [20,21]. Women are more commonly affected than men, which suggest a possible synergistic effect between the female sex hormones and smoking [20]. According to them, the brown-black lesions most often involve the anterior labial gingiva, followed by the buccal mucosa [20]. Smoker’s melanosis usually disappears within 3 years of smoking cessation. Zaraa et al. [15] mentioned that biopsy should be performed if there is surface elevation or increased pigment intensity or if the pigmentation is in an unexpected site. There is no evidence supporting the malignant transformation of smoker’s melanosis, but caution should be taken about other systemic complications associated with smoking. Smoker’s melanosis can be used as a clinical finding to identify the smoking history [21].

Amalgam tattoo and other foreign-body

Pigmentation

Amalgam tattoo is one of the most common causes of intraoral pigmentation [22]. It presents clinically as a localized flat, blue-gray lesion of variable dimensions [Fig. 3]. The gingiva and alveolar mucosa are the most common sites, but these lesions may also involve the floor of the mouth and the buccal mucosa. No signs of inflammation are present at the periphery of the lesion. Diascopy is a test whether lesion is vascular or nonvascular or hemorrhagic by applying pressure with a finger glass slide and observing color changes [23]. A negative response was seen with diascopy. In some cases, especially when the amalgam particles are large enough, they can be seen in intraoral radiographs as fine radiopaque granules. In these circumstances, the diagnosis of amalgam
tattoo can be made on the basis of the clinical and radiographic findings. In case of doubt, a biopsy should be performed to demonstrate the presence of amalgam particles in the connective tissue [8]. Graphite may be introduced into the oral mucosa through accidental injury with a graphite pencil. The lesion occurs most frequently in the anterior palate of young children, appearing as an irregular gray to black macule. A history of injury confirms the diagnosis; otherwise, a biopsy should be performed to exclude the possibility of melanoma. As amalgam fillings still are ubiquitous and amalgam tattoos remain one of the most common causes of intraoral pigmentation, we consider amalgam tattoos to be an important differential diagnosis consideration, when assessing patients suspected for mucosal melanoma of the oral cavity. Information regarding previous prosthetic dental work should be included in the patient’s medical history, and an X-ray showing metal deposits in the mucosa can safely rule out mucosal melanoma. But when in doubt, we recommend a diagnostic biopsy for histopathological examination [8]. This lesion is just a localized reaction to metal deposition in the mucosa.

Drug-induced pigmentation

A number of medications may cause oral mucosal pigmentation such as Antimalarials (quinacrine, chloroquine, hydroxychloroquine, Quinidine, Zidovudine (AZT), Tetracycline, Minocycline, and Chlorpromazine), Oral contraceptives, Clofazimine, and Ketoconazole. The pathogenesis of drug-induced pigmentation varies, depending on the causative drug. It may involve accumulation of melanin, deposits of the drug or its metabolites, synthesis of pigments under the influence of the drug or deposition of iron after damage to the dermal vessels [9]. Chloroquine and other quinine derivatives are used in the treatment of malaria, cardiac arrhythmia and a variety of immunologic diseases including systemic and discoid lupus erythematosus and rheumatoid arthritis. Mucosal discoloration associated with these drugs mostly involves the hard palate only and appear as blue-gray or blue-black in color [9,10,24]. Laboratory studies have shown that these drugs may produce a direct stimulatory effect on the melanocytes [25]. However, the reason why this effect is limited to the palatal mucosa is not understood. Minocycline is a synthetic tetracycline used in the long term treatment of refractory acne vulgaris. It can cause pigmentation of the alveolar bone, which can be seen through the thin overlying oral mucosa (especially the maxillary anterior alveolar mucosa) as a gray discolouration [26]. Minocycline has also been reported to cause pigmentation of the tongue mucosa. [27]. Drug induced lesions are local reactions which are seen in oral cavity and no reports of malignant transformation have been reported in this regard.

Disease-associated melanosis

**Peutz-Jeghers syndrome**

Peutz-Jeghers syndrome is a rare genetic disorder and is characterized by pigmented mucocutaneous macules, intestinal hamartomatous polyposis and increased risk of cancer in many organs, including the small intestine, colon, stomach, pancreas, breast and genital tract [4–6]. The melanotic spots of Peutz-Jeghers syndrome are characterizedly small and multiple, and are very obvious around the lips. Pigmented spots also occur inside the mouth, in the mucosa of the nose, conjunctiva and rectum, and on the skin of the extremities [7]. The melanotic spots do not require treatment and are not associated with increased risk of melanoma. However, the patient should be monitored for the development of internal malignancies. Such oral lesions help in early diagnosis and should alert the clinician to prompt the patient to screen for cancers in organs implicated in this syndrome.

**Addison’s disease**

Oral mucosal pigmentation associated with Addison’s disease develops and progresses during adult life and is usually accompanied by systemic manifestations including weakness, nausea and vomiting, abdominal pain, constipation or diarrhea, weight loss and hypotension. Addison’s disease, or primary hypoadrenalism, is due to progressive bilateral destruction of the adrenal cortex by autoimmune disease, infection or malignancy [11]. The lack of adrenocortical hormones in the blood stimulates production of adrenocorticotropic hormone (ACTH) by the anterior pituitary gland. The increased production of ACTH induces melanocyte-stimulating hormone, which results in diffuse pigmentation of the skin and oral mucosa. Oral involvement presents as diffuse brown patches on the gingiva, buccal mucosa, palate and tongue, which may resemble physiologic pigmentation [15]. However patients presenting with these features should be sent for medical evaluation and laboratory tests to assess levels of ACTH, plasma cortisol and serum electrolytes. Addison’s disease can be fatal if left untreated. Management involves treatment of the underlying cause and corticosteroid replacement therapy. No cases of malignant transformation have been reported.

**Melanocytic nevi**

Pigmented nevi are a rare cause of focal oral pigmentation. They present as either brown or blue lesions. Histologically, nevi are composed of an accumulation of nevus cells in the basal epithelial layers, the connective tissue or both. As such, they are classified as junctional, intradermal or intramucosal, and compound nevi. Junctional nevi are flat and dark brown in color because the nevus cells proliferate at the tips of the rete pegs close to the surface. Intramucosal and compound nevi are typically light brown, dome-shaped lesions. Blue nevi are characterized by proliferation of dermal melanocytes within the deep connective tissue at some distance from the surface epithelium, which accounts for the blue color. Buchner et al. [28] stated that intramucosal nevus is the most common type and is seen most frequently on the buccal mucosa. The blue nevus is the second most common type, occurring most commonly in the palate [28]. It may be difficult to differentiate clinically between a nevus and an early lesion of mucosal melanoma, especially in the palate, the most common site for both lesions. Although transformation of oral pigmented nevi to melanoma has not been well documented, it is believed that nevi may represent precursor
lesions to oral mucosal melanoma [29]. It is therefore recommended to completely excise these lesions and submit it for histopathologic examination.

**Oral melanoacanthoma**

Oral melanoacanthoma is uncommon benign pigmented lesion of the oral mucosa, characterized by proliferation of dendritic melanocytes dispersed throughout the thickness of an acanthotic and hyperkeratotic surface epithelium [15,30]. Clinically, the lesion appears hyper pigmented black or brown, flat or slightly raised. This lesion, in contrast to most of the benign pigmented lesions discussed above, has a tendency to enlarge rapidly, which raises the possibility of a malignant process in the clinical differential diagnosis [31]. However its tendency to occur in young black females distinguishes it from melanoma, which is uncommon in this age and racial group. Goode et al. stated that the buccal mucosa is the most common site of occurrence, which may be related to greater frequency of trauma in this area [30]. Oral melanoacanthoma appears to be a reactive lesion with no malignant potential. In some cases, the lesion disappears after incisional biopsy or removal of the offending stimulus [31].

**Oral melanoma**

Oral mucosal melanoma is rare. It accounts for less than 1% of all oral malignancies. It is characterized by proliferation of malignant melanocytes along the junction between the epithelium and connective tissue or may occur deep inside the connective tissue. The palate is the most common site, which account for about 40% of cases, and gingival account for one third of case [29]. Other oral mucosal sites may also be affected [Fig. 4]. Oral melanoma is generally encountered between the fourth and seventh decades of life, with a greater incidence in men than women [32]. Clinically, oral melanoma may present as an asymptomatic, slowly-growing brown or black patch with asymmetric and irregular borders or as a rapidly enlarging mass associated with ulceration, bleeding, pain and bone destruction. A few oral melanomas are non-pigmented (amelanotic). Although oral mucosal melanomas are rare, they represent a serious and often fatal disease. Internationally, oral melanoma is more common in the Japanese than in other groups. In Japan, oral melanomas account for 11-12.4% of all melanomas, and males may be affected slightly more than females. This percentage is higher than the 0.2-8% reported in the United States and Europe. Although occurrence of cutaneous melanomas is less common in dark skinned races, these races have a greater relative incidence of oral mucosal melanomas. Oral mucosal melanoma tends to be more aggressive than its cutaneous counterparts and is mostly presented at a later stage of the disease. Treatment involves radical surgical excision with clear margins. This may be difficult to accomplish because of anatomic constraints and proximity to vital structures. Radiation and chemotherapy are ineffective, which further makes the management of this malignancy complicated. The prognosis for patients with oral melanoma is poorer than those with cutaneous lesions, and the overall 5-year survival rate is 15%. The best way to improve prognosis is early diagnosis [29,33]. Primary oral mucosal melanomas are biologically aggressive malignancies though they are rare. Oral melanoma clinically mimics many other pigmented lesions of the oral cavity. It is essential to include oral examination as a part of full body examination with skin examinations, dentures should be removed for examination. Suspicious pigmented and non-pigmented lesions should be biopsied appropriately. Early diagnosis and intervention result in a better prognosis [8].

**Fig. 4 – Shows oral melanoma on lips.**

**Focal pigmentation**

**Hemangioma and vascular malformation**

Hemangioma is a benign proliferation of the endothelial cells that line vascular channels [8]. Vascular malformation is a structural anomaly of blood vessels without endothelial proliferation. Both lesions are developmental abnormalities characterized by onset during infancy. Hemangiomas regress as the patient ages, but vascular malformation persists throughout life. The multi nodularity is racemose and diffuse. Tongue angiomas frequently extend deeply between the intrinsic muscles of the tongue. The lip mucosa is another common site for hemangiomas in children; they appear mostly as localized, raised blue tumors.

**Varix and thrombus**

Pathologic dilatations of veins or venules are varices or varicosities, and the chief site of such involvement in the oral tissues is the ventral tongue [3-5]. Varicosities become progressively prominent with age, thus lingual varicosities are mostly seen in elderly individuals. Lingual varicosities appear as tortuous serpentine blue, red or purple elevations that course over the ventrolateral surface of the tongue, with extending anteriorly. Even though they may be quite striking in some patients, they represent a degenerative change in the adventitia of the venous wall and are of no clinical consequence. They are painless and are not subjected to rupture and hemorrhage. If the varix contains a thrombus, it presents as a firm bluish purple nodule that does not blanch on diascopy. Thrombi are more common on the lower lip and buccal mucosa [15].
Hematoma and other hemorrhagic lesions

As stated by Barker et al. [32]. Hematomas, petechiae, purpurae and ecchymoses are caused by extravasation of blood into the soft tissues. They may appear as nonblanching flat or elevated pigmented lesions. They may occur spontaneously in certain systemic conditions such as idiopathic thrombocytopenic purpura, or they may result from trauma [21]. The color produced due to degradation of hemoglobin to bilirubin and biliverdin, varies among red, purple, blue and bluish black depending on the length of time the blood has been present in the extravascular spaces. It may take up to 2 weeks for the color to become normal again. If hemorrhagic lesions occur in the absence of recent trauma, the patient should be investigated for platelet disorders and coagulopathies.

Discussion

Intraoral pigmention could be focal, diffuse or multifocal. They may be black, gray, blue, purple or brown in color. They may be flat or swollen. They can be localized accumulations of melanin, hemosiderin, exogenous metal or some are even indications of an internal disease. The differential diagnosis can be lengthy in certain conditions with multiple and complex lesions with pigmentations. Although biopsy is a helpful aid to diagnosis for localized lesions, the more diffuse lesions will require a thorough history and laboratory studies in order to arrive at a definitive diagnosis [8]. Thorough examination of the oral pigmentation together with complete history and clinical findings are necessary for early diagnosis and prompt treatment. Even though only a few lesions are reported to undergo malignant transformation, yet this limited data regarding malignancy transformation in oral lesions cannot be simply ruled out. All general practitioners should have thorough knowledge in order to establish a probable differential diagnosis as well as definitive diagnosis for prompt treatment. In case of a doubt referral to specialist is recommended.

Conclusion

The diagnostic procedure of pigmented lesions of the oral cavity and perioral tissues is quite challenging. Clinicians may benefit to a certain extent from the available epidemiological data or they can make the diagnoses on clinical grounds alone; however such diagnosis will remain “provisional”. Histopathological evaluation of oral pigmentation is required for a definitive diagnosis. Unfortunately the available data based on randomized controlled trials is quite limited to draw a statistical analysis. We have tried to highlight the oral pigmented lesions that clinicians can most possibly come across during a routine checkup of the patients. The management of pigmented oral lesions varies greatly based on the diagnosis, understanding of the underlying causes of mucosal pigmentation and appropriate evaluation of the patient is therefore essential.

General dental practitioners can benefit from this review as it delineates the factors that will help them to differentially diagnose pigmented lesions of the oral cavity and also improve their understanding differentiate between normal and diseased conditions, so that they can master the skill of early definitive diagnosis and prompt treatment.

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Endodontic irrigant as a root conditioning agent: An in vitro scanning electron microscopic study evaluating the ability of MTAD to remove smear layer from periodontally affected root surfaces

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ABSTRACT

Background: Instrumentation of the root surface, results in formation of a smear layer of organic and mineralized debris which serves as a physical barrier, inhibiting new connective tissue attachment to the root surface. The present study advocates the use of an endodontic irrigant MTAD (mixture of tetracycline, citric acid and detergent) as a root conditioning agent.

The main aim of the study was to compare the root conditioning ability of an endodontic irrigant MTAD (mixture of tetracycline, acid and detergent) with 17% EDTA (ethylenediaminetetraacetic acid).

Materials and methods: Sixty freshly extracted human single rooted teeth with confirmed periodontal involvement were selected for this study and decoronated. The apical third of each root was removed and the remaining root was sectioned longitudinally to produce a 6 mm to 8 mm long tooth section. The root surface was then instrumented by hand using a sharp Gracey 1-2 periodontal curette with 6-8 strokes per area to achieve a smooth glass-like surface. A total of 60 specimens were prepared which were randomly divided into three groups (n=20). Each group received the root conditioning treatments as follows:

Group A: Control Group: only saline rinsing.
Group B: root conditioning treatment with 17% EDTA for 5 min.
Group C: root conditioning treatment with BioPure MTAD for 5 min.

All specimens were prepared for SEM and scored according to the presence of smear layer.

Results and conclusions: MTAD removed the smear layer successfully from the root surfaces. The mean smear score for samples treated with Biopure MTAD was lower than those treated with EDTA, (p=0.04). MTAD can be used as a root conditioning agent with efficient smear layer removal ability and known antimicrobial and anticollagenase activity.

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Introduction

The main aim of periodontal therapy is to achieve predictable regeneration of the periodontal tissues in areas previously affected by disease. Teeth affected by periodontal disease are exposed to bacterial products from the plaque and calculus and such teeth become hypermineralized and contaminated with the endotoxins as well as other toxic bacterial products [1]. Such a surface does not encourage cell attachment or migrations which are necessary events for optimal spontaneous periodontal healing [2]. Decontamination of these diseased root surfaces is not possible exclusively with mechanical instrumentation (i.e. by scaling and root planning alone), because it often leads to creation of a smear layer [3,4]. The smear layer may range in thickness from 2 to 15 μm and serve as a physical barrier between the periodontal tissues and the root surface inhibiting new connective tissue attachment to the root surface [5,6]. Therefore the root surfaces must be devoid of any smear layer in order to facilitate periodontal healing through regeneration or new attachment [6]. Conditioning of the root surface after scaling and root planning with various acids and chelating agents has been advocated as an effective procedure for smear layer removal and detoxification. Root conditioning with various chemical agents is seen as an adjunct to mechanical root therapy and has been performed as early as the latter half of the 19th century. Till now a variety of chemicals like EDTA, phosphoric acid, citric acid, and tetracycline have been tested in this direction but none has come out as a gold standard. Among these chemicals citric acid and tetracycline HCl have shown to have additional effect of demineralizing the root surface, removing the smear layer and exposing collagen matrix of the mineralized radicular dentin [7,8]. Tetracyclines comprise a broad-spectrum antimicrobial agent, which is effective against many species of periodontal pathogens. Besides its antimicrobial effectiveness, this group of drugs has other special properties which include its anti-inflammatory action, collagenase inhibition, bone resorption inhibition and its ability to improve fibroblast attachment. Tetracyclines are still used in association with bone grafting and as conditioner agents for the root surface, and they enhance periodontal tissue regeneration [9,10]. The substantivity of tetracyclines is another important property for periodontal therapy. This property allows the substance to affix to a substrate and realize slow release, which is important in maintaining the antimicrobial and nonantimicrobial properties acting on the periodontal tissues for an extended time, when the drug is locally applied after periodontal instrumentation [7,10]. Even though some studies have demonstrated that the use of citric acid as root conditioner agent is similar to tetracycline [8,11] this substance has no antimicrobial or anti-inflammatory properties [12]. A combination of citric acid and tetracycline along with a detergent is found in a present day endodontic irrigant MTAD (mixture of tetracycline, acid and detergent). The introduction of MTAD by Torabinejad et al. in 2003 [12] represents an advance in endodontic irrigation research. The tetracycline present in MTAD is doxycycline hyclate, acid is citric acid and the detergent is Tween-80 (polysorbate-80). MTAD has been reported to remove smear layer effectively, eliminate microbes that are resistant to conventional endodontic irrigants and dressings, and provide sustained antimicrobial activity [13–15]. Thus MTAD can be seen as a potential root conditioning and smear layer removal agent.

The aim of this study was to compare the effectiveness of root conditioning ability of MTAD to EDTA.

Materials and methods

Sixty freshly extracted human single rooted teeth were selected for this study. The teeth selected were periodontally involved and showed clinical gingival recession, and loss of attachment. After extraction the teeth were stored saline solution to avoid dehydration of the specimens. The present study involved mainly the use of anterior teeth with majority of teeth being mandibular incisors and no premolars were used. All teeth were decoronated with the help of a diamond disc at high speed under water cooling. The apical third of each root was removed and the remaining root was sectioned longitudinally through the root canal to produce a 6 mm to 8 mm long tooth section. All pulpal tissue was thoroughly removed and an identification notch placed on the pulpal root surface. The root surface was then instrumented by hand using a sharp Gracey 1–2 periodontal curette with 6–8 strokes per area to achieve a smooth glass-like surface. A total of 60 specimens were prepared from extracted teeth. After this the specimens were randomly divided into three groups, two experimental groups and one control group. Each group comprised 20 specimens.

The groups were formed on the basis of the root conditioning agent to be used. The root surfaces of the specimens in each group received the root conditioning treatments as follows:

**Group A:** Control Group (n=20): received only saline rinsing of the root surface and no other root conditioning treatment.

**Group B:** EDTA Group (n=20): received root conditioning treatment with 17% EDTA (Canalarge; Ammdent, Chandigarh, India) for 5 min.

**Group C:** MTAD Group (n=20): received root conditioning treatment with BioPure MTAD (Dentsply Tulsa Dental, Tulsa, OK, USA) for 5 min.

The root conditioning treatment of the specimen was done according to a fixed protocol in all groups so that there was no difference in the method of conditioning and the time period for which the conditioning agent was in contact with the root surface of the specimen. The conditioning agents were applied with cotton pellets which were replaced every 30 s to ensure the uniform contact of the root surface area of each specimen with the conditioning agent. After this the samples were thoroughly rinsed with 5 ml of distilled water to rid the specimens of any remaining/pooled conditioning agent on the root surface. Washed samples were then dried and scheduled for scanning electron microscopic evaluation.
The dried samples were coded before sending for scanning electron microscopic evaluation to ensure blinding with respect to the type of irrigant used.

**SEM evaluation**

Specimens were dehydrated with ascending concentrations of ethyl alcohol (30–100%), and placed in a desiccator for at least 24 h, mounted on metallic stubs, gold sputtered and viewed under scanning electron microscope (Inca-x 50, Oxford Instruments, England 2.0 nm@ 30 kV 5 × – 50000 ×). After a general survey scan of each specimen at a magnification of 250 × an image of the most representative area of that specimen was taken with 500 ×, 1000 × and 2000 ×. The images of 1000 × were then analyzed for the amount of smear layer present by three independent observers without knowing which group they were analyzing. Evaluation was repeated twice for the first 10 specimens to ensure intra-examiner consistency.

The amount of smear layer remained on the root surface and dentinal tubules were scored according to the following criteria used [16]:

0 = No smear layer (Fig. 1a)  
1 = Smear layer involving random areas of surface that totals between 1–32% of total surface area. (Fig. 1b)  
2 = Smear layer involving random areas of surface that totals between 33–65% of total surface area. (Fig. 1c)  
3 = Smear layer involving > 66% of total surface area. (Fig. 1d)

The data was analyzed through Mann–Whitney U-test and comparisons were made as follows:

1) Comparison of all groups with the control.  
2) Comparison of the experimental groups with each other.

**Results**

The examination of the root surfaces in group A (control group) showed the presence of a heavy smear layer throughout the entire prepared surface of the root (Fig. 2a and b). The examination of the root surfaces in both experimental groups

![Fig. 1 - (a) Score 0 = No smear layer, (b) Score 1 = Smear layer involving random areas of surface that totals between 1% and 32% of total surface area. (c) Score 2 = Smear layer involving random areas of surface that totals between 33% and 65% of total surface area. (d) Score 3 = Smear layer involving > 66% of total surface area.](image-url)
showed the smear layer removed and dentinal tubules opened (Fig. 3a and b, Fig. 4a and b). The mean smear scores of the samples for both experimental groups (groups B and C) were less than those of the control group (Table 1). The comparison of both the experimental groups with the control group showed that the root surfaces were significantly cleaner in both group B and group C than in group A ($p<0.001$). Intergroup comparison of groups B and C showed that the root surfaces were comparatively cleaner in group C (where MTAD was used as root conditioning agent) than in group B (where EDTA was used) with mean score of group C (1.05) less than that of group B (1.65), (Table 1). However the difference between the two results was just marginally significant ($p=0.04$).

**Discussion**

Regeneration of supporting tissue to tooth surfaces affected by periodontitis has long been an ideal of periodontal therapy. Periodontitis affected root surfaces are hypermineralized and contaminated with cytotoxic and other biologically active substances [17]. Such surfaces are not biocompatible with adjacent periodontal cells the proliferation of which is pivotal for periodontal wound healing [18]. Traditional treatment of pathologically altered root surfaces has relied on mechanical removal of plaque, calculus, root bound toxins and contaminated cementum and appears to be essential for periodontal regeneration [19]. Instrumentation of the root surface, however, results in formation of a smear layer of organic and mineralized debris. This smear layer usually ranges from 2 to 15 $\mu$m in thickness and may serve as a physical barrier between the periodontal tissues and the root surface inhibiting the formation of new connective tissue attachment to the root surface [4,20]. Furthermore, it is not possible to completely decontaminate the root surface by mechanical therapy alone therefore biological modification or conditioning of the root surfaces is often needed to make these surfaces more conducive to the periodontal regeneration [21].

Demineralization of root surfaces during periodontal therapy has been performed to enhance regeneration of the lost periodontal attachment. Demineralizing agents have been shown to expose dentinal collagen, widening the orifices of dentinal tubules and cementum bound proteins [22].
Furthermore, demineralizing agents have been found to elute retained toxins from the altered root surface. A number of agents have been proposed for the demineralization procedures including phosphoric acid, EDTA, citric acid, PDGF-BB, IGF-1 and tetracycline. The present study tested an endodontic irrigant MTAD (mixture of tetracycline, citric acid and detergent) for its root conditioning ability.

MTAD (commercially available as BioPure™ MTAD, Dentsply Tulsa Dental, Tulsa, OK, USA) was developed by Torabinejad et al. [13] as a final endodontic irrigant to disinfect the canal and remove the smear layer. Shabahang et al. [14,23] showed that BioPure MTAD was an effective disinfectant of the root canal system and a combination of 1.3% NaOCl and BioPure MTAD as a final treatment eliminated E. faecalis from human tooth cementum and dentin. They attributed the effectiveness of BioPure MTAD to its anticollagenase activity, low pH, and ability to be released gradually over time. BioPure MTAD has been found to adsorb to hydroxyapatite with prolonged and gradual release at therapeutic levels [24]. In addition, presence of a detergent (Tween 80) in BioPure MTAD reduces its surface tension and thus improves its penetration into deep layers of dentin. In a study [24] evaluating the antimicrobial substantivity of MTAD, chlorhexidine (CHX) and sodium hypochlorite, BioPure MTAD showed significantly higher antimicrobial substantivity than CHX and was retained in root canal dentin for at least 28 days. These properties of Biopure MTAD can be useful in periodontal root conditioning. Biopure MTAD will remove the smear layer, show improved penetration into the root surface dentin and/or cementum, expose the dentinal tubules, and provide antimicrobial activity.

Present study compared the root conditioning ability of EDTA and Biopure MTAD (a final endodontic irrigant) with normal saline as control. Both the experimental solutions removed the smear layer successfully from the root surfaces and the experimental samples were significantly cleaner than the control group (p<0.001). The results demonstrated that the mean smear score (Table 1) for samples treated with Biopure MTAD was lower than those treated with EDTA, however the results were marginally statistically significant (p=0.04). The cleaner root surfaces in the samples treated with Biopure MTAD can be attributed to its low pH and presence of detergent (tween-80) enhancing its penetration and thus better removal of the smear layer and more effective opening of dentinal tubules. Therefore Biopure MTAD can be seen as a potential root conditioning agent with effective smear layer removal from the root surfaces. However, MTAD has antimicrobial activity, anti-collagenolytic activity and the presence of polysorbate-80 (TWEEN80) likely improves its penetration into the cementum and root dentine and hence make it more effective than EDTA.

### Table 1 – Mean smear scores (± SD) for all groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Score</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline (control group)</td>
<td>0 0 0 20 3</td>
<td></td>
</tr>
<tr>
<td>EDTA</td>
<td>3 4 10 3 1.65</td>
<td></td>
</tr>
<tr>
<td>MTAD</td>
<td>5 8 6 1 1.05</td>
<td></td>
</tr>
</tbody>
</table>

### Conclusion

Within the experimental protocol of the present study it can be concluded that Biopure MTAD is an effective root conditioning agent showing similar smear layer removing ability when compared to EDTA. Further studies should be conducted before considering the use of MTAD as a periodontal root conditioner.

### References


Complications associated with the occurrence and treatment of impacted maxillary canines

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Keywords:
- Impacted maxillary canine
- Complications of impacted canine
- Treatment of impacted canine
- Root resorption

Abstract

Background: The aim of this study was to evaluate the complications associated with the occurrence and treatment of impacted maxillary canines.

Methods: This retrospective study was conducted on 533 Southern Chinese children and adolescents who attended the Paediatric Dentistry and Orthodontics Clinics and had at least one impacted maxillary canine. The study material included all the documentation files and radiographs of these patients. Complications that had been recorded in the clinical and surgical notes and that could be diagnosed from the available radiographs were noted. The data obtained were descriptively analyzed.

Results: The most frequently reported phenomenon associated with the occurrence of impacted maxillary canine (prior to surgical treatment) was root resorption of an adjacent permanent tooth in 22 (4.1%) patients. The most frequently reported sequelae observed after any surgical procedure was swelling of the soft tissues around the operation site which often persisted for 48 h as seen in 76 (18.8%) patients. Complications reported most commonly after any form of surgery included post-operative bleeding: 7(1.7%), hematoma: 7(1.7%), post-operative pain: 6(1.5%) and purulent discharge: 6(1.5%), post-operative complications in relation to surgical exposure and bonding of an attachment which included breakage of ligature wire: 5.7%; de-bonding of the attachment: 4.3% and inability to bond the attachment during surgery: 1.4% occurred rarely.

Conclusions: The frequency of root resorption of teeth adjacent to an impacted maxillary canine was low. Swelling of the soft tissue 48 h post-operatively was the most commonly occurring complication after surgical intervention.

Introduction

The prevalence of impacted maxillary canines is reportedly between 1% and 3% and the preferred management of an ectopic permanent canine is early diagnosis and interceptive treatment which involves extraction of the associated primary canine [1–3]. The success of this form of treatment is related to the timing of the treatment and availability of space in the dental arch [1,3–5].
However, frequently, the diagnosis of an impacted canine is delayed and the patient often requires surgical intervention as a part of the comprehensive treatment. While most surgical procedures proceed without untoward events, some produce secondary effects and complications depending on the degree of tissue damage [6]. These complications include ecchymosis of the soft tissues, infection, paresthesia and damage to adjacent structures [7,8]. Further, the presence of an impacted canine may cause resorption of the adjacent tooth; most likely a lateral incisor or the canine itself may undergo cystic changes [2,9]. The capability to recognize and manage these unexpected situations is essential for the practitioners providing the treatment. The ability to understand potential complications and to avoid them facilitates efficient therapy. Although there have been numerous reports on the complications associated with surgery on impacted third molars, very few studies have been carried out to determine the post-operative complications associated with the treatment of impacted maxillary canines [5,10-12]. Therefore, the aim of this retrospective study was to evaluate the complications associated with the occurrence and treatment of impacted maxillary permanent canines.

Subjects and methods

This retrospective investigation was conducted on 533 (206 males and 327 females) Southern Chinese children and adolescents who attended the Paediatric Dentistry and Orthodontics Clinics at the Prince Philip Dental Hospital, Hong Kong SAR between February 1982 and February 2009 and had at least one impacted maxillary permanent canine. Efforts were taken to trace every patient from the clinical and patient records and patients with any form of oro-facial cleft; medical complications including metabolic and endocrine disorders were excluded. The study material included all the documentation files and radiographs of these patients. The diagnosis of an impacted maxillary canine was confirmed and the location of the tooth determined on the basis of radiographs according to established standardized techniques [13]. Complications that were recorded in the clinical and surgical notes and their diagnosis based on the available radiographs were noted. Clinical photographs, where available, were also used to determine the complications associated with the occurrence and treatment of the impacted maxillary canines. The data thus obtained were descriptively analyzed.

Results

Of the 533 patients who had an impacted canine, surgical intervention was required in 404 (75.8%) patients. Whilst most of these patients required surgical removal of the impacted canine as a part of their comprehensive treatment plan, 70 (13.1%) of them required surgical exposure and bonding of an attachment as a part of their treatment.

Amongst the 404 patients who needed surgical intervention, 142 (35.1%) were males, 262 (64.9%) were females while 69 (17.1%) had bilateral impactions. The chronologic age of these patients at the time of surgery ranged from 10.2 to 25.8 years with a mean of 16.7 years. The most frequently reported phenomenon associated with the occurrence of impacted maxillary canines, prior to surgery, was root resorption of an adjacent permanent tooth. A total of 22 patients (male=7, female=15) with a total of 28 teeth were diagnosed with resorption of adjacent teeth. Half of these patients (n=11, 50%) had buccally impacted canines whilst 7 (31.8%) had palatally impacted canines; the remaining 4 (18.2%) patients had the impacted canine within the line of the arch. The maxillary lateral incisors were the most commonly affected teeth (n=16), followed by the maxillary central incisors (n=11) and in one case a first premolar.

Likewise, the most frequently reported complication associated with the occurrence of impacted maxillary canines, prior to surgery, was pain (n=8, 1.5%) in the impacted tooth (Table 1).

Six (1.1%) patients reported with cystic changes whilst two (0.4%) complained of swelling in relation to the tooth.

The most frequently reported post-operative sequelae observed was swelling of the soft tissues around the surgery site in 76 (18.8%) patients which was persistent even after 48 h. The most frequently reported complication observed after any form of surgery was post-operative bleeding from the surgical site: 7 (1.7%) and hematoma: 7 (1.7%) of the adjacent tissues (Table 2). Also, other complications reported were post-operative pain: 6 (1.5%), purulent discharge: 6 (1.5%), transient paresthesia: 5 (1.2%), unsatisfactory healing: 5 (1.2%), iatrogenic damage to adjacent soft tissue: 4 (1.0%), maxillary sinus perforation: 2 (0.5%), sub-conjuctival hemorrhage: 2 (0.5%) and discoloration of adjacent teeth: 1 (0.3%) (Table 2).

Post-operative complications were reported by 10 (14.3%) of the 70 patients who underwent surgery to expose and bond an attachment to facilitate orthodontic traction. The complications specifically in relation to this procedure are listed in Table 3 and included breakage of the ligature wire: 4 (5.7%); de-bonding of the attachment: 3 (4.3%), no movement of the tooth after traction: 2 (2.9%) and failure to bond the attachment during surgery: 1 (1.4%).

<table>
<thead>
<tr>
<th>Pre-operative complications</th>
<th>Number of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain in the impacted tooth</td>
<td>8 (1M, 7F)</td>
<td>1.5</td>
</tr>
<tr>
<td>Cystic changes</td>
<td>6 (2M, 4F)</td>
<td>1.1</td>
</tr>
<tr>
<td>Swelling in relation to the impacted tooth</td>
<td>2 (2F)</td>
<td>0.4</td>
</tr>
</tbody>
</table>

*M = male and F = female.

Discussion

Incisor root resorption is a well recognized phenomenon caused by impacted canine. This most commonly affects
maxillary lateral incisors and while central incisors may also be involved, rarely first premolars are affected. In the current study too, maxillary lateral incisors were the most commonly affected teeth followed by the maxillary central incisor thereby confirming previous studies [14,15]. Most studies had focused on the resorption caused by palatally impacted canines, although buccally impacted canines can also cause resorption of incisors [15,16]. Knight in his study found that 33% of the canines associated with root resorption were buccally placed [16]. While the present study supports his finding; the occurrence was much higher with 50% of the patients with buccally impacted canines exhibiting root resorption. Also, a further 31.8% of the patients with root resorption had their canines palatally impacted. Many studies have found resorption of an incisor to be more common in females. These studies have quoted the female:male ratio variously as 2:1, 4:1 and 10:1 [14,15,17]. Our study is in agreement with the lower ratio of 2:1.

The reported frequency of resorption varies widely from 1% to 12% and may in part depend upon the imaging technique used [7,15,18]. Superimposition of the incisor roots and the crown of an impacted canine on intra-oral radiographs are said to obscure the root morphology in 45% of cases [19]. Computed tomography (CT) overcomes this problem as it provides detailed images of the location of an impacted canine and root resorption [20]. The use of CT by Ericson and Kurol indicated that 48% of patients with impacted canines exhibited root resorption of adjacent teeth [21]. While in the present study, the frequency of root resorption was found to be much lower (4.1%); it was in agreement with the findings of Olow-Nordenram and Anneroth [22]. All available radiographs were used to determine the status of the roots of adjacent teeth to achieve as accurate a figure as possible. As the study was in part dependent upon the availability of suitable radiographs, which had been taken solely for clinical purposes and so CT images were available for only a few cases. Thus, the reported frequency of root resorption in this study should be considered to be an underestimation.

The most frequently reported complication associated with the occurrence of impacted maxillary canines, prior to surgery, was pain associated with the impacted tooth. Due to the retrospective nature of the study, it was difficult to determine the exact cause of the pain. However, it was noted that six of the patients who complained of pain had cystic changes associated with the impacted tooth. Further, the remaining two patients had a retained carious primary canine and it can only be hypothesized that the carious primary canine may be the cause of pain. Cystic changes with impacted maxillary canines have been reported previously [9]. In a four-year-period retrospective study of 12,129 Turkish patients aged 14–80 years, 970 had impacted maxillary canines. Fifty-five (5.7%) of the patients with impacted maxillary canines demonstrated cystic changes associated with the impacted tooth [9]. In the present study, six patients reported with cystic changes associated with their impacted canines. Radiographically, the cysts in all the cases showed a well-defined radiolucency surrounding the crown of the unerupted canine making this finding consistent with the diagnosis of a dentigerous cyst [9,23]. Two patients reportedly complained of swelling in relation to the unerupted canine. However, from the clinical records it was derived that both

### Table 2 – Post-operative complications experienced by 404 of the 533 patients who underwent any form of surgery for treatment of an impacted maxillary canine.

<table>
<thead>
<tr>
<th>Post-operative complication</th>
<th>Number of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding from the site of the surgery</td>
<td>7 (2M, 5F)</td>
<td>1.7</td>
</tr>
<tr>
<td>Hematoma</td>
<td>7 (3M, 4F)</td>
<td>1.7</td>
</tr>
<tr>
<td>Purulent discharge</td>
<td>6 (3M, 3F)</td>
<td>1.5</td>
</tr>
<tr>
<td>Transient paresthesia</td>
<td>5 (1M, 4F)</td>
<td>1.2</td>
</tr>
<tr>
<td>Unsatisfactory healing</td>
<td>5 (3M, 2F)</td>
<td>1.2</td>
</tr>
<tr>
<td>Iatrogenic damage to adjacent soft tissue</td>
<td>4 (1M, 3F)</td>
<td>1.0</td>
</tr>
<tr>
<td>Maxillary sinus perforation</td>
<td>2 (2F)</td>
<td>0.5</td>
</tr>
<tr>
<td>Sub-conjunctival hemorrhage</td>
<td>2 (1M, 1F)</td>
<td>0.5</td>
</tr>
<tr>
<td>Discoloration of adjacent teeth (non-vital)</td>
<td>1 (1M)</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*M = male and F = female.

### Table 3 – The complications experienced by the 10 patients out of the group of 70 who underwent surgery to bond attachment for orthodontic traction of an impacted maxillary canine.

<table>
<thead>
<tr>
<th>Complication</th>
<th>Number of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakage of the ligature wire</td>
<td>4 (2M, 2F)</td>
<td>5.7</td>
</tr>
<tr>
<td>De-bonding of the attachment</td>
<td>3 (3F)</td>
<td>4.3</td>
</tr>
<tr>
<td>No movement of the tooth after traction</td>
<td>2 (1M, 1F)</td>
<td>2.9</td>
</tr>
<tr>
<td>Attachment could not be bonded during surgery</td>
<td>1 (1F)</td>
<td>1.4</td>
</tr>
</tbody>
</table>

*M = male and F = female.
the patients had mistaken the bony canine eminence for the swelling in relation to the tooth. The location of the canine requires extra-anchorage which is furnished by the length and shape of their roots and by the bony projection or canine eminence.

The most commonly occurring post-operative sequela was found to be swelling of the soft tissue which was persistent even after 48 h (18.8%). In post-surgical wound healing, swelling is one of the key factors alerting patients to seek professional care out of concern for diminished healing [24,25]. Post-operative swelling results from accumulation of protein rich exudates within the surrounding tissue. This reaction may be a consequence of the formation of prostaglandins and other mediators of inflammation derived from membrane phospholipids which are released during surgery [25,26]. Whilst post-operative swelling associated with surgical removal of an impacted tooth is dependent on a number of factors including age, operation time and type of impaction; most swellings subside considerably within 48 h [27,28].

One prospective study, reported that approximately 3% of the patients who were treated using the closed eruption technique reported severe pain on the third day after surgery and none in the subsequent days, whilst severe pain was reported in patients who had been treated using the open-eruption technique up to the seventh day after surgery [29]. The closed eruption technique is most often employed when the tooth is in a position that does not permit the repositioning of the flap after crown exposure. This technique is frequently used for palatal impactions that are not close to the ridge of the alveolar process. In addition, when a canine is impacted high on the buccal aspect of the maxilla, this technique provides exposure without compromising the periodontal status [30]. However, if the permanent canine has the correct inclination, the open surgical exposure is the treatment of choice. In this technique the tooth is identified, uncovered and left exposed to the oral cavity to allow the canine to erupt naturally [31]. Excision of the gingival over the canine with bone removal is sufficient to allow eruption of the canine. The orthodontic attachment may or may not be placed at the time of the surgery.

All surgical procedures produce secondary effects and complications; the intensity of which depends upon a number of factors including the degree of tissue damage [6]. As with any surgical procedure, patients often experience some degree of pain; moreover it has been suggested that there is slightly more post-operative pain from surgery on impacted maxillary canines than for the surgery related to other impacted teeth [8]. However, a significantly lower incidence of pain (1.5%) was reported by the patients in this study 48 h after the surgery. The overall lower recovery time could have been influenced by the surgical techniques employed and the almost routine use of antibiotics and suitable analgesics. Future investigations to evaluate the efficacy of pre-operative medication, surgical techniques employed, post-operative analgesics and antibiotics and other variables need to be conducted to determine the exact role of surgical trauma in causing post-operative complications.

Uneventful healing of a post-extraction alveolus occurs in most cases following the surgical removal of an impacted tooth [25]. However, occasionally healing is unsatisfactory and not only limited to localized symptoms of pain and swelling but also complications of healing such as alveolar osteitis, acutely inflamed alveolus and acutely infected alveolus [25]. The clinical evaluation of the post-extraction alveolus healing was based on the following criteria: severe pain accompanied by a partially or totally disintegrated blood clot, painful alveolus with profoundly inflamed tissue or a painful alveolus with suppuration, erythema and edema with or without systemic fever [25]. Further, unsatisfactory healing is often the result of interruption of the blood supply to the soft tissue flap during surgery or post-operative infection [8]. When a flap is thin it is easy to compromise the blood supply and hence careful designing and handling of the flap is important to avoid post-operative unsatisfactory healing. In the present study, only 1.2% of the patients presented with unsatisfactory healing after the surgical procedure. This figure is very low when compared to results from other studies involving impacted teeth [24,25]. A possible explanation for this discrepancy could be the absence of absolute and objective clinical criteria to assess unsatisfactory healing and the varying methodology used in the different studies.

The position of an impacted canine in the arch influences the potential sequaeae and complications that may arise with the occurrence and surgical management of the impacted tooth. The location of the impacted canine in close proximity to the roots of the neighboring teeth may cause damage to them [7]. Displacement of a root into the maxillary sinus, or nasal cavity can occur during surgical removal [8]. Also, an oro-antral or naso-antral fistula can follow surgical removal of an ectopic maxillary canine [7]. However, these post-operative complications are uncommon. Likewise, when an impacted maxillary canine is located near to the neurovascular bundle, paresthesia may be sequelae of surgery [8]. If the maxillary canine is impacted palatally, the nasopalatine nerve may be affected, although it rarely presents a problem for the patient. Our study is concomitant with these findings as the complications associated with the occurrence and surgical management of impacted maxillary canines were observed in very low numbers.

Brackets and lingual buttons were commonly used in patients who required surgical exposure and bonding of an attachment as a part of the comprehensive treatment plan. After the tooth was surgically exposed the enamel was etched for 30 s and then irrigated. Success is often directly related to the degree of hemostasis. Once hemostasis was achieved, the primer was placed on the tooth. The bonding agent was then placed on the bracket and pressed firmly against the enamel surface of the tooth followed by curing for 20–40 s. The ligature wire was then attached to the arch wire if present or a tooth if not present. The vector of force used to move the canine could be changed to move the canine away from the incisor roots and then move it vertically. It is advisable for the surgeon to provide photographic or pictorial documentation to familiarize the orthodontist with the relative position of the canine.

Undesirable complications during the course of orthodontic traction to manage impacted canines include failure to erupt, bond failure and ankylosis [2]. Also, it has been suggested that the disadvantage of applying an attachment at the time of surgical exposure is that it is technique sensitive and that the use of a ligature wire to facilitate traction is unreliable [32]. However, in our study the bracket could not be bonded, at the time of surgery, in only one (1.4%) case suggesting that the complications associated with orthodontic traction to manage impacted canines are minimal. Also, breakage of the ligature
wire subsequently occurred in only 4 (5.7%) of the 70 cases treated by surgery. There was no movement of the impacted canine in just two cases (2.9%) after traction was applied post-operatively. Subsequently, in one of the cases, repeat surgery led to successful traction of the impacted canine. While it could not be definitely concluded that the failed traction occurred due to ankylosis of the tooth, it is unlikely as the tooth was not apparently ankylosed when investigated during the pre-surgical procedures.

The results of this study suggest that exposure of impacted canines followed by bonding of an attachment in the closed flap technique, followed by orthodontic eruption produces a predictable successful outcome with minimal complications.

Conclusions

The frequency of root resorption of teeth adjacent to an impacted maxillary canine was found to be low. Females were found to exhibit root resorption of adjacent teeth twice more often than males. Complications after surgical intervention which occurred rarely were post-operative bleeding from the surgical site, hematoma, post-operative pain, purulent discharge, transient paresthesia, unsatisfactory healing, iatrogenic damage to adjacent soft tissue, maxillary sinus perforation, sub-conjunctival hemorrhage and discoloration of adjacent teeth. Nevertheless, surgical exposure of an impacted maxillary canine and bonding of an attachment to allow orthodontic traction is a reliable treatment option with minimal complications.

References

Abstract

Background: Matrix Metalloproteinases (MMPs) are directly responsible for pathogenesis of periodontal diseases and their activity is regulated by Tissue Inhibitor of Metalloproteinases (TIMPs). This study was aimed to evaluate changes in gingival crevicular fluid (GCF) levels of MMP-1 and TIMP-1 in periodontal health and disease.

Materials and method: Clinical parameters were recorded and GCF samples were collected from 30 subjects with chronic generalised periodontitis and 20 periodontally healthy subjects. Subjects with periodontitis underwent scaling and root planing (SRP). GCF samples were collected and clinical parameters were recorded again after 1 month of SRP. GCF levels of MMP-1 and TIMP-1 were detected by ELISA.

Results: GCF levels of MMP-1 were significantly increased in subjects with periodontitis at baseline (P0) as compared to periodontally healthy subjects (C). GCF levels of MMP-1 reduced significantly in subjects with periodontitis after treatment (P1) as compared to P0. GCF levels of TIMP-1 were significantly reduced in P0 as compared to C. GCF levels of TIMP-1 increased significantly in P1 as compared to P0.

Conclusion: Substantial elevation in GCF levels of MMP-1 and reduction in TIMP-1 were found in periodontitis as compared to healthy subjects. GCF levels of MMP-1 and TIMP-1 improved significantly after treatment.

Introduction

Periodontitis is a multifactorial infectious disease characterised by destruction of the bone and connective tissue caused primarily by specific periodontopathic bacteria and modified by interaction with host and environmental factors [1]. The initial host response comprises an innate recognition of microbial components – lipopolysaccharides (LPS) complex by host cells and the subsequent production of inflammatory mediators, such as; eicosanoids, reactive oxygen species, Matrix Metalloproteinases (MMPs), chemokines and cytokines which are directly responsible for periodontal destruction [2].

Keywords:
MMP-1
TIMP-1
Periodontitis
Periodontal disease

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MMPs are a zinc/calcium-dependent family of neutral proteases that are released from different cell types including macrophages, leucocytes, fibroblasts and other resident cells [3]. They are believed to participate in embryonic development, arthritis, angiogenesis, morphogenesis, reproduction, tissue resorption, tissue remodelling and tumour growth, invasion and its metastasis through breakdown of extracellular matrix (ECM) [4]. MMP-1, prototype interstitial collagenase is the first vertebrate collagenase [5]. It is distributed widely in tissues and expressed by fibroblasts, keratinocytes, endothelial cells, osteoblasts, chondrocytes, and monocytes/macrophages [6,7].

Activity of various MMPs is regulated at multiple levels (transcriptional, post-transcriptional, and post-translational) and also by endogenous inducible inhibitors, the Tissue Inhibitors of Metalloproteinases (TIMPs) [3]. TIMPs, family of proteins, appear to regulate matrix degradation both by proteinase inhibition and by blockage of autocatalytic MMP activation [8]. Among all the TIMPs, TIMP-1 inhibit collagenase more effectively. TIMP-1 is a 30-kDa glycoprotein that is synthesised and secreted by most connective tissue cells as well as by macrophages; it can be identified in most body fluids [9].

Previously, increased expression of MMP-1 mRNA was found in inflamed gingival tissue of subjects with chronic periodontitis as compared to healthy controls in various studies [7,10–13]. But, very few studies available demonstrating changes in gingival crevicular fluid (GCF) levels of MMP-1 and TIMP-1 in periodontal health and in periodontal disease. Also, only few reports available showing association between clinical parameters and GCF levels of MMP-1 and TIMP-1. Therefore, the present study was aimed to evaluate changes in gingival crevicular fluid (GCF) levels of MMP-1 and TIMP-1 in periodontal health and disease before and after periodontal treatment. Furthermore, we also correlated biochemical parameters with clinical parameters.

Materials and method

Study population

30 subjects with chronic generalised periodontitis (13 male and 17 female, mean age 37 yr) and 20 periodontally healthy subjects (10 male and 10 female, mean age 34 yr) were enrolled in this study from Department of Periodontology, during August 2012 to November 2012. All selected subjects were in good general health. Selected subjects had age range of 21–55 yr.

The periodontal status of all included subjects were assessed according to the classification of periodontal disease by the American Academy of Periodontology [14]. Diagnosis of subjects with chronic generalised periodontitis was based on clinical and radiographic findings. Subjects with probing depth (PD) ≥ 4 mm and clinical attachment loss (CAL) ≥ 2 mm in at least 30% of sites and radiographic evidence of bone loss were selected. While subjects who had clinically healthy gingiva, no clinical attachment loss (CAL) and probing depth (PD) <3 mm were categorised as periodontally healthy subjects.

The following exclusion criteria were used; (1) presence of <20 permanent teeth, (2) individual with history of systemic conditions such as heart disease, diabetes, Tuberculosis, etc., (3) postmenopausal women and smokers, (4) any medication use that could affect the manifestations of periodontal disease, such as chronic antibiotic use, phenytoin, cyclosporine, anti-inflammatory drugs, or calcium channel blockers, (5) individual with periodontal abscess, necrotising ulcerative diseases, aggressive periodontitis, (6) those who have received any type of periodontal treatment in past 6 months or subjects on periodontal maintenance therapy.

Clinical examination

All selected subjects were fully informed about purpose of the study and consent was obtained. Clinical evaluation was based on the following indices: gingival index (GI) [15], plaque index (PI) [16], probing depths (PD) and Clinical attachment loss (CAL). Clinical parameters for each subject were recorded by a single examiner with full mouth clinical examination, excluding third molars. All clinical parameters were recorded on 4 sites per tooth (mesiobuccal, buccal, distobuccal, palatal) using calibrated UNC-15 Probe. Probing depth and CAL were measured with a calibrated UNC-15 Probe, using free gingival margin and cement-enamel junction as reference point.

Collection and storage of gingival crevicular fluid sample

Subjects were made to sit comfortably in an upright position on the dental chair with proper illumination. The most severely affected upper anterior sextant (maxillary incisors and the canine teeth) was chosen for the study due to good accessibility in that area. The test site was air dried, isolated with cotton rolls and supragingival plaque was removed without touching the marginal gingiva. Colour coded 1–5 μl calibrated volumetric microcapillary pipettes were used for collecting GCF samples. Samples were collected by placing the tip of the pipette in to gingival crevice. The test sites which did not express any volume of GCF and micropipette contaminated with blood and saliva were excluded from the study. Samples were immediately transferred to plastic vials and stored at −70 °C till the time of the assay.

Periodontal treatment

After clinical examination and GCF collection, subject with periodontitis underwent periodontal treatment at the same appointment. Periodontal treatment included oral hygiene instructions as well as scaling and root planing (SRP). Scaling and root planing were performed using extremely sharp sickles, Gracey curettes and ultrasonic instruments. After 1 month of SRP, clinical parameters were recorded and GCF samples were collected from same site of each subject with periodontitis. During whole study period of a month each subject with periodontitis were recalled at intervals of 1 week and plaque control measures were performed.

Enzyme Linked Immunoabsorbent Assay (ELISA)

GCF levels of MMP-1 and TIMP-1 were analysed using ELISA, performed by using a commercial ELISA kit (RayBio®Human MMP-1 ELISA Kit and RayBio®Human TIMP-1 ELISA Kit)
specific for human MMP-1 and human TIMP-1. GCF samples were expelled from micropipettes with jet of air using blower provided with pipette and by further washing with fixed amount of diluent. The samples were diluted with the diluent provided with ELISA kit in the ratio of 1:40 for MMP-1 and 1:100 for TIMP-1. All assay procedures were carried out according to the manufacturer’s instructions. After preparation, samples and standards were incubated 2.5 h at room temperature in precoated wells. Then the solution was discarded and each well was washed 4 times. 100 μl prepared biotin antibody was added and incubated 1 h at room temperature. Followed by washing, 100 μl prepared HRP Streptavidin solution was added and incubated 45 min at room temperature. After washing, 100 μl tetramethylbenzedine one-step substrate reagent was added and incubated 30 min at room temperature and then the reaction was stopped by adding 50 μl Stop Solution to each well. Optical densities of standards and samples were obtained by reading immediately at 450 nm wavelength. Standard curve was plotted with standard concentration on the x-axis and absorbance on the y-axis to determine levels of MMP-1 and TIMP-1.

**Statistical analysis**

Data analysis was performed using the statistical package SPSS 19 software. The clinical and biochemical parameters of subjects with chronic periodontitis before periodontal treatment (P0) and after periodontal treatment (P1) were analysed using Wilcoxon signed-rank test. Mann–Whitney U test was used to determine significant difference among healthy controls (C) and subjects with periodontitis before treatment (P0) and among healthy controls (C) and subjects with periodontitis after treatment (P1). Correlation (r) between clinical and biochemical parameters among subjects with periodontitis were analysed with Pearson’s correlation test. The P value <0.05 was considered as statistically significant.

**Results**

**Biochemical parameters**

GCF levels of MMP-1 were significantly higher among P0 (20.36 ± 23.55 ng/ml) as compared to C (7.29 ± 11.83) (P value 0.026). GCF levels of MMP-1 were significantly reduced in P1 (9.26 ± 15.9 ng/ml) as compared to P0 (P value 0.004). There was no significant difference found in GCF levels of MMP-1 among C and P1 (P value 0.63) (Table 1, Fig. 1).

GCF levels of TIMP-1 were significantly lower among P0 (113.65 ± 137.11 ng/ml) as compared to C (351.46 ± 99.5 ng/ml) (P < 0.001). GCF levels of TIMP-1 were significantly raised in P1 (280.39 ± 162.15) as compared to P0 (P < 0.001). There was no significant difference found in GCF levels of TIMP-1 among C and P1 (P value 0.087) (Table 1, Fig. 2).

The ratio of MMP-1 to TIMP-1 in GCF was significantly higher in P0 (0.88 ± 1.47) than C (0.08 ± 0.26) (P value 0.021), but it reduced significantly in P1 (0.13 ± 0.46) as compared to P0 (P value 0.002) and there was no significant difference found in ratio of MMP-1 to TIMP-1 among P1 and C (P value 0.671) (Table 1, Fig. 3).

**Clinical parameters**

Gingival Index (GI) scores (Mean ± SD) were significantly higher among P0 (1.94 ± 0.08) as compared to C (0.65 ± 0.27) (P < 0.001). GI scores were significantly reduced in P1 (0.95 ± 0.24) as compared to P0 (P < 0.001). Statistically significant difference was found between P1 and C (P < 0.001) (Table 1).

![Fig. 1 – Comparison of GCF levels of MMP-1 among subjects with chronic periodontitis at baseline (P0), at the 1 month after treatment (P1) and healthy controls (C).](image-url)
Plaque Index (PI) scores (Mean ± SD) were significantly higher among P0 (2.12 ± 0.2) as compared to C (0.69 ± 0.3) (P < 0.001). PI scores were significantly reduced in P1 (1.05 ± 0.23) as compared to P0 (P < 0.001). Statistically significant difference was found between P1 and C (P < 0.001) (Table 1).

Probing Depth (PD) scores (Mean ± SD) were significantly higher among P0 (4.24 ± 0.54) as compared to C (1.52 ± 0.35) (P < 0.001). PD scores were significantly reduced in P1 (3.66 ± 0.47) as compared to P0 (P < 0.001). Statistically significant difference was found between P1 and C (P < 0.001) (Table 1).

Clinical Attachment Loss (CAL) scores (Mean ± SD) were significantly higher among P0 (2.03 ± 0.69) as compared to C (0 ± 0) (P < 0.001). CAL scores were significantly reduced in P1 (1.66 ± 0.71) as compared to P0 (P < 0.001). Statistically significant difference was found between P1 and C (P < 0.001) (Table 1).

Correlation among clinical and biochemical parameters

Statistically significant negative correlation was found between GCF levels of MMP-1 and TIMP-1 (r = −0.22, P = 0.088). GCF levels of MMP-1 had shown significant positive correlation with GI (r = 0.28, P = 0.028) and PI (r = 0.28, P = 0.031). GCF levels of TIMP-1 had shown significantly negative correlation with GI (r = −0.62, P < 0.001), PI (r = −0.65, P < 0.001), PD (r = −0.47, P < 0.001) and CAL (r = −0.36, P = 0.005) (Table 2).

Discussion

Periodontitis is an inflammatory disease of supporting structures of teeth resulting in destruction of alveolar bone and connective tissue. Possible mechanism for the degradation of collagen fibres and extracellular matrix in periodontitis is independent and/or cooperative action of both human and bacterial proteinases [17,18]. Periodontal destruction is most likely caused by host cell derived MMPs [19]. It has been suggested that MMP-1 may play an important role in the initiation of collagen degradation in periodontal disease [7]. Previously, increased expression of MMP-1 mRNA was found in inflamed gingival tissue of subjects with chronic periodontitis as compared to healthy controls in various studies [7,10–13]. Tissue inhibitors of metalloproteinases bind to Matrix Metalloproteinases and irreversibly inhibit their enzyme activity. Altered TIMP expression is also known to occur in many disease processes and affects the processing of extracellular matrix [20]. Moreover, it was speculated that TIMP-1 appears to be more effectively inhibit MMP-1 [9]. Hence, we investigated changes in GCF levels of MMP-1 and TIMP-1 in subjects with periodontal health and disease.

Wide varieties of immunological method are used to detect GCF levels of MMPs and TIMPs. In comparison to other assay systems, ELISA tests have several advantages including improved sensitivity (at least compared to zymography), ease of use, moderately rapid throughput, the ability to quantify enzyme levels and the flexibility to test for multiple MMPs in single samples. Moreover, ELISAs may be more adaptable to use in office settings because of their simpler and more robust instrumentation [21]. Therefore ELISA has been
selected for detection of GCF levels of MMP-1 and TIMP-1 in gingival crevicular fluid in present study.

In this study, we found that GCF levels of MMP-1 were significantly elevated in subjects with periodontitis before treatment (P0) as compared to healthy subjects (C), which is in agreement with previous studies [22,23]. It is in contrast with Birdt et al. [24], stated that there was no significant difference in GCF levels of MMP-1 in diseased and healthy sites. This variation in finding can be due to difference in sample size as well as other difference in methodology of both studies. We also found that GCF levels of MMP-1 were significantly reduced in subjects with chronic periodontitis 1 month after scaling and root planning (P1) as compared to P0 and remained close to GCF levels MMP-1 of healthy subjects (C). These findings are in accordance with Tuter et al. [23].

In present study, we found that GCF levels of TIMP-1 were significantly reduced in P0 as compared to C which is in accordance with previous findings by Bildt et al. [24]. GCF levels of TIMP-1 were increased significantly in P1 as compared to P0. These findings are in accordance with Pozo et al. [25] and Tuter et al. [26]. Furthermore, our findings are consistent with Haerian et al. [27] who reported that the GCF levels of TIMP increases at follow up examination at 6 weeks hygiene phase therapy.

In present study, we found the ratio of MMP-1/TIMP-1 significantly higher in subjects with periodontitis before treatment and it decreased significantly after treatment. Thus, it can be suggested that balance in GCF levels of MMP-1 and TIMP-1 also play significant role in maintaining healthy periodontal condition.

We also found that all the clinical parameters improved significantly in periodontitis after SRP. Considerable evidences support role of SRP as an essential and effective therapy for reductions in inflammation and progression of periodontal diseases. This reduction in inflammation inhibits up-regulated MMPs expression in periodontitis, resulting in decreased MMP-1 after SRP [28,29]. Several possible explanations for the increased TIMP-1 levels after periodontal therapy: (1) a reduction in MMP-1, which would bind to free TIMP; however, the regulation of TIMP-1 may not solely be dependent on the MMP-1 [9], (2) the decreased levels of TIMP-1 in periodontally diseased subjects may be due to the selective degradation of TIMP-1 by neutrophil elastase or the inactivation of TIMP-1 by neutrophils themselves following oxidant release [30,31], (3) the increased levels of its TIMP-1 may reflect its involvement in the healing process, (4) unidentified mechanisms for clearance of MMP-TIMP-1 complexes [27].

On comparison of biochemical and clinical parameters in present study showed significantly negative correlation among GCF levels of MMP-1 and TIMP-1 which is in accordance with Tuter et al. [23]. We also found significantly negative correlation of GCF levels of TIMP-1 with all the clinical parameters (GI, PI, PD, CAL) which are in accordance with; Pozo et al. [25], found negative correlation among GCF levels of TIMP-1 and probing depth and CAL and Tuter et al. [26], found negative correlation between GCF levels of TIMP-1 and gingival index, plaque index and probing depth.

While, significantly positive correlation of GCF levels of MMP-1 was found with GI and PI, which is in contrast with Tuter et al. [26] who did not find any significant correlation. Furthermore, Villela et al. [32] reported a positive but rather weak correlation between PD and GI and collagenase activity while Gangbar et al. [33] failed to find any correlations between collagenase activity and clinical parameters. Different methods of GCF sampling and laboratory techniques as well as variations in reporting the results may influence the variation found in correlation between clinical and biochemical parameters in various studies.

In present study, we used ELISA to determine GCF levels of MMP-1 and TIMP-1, which measure total enzyme level (both active and latent) in GCF rather than active enzyme level. It can be possible that proportional amount of active enzyme would be low after treatment. Thus, it is advisable in future to perform study that can discriminate between active and latent (inactive) form of enzymes. In the present study we evaluated GCF levels of MMP-1 and TIMP-1 in periodontitis before and after SRP but, longitudinal studies which determine prognostic values of GCF levels of MMP-1 and TIMP-1 will be required to carry out in future to further clarify the role of MMP-1 and TIMP-1 in periodontal destruction. Understanding of expression patterns and levels of MMPs in periodontal tissues and various oral fluids help for the future development of functional and/or immunological MMP diagnostic tools to monitor the course of periodontitis as well as the effects of various treatment modalities of periodontitis.

**Conclusion**

Within the limits of present study we concluded that a substantial elevation in GCF levels of MMP-1 and reduction in GCF levels of TIMP-1 were found in subjects with periodontitis as compared with healthy controls. GCF levels of MMP-1 decreased and TIMP-1 increased after scaling and root planing as compared with their level before treatment. This indicate important role of MMP-1 and TIMP-1 in periodontal destruction.

**References**


Case report

Complete denture copy technique—A practical application

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A B S T R A C T

The copy denture technique is a misnomer for the clinical and laboratory procedures involved in making complete dentures that replicate most of the features of the original prosthesis. The aim is to replicate the good features of an otherwise successful prosthesis that now requires replacement and to alter the poor features and so it is strictly speaking not a copy. There are many purported advantages to this technique which include reduced treatment time, increased patient acceptance especially for the elderly who may not adapt so well to a new prosthesis, maintenance of tooth position and vertical dimension. A typical case is presented illustrating the clinical stages involved with a discussion of the merits of this technique.

Introduction

The copy denture technique is not a single technique, but a variety of techniques designed to replicate complete dentures [1–3]. A range of techniques both clinical and laboratory exist which vary in their ability to “copy” a prosthesis. If one thinks of a denture as having three surfaces—occlusal, polished and fit surface—then it becomes easier to decide which of these one should copy or alter as the clinical situation requires.

Of course prior to constructing a new prosthesis, the clinician should have a good indication for using this treatment modality based on an accurate diagnosis of the problem and reason for replacement. An exact copy of a denture may be indicated if the patient is entirely satisfied with the prosthesis and there are no errors of a technical variety that impact clinically.

For example, if the denture material has simply degraded or has fractured and cannot be repaired satisfactorily then a direct copy may be indicated. A patient may request a spare set of dentures.

However, it is more common to see dentures in which one or more surfaces can be improved by relining or replacing worn teeth. The polished surface is probably the least often cited requiring alteration and the one the patient will notice the most if changed. An exception to this might be if speech is not satisfactory changes are need to the palatal contour to aid pronunciation of certain sounds. Therefore, by definition, if the dentures are modified in any way it is not a “copy” and hence the term “replica” might be more suitable.

Case study

Mr N was a 49 year old male who presented with a fractured upper complete denture. His present dentures were made 3...
years ago following the loss of all his teeth i.e. an immediate denture. He was otherwise very happy with the appearance, comfort and function and wanted a replacement set without too many changes that others might notice.

**Clinical findings**

The upper and lower arches were U-shaped with well-formed minimally resorbed ridges showing signs of scalloping where the natural teeth were present. The ridges were firm and the mucosa healthy (Figs. 1–3).

**Current dentures**

The upper and lower dentures were stable, retentive and well-supported. With both dentures in situ the appearance, centre line and occlusal vertical dimension (OVD) were acceptable (Fig. 4). The occlusal plane and incisal level were satisfactory. There was a partial fracture in the midline of the upper denture palatally (Fig. 8).

Examination of the static occlusion showed bilateral simultaneous contacts in maximum intercuspation (MI) which was coincident with retruded contact position (RCP). Examination of the dynamic occlusion showed that in protrusion there were only posterior contacts with no anterior contact (Fig. 5). Lateral excursions were canine guided and there were no non-working side (NWS) contacts (Figs. 6 and 7).

**Diagnosis**

The following diagnoses were made:

1. Fractured upper denture and stained lower denture (Figs. 8 and 9).
2. Poor occlusal scheme not ideal for removable complete prostheses.
The treatment objective was to replicate the bucco-lingual tooth position and maintain the OVD. After 3 years post-extraction a degree of bone resorption was expected and hence a new fitting surface was indicated. The occlusal scheme was unsatisfactory and a balanced occlusion and articulation was to be developed necessitating a change in the occlusal surface. The appearance could be improved with minor changes in the tooth arrangement and a better mould using higher quality teeth. Interestingly the patient had no complaints pertaining to the fit or occlusal surface, but from a clinical and technical perspective improvements could be made.

**Treatment plan**

The treatment plan is outlined below:

1. Repair existing upper denture to be kept as a spare.
2. Construct new upper and lower dentures using copy technique to replicate tooth position and polished surfaces, but allow for minor improvements to mould, shade and arrangement.
3. Take wash impressions to improve accuracy of fit surface.
4. Ensure balanced occlusion and articulation at the same OVD.

**Treatment**

1. Make clear acrylic copies of existing dentures in laboratory silicone (Figs. 10–12).
   Heavy bodied silicone is rigid enough to be used without additional support. However, if extra rigidity is required then two large stock trays for each denture can be used to contain and support the impression material.
2. Take wash impression, after reduction of any undercuts, with ZnOE using open mouth technique (Figs. 13 and 14).
   The acrylic copies are effectively used as close-fitting special trays. They must have the undercuts removed prior to the wash so that once poured in die-stone, the denture can be removed without damage to the model. A fluid wash impression material is used to ensure a thin impression which will not significantly increase the OVD and also capture the denture bearing area accurately. Pressure relief holes in the palatal vault will aid escape

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**Fig. 6** – Current dentures in right lateral excursion.

**Fig. 7** – Current dentures in left lateral excursion.

**Fig. 8** – Current upper denture showing fracture palatal to upper centrals.

**Fig. 9** – Current lower denture showing staining from smoking.
of material, reduce pressure build up and ensure a thin impression.

An open mouth technique is clinically easier to perform than a closed mouth technique the advantage of which it is thought will minimise changes in the OVD. In practice it is very difficult for the patient to occlude with precisely the correct force to avoid changes in the vertical dimension. Border moulding is also easier with the open mouth technique. If the OVD is recorded and checked at each stage then as the occlusal surface is being changed, it is easy to keep control of this dimension.

3. Take jaw registration at same visit as step 2. Maintain the same OVD. Silicone jaw registration material to be used (Fig. 15).

The acrylic copies serve a double purpose i.e. that of a registration block as well as special tray. If the OVD has increased then it will have to be reduced with an acrylic bur and balanced occlusal contact developed. The choice of jaw registration material is up to the clinician.

4. Facebow record and mounting on Kavo semi-adjustable articulator.

The need to take a facebow record will necessitate that the jaw registration material will allow separation of the dentures. Silicone will allow this to be done cleanly and easily.

5. Tooth-try in wax to verify tooth position and OVD (Figs. 16 and 17).

Tooth mould and shade information can be taken from the existing dentures. However, the patient may wish to take this opportunity to change the aesthetics. The buccolingual tooth position was replicated by removing and replacing one tooth at a time. If buccolingual tooth position is critical then a buccal putty index can aid
accurate tooth placement. In this case the contours of the polished surfaces were not critical and were replicated by hand carving the wax.

6. Finish in pink veined high impact acrylic and delivery of dentures (Figs. 18–24).

Discussion

The technique presented above was appropriate and successful in this case. Its use depended upon a correct assessment of the problem that needed addressing. If not applied correctly then it would be all too easy to perpetuate a deteriorating denture situation. The technique has often been used incorrectly when the clinician is unable to correctly diagnose the denture fault with which the patient presents. In these types of cases, copies can be made of the dentures for trial modifications, such as extending borders, adding post-dams, balancing occlusion and increasing or reducing OVD. The patient’s original dentures have not been altered in any way and so nothing is lost. Once the patient is happy with the modifications, then this is copied to make a definitive denture.

There are several ways to make copies of dentures. Metal denture flasks are probably the best option. Alginate is mixed and loaded into one half and the denture is pressed into it so that the alginate is level with the flange. Once set a second
mix of alginate is mixed and loaded into the other half of the flask and the two halves closed. In order to avoid trapping air into the mould, alginate is preloaded into deep depressions or undercuts using a finger. Once set the flask is opened and the denture retrieved. Holes are cut into the heels of the mould for pouring cold cure acrylic resin.

If the patient is able to leave the dentures at the laboratory for a period then reversible laboratory hydrocolloid can be used. In the clinic, a heavy-bodied silicone putty is simplest with or without support using metal stock trays.

Replicating immediate dentures preserves valuable information on tooth position and vertical dimension without having to resort to biometric guidelines applied to the "blank canvas" of edentulous ridges. There is some saving in clinical time at the wash and jaw registration phase which are done at the same time rather than as two separate stages. There can also be time saved at the try-in stage if tooth position is not significantly altered.

The term replicating technique is more accurate than copy technique as there are few situations where an exact copy is what is required. Applied appropriately, it is a useful addition to the prosthodontists treatment choices.

Conclusion

A denture replication technique was used to make a new set of complete dentures. Tooth position and vertical dimension were copied and alterations to the fit surface, to account for resorption and the occlusal surface, to provide balanced occlusion and articulation, were made.

Correct application of this technique can reduce both clinical and laboratory time, but depends on an accurate diagnosis of the problem and an understanding of the advantages and limitations of this method.

References

Case report

Delayed replantation of avulsed tooth with 15-hours extra-oral time: 3-year follow-up

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Abstract

Background: Avulsion is one of the most serious injuries of the tooth which is most commonly seen in young children and occurs in the upper front teeth. Immediate transplantation of the avulsed tooth is recommended treatment and results in good prognosis although this may not be always possible.

Case report: The present case highlights the 3-year follow-up of delayed replantation (after 15 h) of maxillary central incisor which was avulsed due to trauma. The complications seen in the present case were ankylosis and inflammatory resorption, but clinically the tooth was asymptomatic and maintains the esthetics of the individual signifying the importance of delayed replantation even after prolonged extra-oral time.

Clinical implications and conclusion: Although complications like ankylosis or root resorption may be unavoidable, delayed replantation of avulsed tooth may be a good alternative to prosthesis (implant or fixed partial denture) till the growth is completed due to preservation of the alveolar bone and psychological benefit to the patient. Also efforts should be made to educate and update children, teachers and parents regarding management of avulsed tooth at accident site and also the dentists regarding its management in dental office.

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Introduction

Injury to the teeth and associated oro-facial structures is quite disturbing to the child and his parents due to contribution of these structures in esthetics and its subsequent psychological impact. Although all forms of injuries require some immediate attention and management, tooth avulsion (ex-articulation) is a special form of injury in which the prognosis is associated with the duration between the time the tooth is avulsed and when it is replanted [1,2]. Also this form of injury is important because it most commonly involves maxillary central incisors [3] which makes a major esthetic contribution to the smile.

Although recommended, immediate transplantation of the avulsed tooth is not always possible due to the patient's concomitant injuries at the time of accident and lack of knowledge in the management of such injuries at the site of the accident [4]. The purpose of this case report is to report the 3-year follow-up of avulsed 11 which was replanted in the dental office after a period of 15 h.
Case report

A 12-year female child reported to the unit of Pediatric Dentistry, Oral Health Sciences Center, PGIMER, Chandigarh with a chief complaint of broken upper front tooth due to trauma 15 hs back (Figs. 1 and 2). The trauma occurred while the child was playing in the park and there was no history of loss of consciousness or vomiting. The tooth was taken home wherein the tooth was placed in cold milk after half an hour of extra-oral dry time and taken to local dentist. The local dentist referred the patient to our department for subsequent treatment which was far away from the place and hence total extra-oral time for the avulsed tooth was 15 h. On examination, there were no other signs of injury intra-orally and extra-orally. Examination of the tooth socket did not reveal any fracture of the bony wall or tooth segment. An intra-oral periapical radiograph was taken to rule out any broken tooth or bony segment in the socket (Fig. 3). In the dental office, the root surface and the socket were washed with stream of saline and all the debris was removed gently. The root surface was also cleaned with soft pumice prophylaxis and subsequently kept in 2% sodium fluoride solution till the patient was prepared for the procedure of replantation. The tooth was placed in the socket under local anesthesia and splinting was done from canine to canine using multiflex wire for one month (Fig. 4). The occlusion of the patient was checked to verify that there were no pre-mature contacts while biting to avoid further injury to the adjacent periodontal tissues. Esthetics was restored by maintaining the incisal edge of the replanted tooth at same level as the adjacent tooth. A radiograph was also taken to verify the position of re-implanted tooth in the socket (Fig. 5). Access opening was prepared on the same day and pulp extirpated from the canal. The canal was subsequently filled with calcium hydroxide and the chamber sealed with Glass ionomer cement (GIC). The patient was kept on antibiotics (Doxycycline 100 mg twice daily and Ibuprufen 400 mg thrice daily for 7
days). The splint was removed after 4 weeks and intra-canal medicament was changed. The patient was recalled after 1 month and root canal treatment was completed. The patient was kept on routine follow-ups every 6 months. No resorption was evident radiographically at 1 year follow-up (Fig. 6); however initial root resorption was evident at 2-year follow up (Fig. 7) and resorption of the apical third was evident at 3 year-follow-up (Fig. 8). Clinically, the patient has been asymptomatic with no mobility since the splint was removed (Figs. 9 and 10). After 6 months of follow-up, the tooth showed metallic sound on percussion suggestive of ankylosis. The patient will be monitored till her growth is complete and appropriate treatment will be carried out if needed.
Discussion

Tooth avulsion is a serious injury resulting in complete displacement of the tooth outside the socket and consequently damaging its supporting apparatus (i.e. periodontal ligament and bone). Tooth avulsion is more prevalent in males (male: female =3:1) and age group of 7-14 years is most commonly affected [3]. In the present case milk was used as interim transport media for 15 h. Milk is a reasonably good storage media because of its osmolarity and pH and therefore has been shown to preserve PDL cells for up to 8 h [5,6]. However, in the present case the tooth was stored in milk for long time i.e. 15 h; hence it was supposed that the periodontal ligament cells were dead and the condition was categorized into category 4 [7]. Removal of dead periodontal ligament cells is one of the most important actions which need to be taken to slow down the osseous replacement of the root surface [8,9]. To achieve this, the root surface was cleaned with soft pumice prophylaxis to remove remaining non-viable periodontal ligament cells which may act as source of infection and subsequently accelerates infection related resorption [7]. Some authors have even suggested periodontal curettes and scalers for removal of these necrotic periodontal ligament cells; however, excessive scraping of cementum may further accelerate the resorptive process instead of decreasing it. Thus, to maintain a balance of avoiding excessive scraping of cemental layer and at the same time completely remove necrotic periodontal ligament cells, we used soft pumice prophylaxis. The tooth was then immersed in 2% sodium fluoride solution for 20 min till the armamentarium and the patient was prepared for the procedure to minimize loss of precious time. The rationale for this fluoride soak is based on evidence that this procedure will delay but not prevent ankylosis [10]. The pre-treatment of root surface with sodium fluoride has been hypothesized since 1968 due to its beneficial effect by decreasing the rate of osseous replacement in replanted teeth of monkeys [11]. A similar study in humans also demonstrated 50% reduction in progression of root surface resorption after replantation [12]. Stannous fluoride is an alternative that has also been used for treatment of root surfaces before replantation; however, its use was associated with long-standing inflammatory reaction in periodontal ligament [13]. Due to this sodium fluoride solution has remained as the only useful and tested method for root-pre-treatment before replantation [12].

Tooth was placed in the socket and semi-rigid splinting was done for 4 weeks using acid-etch composite resin and multi-flex wire from canine-to-canine. A flexible type of splint (or semi-rigid splint) is the preferred type of splint in avulsion injuries because rigid splints have been shown to accelerate root resorption in both mature and immature teeth [14-16]. Although various types of semi-rigid splints have been suggested, this particular splint was used based on the immediate availability in the department. Also acid etch bonded splint allows maintenance of oral hygiene and is easily tolerated by the patient [17]. Systemic antibiotics in the form of Doxycycline (in a standard dose of 100 mg twice daily) was prescribed as this has been shown to lessen the resorptive attack on the root surface; although pulpal healing remains unaffected [18]. Also, the patient in present case was of 12 years of age and hence, chance of tetracycline discolouration was minimal. If the patient would have been younger than 12 years, penicillin would have been the drug of choice because its antibacterial effect is similar to tetracycline; however; penicillin has the disadvantage that it lacks the anti-resorptive present in tetracycline [18,19].

Endodontic access was prepared in the same visit and pulp debrided. Thereafter, the root canal was filled with calcium hydroxide because it is anti-bacterial [20,21] and microbes are considered an etiology behind root resorption and hence may cause rapid loss of tooth [22]. Calcium hydroxide changes the environment to a more alkaline pH, which may slow the action of the resorptive cells and promote hard tissue formation [23,24]. However, the changing of the calcium hydroxide should be kept to a minimum (not more than every 3 months) because it has a necrotizing effect on the cells that are attempting to repopulate the damaged root surface [25]. The calcium hydroxide was placed in the canal for a total of 2 months in the present case and endodontic treatment completed just after removal of calcium hydroxide. GIC should be used as an intermediate restorative material in the present case because of its longer durability and excellent seal [26]. Jensen et al. (2007) [27] have recommended Glass ionomer with a different color as a preferable material to be used as interim restorative material except when there are esthetic considerations (as in the present case) where-in tooth colored GIC should be used. The patient was recalled at 3 months, 6 months, 1 year, 2 year, 3 year after trauma and is still on yearly follow up.

The complications associated in the present case were inflammatory root resorption and ankylosis (replacement resorption) and it is expected that the tooth will be lost eventually by gradual resorption of the root surface followed by replacement with the bone. Radiographically, ankylosis is characterized by absent periodontal ligament space and continuous replacement of root substance with the bone until little or no tooth substance remains. In contrast, inflammatory resorption is characterized by radiolucent bowl shaped cavitations along the root surface with corresponding excavations in the adjacent bone, often beginning in the cervical third of the root. However, both ankylosis and inflammatory root resorption are similar that they both are usually evident within the first two years after replantation. Clinically, the ankylosed tooth is immobile and infraoccluded whereas the tooth with inflammatory root resorption appears loose and extruded. The percussion tone is often diagnostic in cases of ankylosis which is high compared to a dull tone in teeth with inflammatory root resorption. It should be noted however that in teeth with inflammatory resorption; replacement resorption takes over the resorbed area by filling the defect with bone once the inflammatory resorption process decelerates [28]. Although occurrence of ankylosis can be delayed to some extent by treatment of the root surface; inflammatory root resorption is a factor not under the control of a dentist and seen in 26% of replanted teeth [29]. An ankylosed tooth is often a desirable outcome as a transitional
condition for a growing child or adolescent [30]. An avulsed tooth that is maintained until growth is completed should be considered a successful outcome because tooth loss before this time often includes loss of the alveolar bone as well as further resorption of the bone in the site. This later circumstance greatly compromises options for the missing tooth or teeth and may involve extensive and costly procedures, such as bone augmentation and grafting [7]. Preserving the root preserves the alveolar bone and is advantageous for implant replacement when the child has completed growth. Hence; after the growth is completed other treatment options will be considered for the present case like dental implants or fixed partial dentures.

Another factor which should be highlighted in the present case is to understand the basic reason for delay in seeking treatment in the present case. If the tooth could have been re-implanted immediately by the patient/parents and immediate treatment provided by the private practitioner, the prognosis could have been much better in terms that the resorptive process and its signs could have been delayed or in best circumstances (as in case of immediate replantation) completely prevented. If signs of root resorption are not present within the first two years of injury, the risk of root resorption is significantly reduced, but can still occur [28]. In the present case, resorptive signs appeared radiographically after 2 years of replantation considering that the extra-oral time was 15 h. According to us, the present case can be considered a clinical success because the patient was already 15 years of age at 3-year follow-up and the tooth may be preserved for few more years till the patient completes her growth and further treatment of implants is carried out without doing any bone grafting.

To conclude, it is important that all dentists, teachers of primary schools, physical education teachers and primary healthcare personnel, including nurses, be educated about the importance of preserving an avulsed tooth, its method of preservation and the rationale for replantation and update them the recent guidelines on management of such teeth.

REFERENCES


Case report

Patient induced unusual metallic obturation of the root canal of permanent maxillary central incisor with an immature apex – A rare case report

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A R T I C L E   I N F O

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Foreign objects
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Non-surgical endodontic treatment

A B S T R A C T

Discovery of multiple foreign objects in the root canal is unusual and their removal is often difficult and challenging procedure. Entrapment of the foreign object in the pulp chamber or in root canal usually occur accidentally in children with the habit of chewing or placing various objects in the oral cavity. Clinically it was often encountered in tooth with wide carious lesion, exposed pulp chamber due to trauma or tooth left open for the drainage during root canal treatment. This impacted foreign body may act as a potential source of pain or infection. The attempt to retrieve such foreign object from the root canal with immature apex increases the risk of its displacement into periapical area. The present case report describes an unusual case of a patient with two metallic sewing needles inadvertently broken down in the root canal of the permanent maxillary left central incisor and it’s successful retrieval by non-surgical endodontic treatment.

**Introduction**

Discovery of a foreign object in the root canal is an uncommon finding and often revealed accidentally during routine radiographic examination. Entrapment of such foreign object in the pulp chamber or in root canal is usually encountered in children with the tendency of chewing or placing different objects in the oral cavity. Ingestion or aspiration of the foreign object could be frightening and stressful situation [1]. In most cases parents are unaware of the bizarre situation as children are scared to inform them. The impacted foreign object may act as potential source of infection resulting in pain or swelling.

Various foreign objects lodged in the pulp chamber and root canal of the tooth have been reported in the literature such as, stapler pin [2,3], pencil leads [4], darning needles [5], metal screws [6], beads [7], nail [8], plastic chop stick [9], hat pins [10], dressing pins [11], ornament piece [12] and a conical metallic object [13].

The present case report describes a patient with two metallic sewing needles entrapped in the root canal of permanent maxillary left
central incisor with an immature apex and its successful conservative management.

**Case report**

A healthy 13-year-old male patient reported with his father to the Department of Conservative Dentistry and Endodontics, with a complaint of pain and pus discharge from upper front tooth region since last four days.

Patient’s history and intra-oral examination exhibited following findings:

- History of trauma to maxillary anterior teeth; 5 years ago.
- Fractured tooth 21 (Federation Dentaire Internationale) up to the middle third with discoloured crown (Fig. 1).
- Tooth 21 showed a small incisal opening into the pulp chamber (Fig. 2).
- Presence of draining sinus on the gingiva near the apex of tooth 21.
- Pain on percussion associated with tooth 21.

Electric pulp test (EPT) showed no response in tooth no. 21 and a normal response exhibited in teeth nos. 11, 12 and 22. Intra-oral periapical radiograph of tooth 11 and 21 revealed, the presence of two slender, pointed radiopaque images with radiolucent eyes; appearing one above the other, in the middle and apical thirds of the root canal of tooth 21. Tooth 21 also showed an immature apex and periapical radiolucency (Fig. 3). Widening of periodontal ligament was evident in tooth 11.

After taking the patient and his parent into confidence a careful enquiry of patient regarding the presence of the foreign objects in the tooth 21 was done. It was revealed that, the patient frequently used sewing needle as a toothpick to clean the lodged food from pulp chamber of tooth 21. Three months back during one of such attempts, one sewing needle was inadvertently broken down in the root canal of tooth 21. Subsequently patient tried to remove that needle from the root canal with the help of another sewing needle. Unfortunately, the second needle also broke over the first embedded needle. After this incidence the patient did not inform his parents about the broken needles inside the tooth, due to fear of getting reprimanded. On further questioning, patient revealed that he used to get sewing needles from his uncle who was a professional tailor. After evaluating the clinical and radiographic evidences; the following treatment plan was advised and informed consent of patient’s parent was obtained.

(1) To retrieve both foreign objects by a simple non-surgical technique.
(2) Endodontic treatment of tooth 21 followed by aesthetic restoration.

**Treatment sequence**

(1) Removal of coronal sewing needle:

The tooth 21 was isolated under rubber dam and access cavity was prepared under 3.5× magnifying loupes. The debris from pulp chamber was cleaned by copious irrigation with physiologic saline. To prevent the rusting of the...
metallic objects in root canal and its accidental escape into periapical tissues through an open apex; irrigation with 5.2% sodium hypochlorite was initially avoided. Exploration of the root canal was done with No. 10 Kerr-file (K-file, Mani Inc., Japan) to feel any resistance in the root canal. Though the root canal was wide, the foreign object offered a resistance for its easy retrieval. Firstly instrumentation with No. 10 K-file was done to bypass the coronal object from the mesial and then from the distal aspect of root canal wall. Later, the root canal was sequentially bypassed with No. 15, No. 20 and No. 25 K-files. Subsequently two, No. 25 Headstrom-files (H-file), one from mesial and other from distal aspect of the root canal were inserted. Files were twisted together to engage the coronal object and pulled incisally using braiding technique. After such multiple attempts, the coronal object moved incisally in pulp chamber. It was retrieved successfully with the tweezer and examined carefully (Fig. 4). The object was identified as a sewing needle measured about 7 mm in length and 1.5 mm width. Radiograph of tooth 21 was taken to visualise and ensure the position of the impacted apical object (Fig. 5).

(2) Removal of apical sewing needle:
Similarly, exploration of apical portion of root canal of tooth 21 was done using No.10 K-file but the apical object offered more resistance for its retrieval than coronal object. Similar steps were followed for retrieval of the apical object. The apical object was bypassed with No. 25 K file from the mesial aspect. Subsequently No. 25 H-file was inserted from the mesial aspect and engaged apically to prevent the slippage of the object into the periapical area. An activated ultrasonic scaler tip was put in contact with the metallic blank of No. 25 H-file to facilitate the loosening of an object. Within few minutes the apical object felt slightly loosened and was retrieved successfully in similar manner as for coronal needle. An apical object was also found to be a sewing needle (Fig. 6). Confirmatory radiograph was taken to ensure
the retrieval of both the sewing needles from the root canal of tooth 21 (Fig. 7). Following the retrieval of both the needles, working length was established (Fig. 8). Cleaning and shaping of the root canal was accomplished by conventional technique. Final irrigation of the root canal with 5.25% of sodium hypochlorite using Endo-activator (Dentsply, Tulsa Dental) was performed. Calcium hydroxide was placed as intracanal medicament in tooth 21 and the radiograph was taken (Fig. 9). Intracanal calcium hydroxide was replaced in tooth 21 after 1 month recall. At this time EPT in teeth 11, 12 and 22 showed normal response compared to control teeth.

Patient was recalled for regular follow-up of 3 months. Periapical radiograph of tooth 21, revealed the presence of unresorbed calcium hydroxide in the periapex of tooth 21 (Fig. 10). After 6 months follow-up, the periapical radiograph of tooth 21 exhibited the complete resorption of periapical calcium hydroxide with calcific apical barrier formation. At this time root canal obturation using rolled cone method was planned. To prepare a customised master cone, three No. 80 standardized gutta percha (GP) cones were brought together and passed over an alcohol flame. Immediately cones were rolled together on a glass slab with the help of another cooled glass slab. The customised GP cone was softened over a flame and then tried as a master cone in the root canal of tooth 21. The procedure was repeated for several times till apical tug back was achieved. The root canal was obturated using the prepared customised GP cone [14] (Fig. 11). After 1 year follow up, EPT of teeth 11, 12 and 22 showed normal response as the control teeth and resolving periapical lesion was observed in the radiograph of tooth 21 (Fig. 12). Patient was scheduled for the post endodontic restoration and an aesthetic crown with tooth 21 but unfortunately, the patient failed to report for the further follow ups as he had been shifted to reside to his native place.

Discussion

Patient reporting with the presence of foreign object in the tooth is a rare scenario in dental office. Everytime the dental office may not be prepared to tackle such situation which demands combination of skills, immediate investigations, various radiographs and necessary instruments. Retrieval of the foreign object may be done by conservative means or need surgical intervention depending on position of the foreign object in the root canal and associated complexity in its retrieval. There is a need for proper classification of foreign object.
objects found in teeth and oral cavity with an appropriate treatment protocol to be followed in such special situations.

A tooth with wide carious lesion, traumatic pulp exposure or tooth left open for the drainage; endangers the patient to a risk of foreign body entrapment in the root canal. Thus in case where access cavity is left open for the drainage, the patient and their parents should be instructed about the potential risk of foreign object impaction in the pulp chamber or the root canal of involved tooth. The practitioner should close the access cavity as soon as the purpose of drainage is accomplished.

Various radiographic techniques such as parallax views, triangulation techniques, stereo radiography and tomography [2] play a pivotal role in localisation of the foreign object, in determining its type, location and size [15]. For retrieval of the foreign object from root canal; use of ultrasonic instruments [16], Masserann kit [17], modified Castroveijo needle holder [18] and the dental microscope [19] are reported in literature.

Removal of one foreign object from the root canal is often tedious. However, in the present case it becomes difficult and more risky procedure; when two foreign objects present one above the other and snugly fit in the root canal of tooth with an immature apex. These foreign objects block the root canal and prevent its complete negotiation. Thus, their removal becomes necessary to eradicate the infection and for successful endodontic treatment of affected tooth. To remove such objects, they should be made free from hindrance and at the same time reasonable care should be taken to prevent its displacement into periapical area. In present case, two impacted sewing needles were retrieved with H-files and indirect ultrasonics causing minimal damage to subjacent root dentin [19] avoiding the need of periapical surgery or intentional reimplantation [20].

After retrieval of the foreign object from the tooth with an open apex, closure of the apex is of paramount consideration. Traditionally apexification was performed using intracanal calcium hydroxide due to its long term antimicrobial effect [21], predictable induction of apical closure and its low cost. Caution should be taken for long term use of intracanal calcium hydroxide; as it would significantly increase the risk of root fracture after long term application [22,23]. However, with the advent of Mineral Trioxide Aggregate (MTA), apical barrier is achieved in one visit. The advantages of MTA are reported as, less crucial patient compliance, no alteration in physical properties of dentin and earlier restoration of the tooth [24]. Though MTA is biocompatible material and the procedure is time saving; its cost is the major factor of consideration for its routine clinical use in tertiary dental care centres in developing countries.

Summary
The case report describes conservative management of the patient having a complicated crown fracture; along with accidentally impacted sewing needles in the root canal of tooth 21, with an immature apex and periapical pathology.

References


Case report

Rapid fabrication of silicone orbital prosthesis using conventional methods

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Abstract

Restoration of orbital defects with silicone prosthesis has been a well-documented and accepted treatment option. Adhesive retained prosthesis offer the patients with adequate retention and treatment satisfaction. However, marginal breakdown and discoloration are common problems associated with these prostheses, necessitating their refabrication. Fabrication of a silicone orbital prosthesis is time consuming and requires multiple clinical and laboratory procedures. This technical article describes simple and cost effective steps for rapid fabrication of a silicone prosthesis using conventional methods.

Introduction

Exenteration of the eye can lead to a debilitating defect that can negatively affect patient's quality of life. To minimize these effects, exenterated orbital defects are rehabilitated using facial prosthesis, which mimic the patients' normal anatomy. Silicone elastomers are the most widely used material for prosthesis fabrication due to their acceptable color integration and texture [1]. However, they have to be refabricated every 1.5–2 years due to the damaging effects of weathering and regular wear and tear [2].

The conventional method of silicone prosthesis fabrication requires several clinical settings and laboratory hours to be completed. Computer-aided design and computer-aided manufacturing technologies (CAD–CAM) have helped to reduce this time significantly [3] but they are not readily accessible to most clinicians primarily due to high equipment cost and lack of technical expertise. The objective of this article is to describe clinical and laboratory steps to duplicate patient’s existing prosthesis in order to fabricate a new one in a relatively short period of time, reducing the patient’s burden of multiple visits to the clinic.

Technique

(1) Take chair-side impression of the defect side using polyvinyl siloxane impression material (Multisil Epithetik soft and hard form; bredent GmbH & Co. KG, Senden, Germany) (Fig. 1). Use wooden sticks as a matrix for the impression material.

(2) Fabricate a working cast of the defect side by pouring the impression with Type IV dental stone (Nok Stone; Lafarge, Thonburi, Thailand) (Fig. 2).

(3) Mix irreversible hydrocolloid impression material (Kromopan; Lascod SpA, Firenza, Italy) and place it on the lower half of a metal flask (Varsity Flask; Hanau, NY).
Remove the ocular prosthesis from the existing silicone orbital prosthesis. Place the orbital prosthesis in the impression material such that the cameo surface of the prosthesis faces downwards and the margins of the silicone prosthesis are submerged in the impression material.

(4) After the impression material sets, place the upper half of the flask. Mix irreversible hydrocolloid impression material and pour it into the flask to adequately cover the intaglio surface of the prosthesis.

(5) Separate the upper and lower halves of the flask, after the impression material sets. Carefully remove the silicone orbital prosthesis from the flask.

(6) Using a circular hollow tube of 10 mm diameter remove the irreversible hydrocolloid impression material from the upper part of the flask to create a channel which can access the mold space formed after removal of the orbital prosthesis (Fig. 3).

(7) Place the upper and lower halves of the metal flask together. Heat baseplate wax (Cavex TT 100 Soft; Cavex, Haarlem, Netherlands) at 60 °C in a water-bath (Hanau Low Temperature Water Bath; Teledyne Hanau, NY) and pour the molten wax through the channel into the mold space (Fig. 4).

(8) Separate the upper and lower halves of the metal flask after the wax solidifies to obtain a wax replica of the existing orbital prosthesis (Fig. 5).

(9) Remove wax from the intaglio surface of the wax replica until the space for the ocular prosthesis is reached.

(10) Place the patient’s existing ocular prosthesis in the wax replica using an intaglio approach and seal with baseplate wax (Fig. 6).

(11) Clinically evaluate the wax replica in the patient and verify the position of the ocular prosthesis (Fig. 7).

(12) Adapt the margins of the wax replica on the new working cast and perform necessary adjustments on the wax-up to replicate the patient’s non-defect side.
(13) Try-in the final wax replica to confirm its form and adaptation. Place the wax replica on the stone mold and seal with margins with baseplate wax. Attach a 1 cm long acrylic resin rod to the center of the ocular prosthesis using a cyanoacrylate adhesive. Apply separating medium (F-901 Separating Film Tinfoil Substitute; Factor II Inc., Ariz) on the working cast. Adapt boxing wax (Boxing Strips; Kerr Corp., Calif) along the periphery of the new working cast and pour type IV dental stone in it to fabricate a two-piece mold.

(14) After complete setting of the mold, perform de-waxing. The ocular prosthesis will be attached to the intaglio surface of the upper half of the two-piece mold (Fig. 8). Apply separating medium (F-901 Separating Film Tinfoil Substitute; Factor II Inc., Ariz) to the surfaces of the upper and lower halves of the two-piece mold.

(15) Dispense room temperature vulcanizing silicone (Multisil-Epithetik; bredent GmbH & Co. KG) in a mixing pad and add intrinsic color pigments (Intrinsic coloring kit, Factor II Inc.) to obtain a base shade matching to that of the patient.

(16) Pack the silicone into the upper and lower halves of the stone mold.

(17) After complete polymerization, separate the two halves of the mold (Fig. 9). Remove the ocular prosthesis from the upper half of the two-piece mold and place it in the new silicone prosthesis. Trim the excess flash and perform chair-side extrinsic staining.

(18) Fix the extrinsic staining with a silicone medical adhesive (A-564; Medical Adhesive, Factor II Inc.) and deliver the new orbital prosthesis to the patient (Fig. 10).

Discussion

The fabrication of silicone prosthesis has a significant positive impact on the patient’s quality of life [4,5]. Although implant retained prosthesis offers greater retention and overall treatment satisfaction [4], an adhesive retained prosthesis is a cost effective and noninvasive treatment option. However, frequent aftercare is one of the major drawbacks associated with silicone prosthesis. Discolouration and breakdown of the margins following use is commonly observed with adhesive retained prosthesis [5]. This can affect the overall retention and esthetics of the prosthesis, necessitating their refabrication.

Unlike auricular and nasal prostheses, the previous stone mold cannot be reused during refabrication of orbital prosthesis because it comprises of two parts – the acrylic ocular prosthesis and the silicone prosthesis. It is difficult to reattach the ocular prosthesis back into the correct orientation in
the mold, once it is removed. The described duplication technique is simple and cost effective, and a new prosthesis can be fabricated within two appointments. By following these steps, a wax replica of the prosthesis can be easily obtained which saves a significant amount of time as compared to carving an entirely new wax-up. During the wax trial, the margins can be reconfirmed to the new working cast for better adaptation. The form and counters of the wax replica can be clinically adjusted and verified to improve upon the esthetics of the original prosthesis.

Adequate knowledge of the materials and laboratory skills are required to obtain the ideal results. Irreversible hydrocolloid impression material provides good reproduction of the details for duplication but delayed pouring may affect its dimensional stability [6]. Baseplate wax was used because of its easy availability, reusability and low cost. To prevent distortion of the baseplate wax, adequate time should be given for the material to cool down. It is recommended that the wax replica be clinically tried to reconfirm the form and marginal adaptation before silicone is packed. However, if the prosthesis is lost, this technique cannot be applied as it involves the duplication of the existing prosthesis to fabricate a new one.

Conclusion

This straightforward technique for duplication of existing silicone orbital prosthesis is both cost effective and time saving for the clinician and the patient. It is suitable for rapid prosthesis fabrication when digital duplication and milling techniques are not available.

REFERENCES

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