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Rapid fabrication of a digital prosthesis



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Letter from the Editor

Are you practicing dogma?



Many of us would like to believe that we practice our profession with a lot of evidence. Our belief stems from the act of having read and planned for treatment planning seminars as students. As we read the papers we rarely, if ever ask – what paper is this? An opinion, a bench study or what?

We should actively evaluate what level of evidence is being presented to us. Anything which is just a belief or opinion held to be true is simply put – a dogma. “Extension for prevention” as a principle in cavity preparation is a dogma! Until there is good evidence to support the usefulness of the idea, such as a randomised clinical trial (RCT), the idea may just be an idea, an opinion or a dogma.

Not all dogmas are bad for the patient and perhaps most dogmatic practices were birthed with good intentions. Let us take the use of the rubber dam during root canal treatment. Purportedly, rubber dams are used to reduce infection risk from exposing the root canals to saliva. Yet, there is not one randomised controlled trial to show that the use of rubber dam reduces infection; there is only one cohort study. Subjects were randomly selected from a population database of Taiwan and followed from 2005 to 2011, a total of seven years. The database has provisions for showing whether rubber dams were used or not. It was shown that the use of rubber dams gave rise to significantly better outcomes of root canal treatment (*J. Endod.* 2014 Nov; 40(11):1733–7).

Such a large population of 517,234 teeth may seem representative of the entire population; however, there are still things that are not clear. For instance, one does not know when one is reading the article if dentists who used rubber dams had specialist training or were supervised in teaching clinics by specialists. So, the positive outcome, whilst related to the use of rubber dam by the data, may be due to the effect of better training or better supervision among dentists who used rubber dam in that particular study. The decision of whether the use of rubber dam directly affects the outcome of root canal treatment is thus not as straightforward as it might seem.

Be that as it may, I am sure nearly all of us use the rubber dam when doing root canal treatment. It prevents the foul tasting irrigant from getting into the mouth; it prevents files from dropping into the mouth or worse, into the throat and there are risks of the instrument either being inhaled or swallowed to worry about as well. Hence, though there may not be very concrete evidence (RCT) that the use of rubber dams gives rise to a better outcome to our endodontic treatment, we continue practicing the dogma for the sake of common sense safety.

Each dogma we practice needs to be evaluated carefully, lest we incur unnecessary costs in providing care.

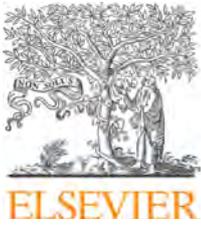
There are of course many procedures in our practice that are supported by evidence and are not dogma: tooth-brushing reduces gum inflammation and periodontal disease and acid etching of enamel and bonding with Bis-GMA can provide good retention for fillings, among others.

Can you identify the dogmas we practice in dentistry? There are many. After we graduate from dental schools, nearly all of us have little access to the library of information housed within universities. Most of us depend on accessing the internet for information. What your dental education must have done for you, to prepare you for your craft, must have been also to teach you how to recognise which practices are dogma and which are scientifically validated. It would have taught you to discern the nuanced statements made in guidelines to dental practice as well as to discern which articles are about ideas that are not yet validated.

Editor
Sum Chee Peng

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Review

Clinical issues in occlusion – Part II



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ABSTRACT

Occlusal diagnosis plays an important role in the planning and subsequent delivery of predictable functional and aesthetic restorations and prostheses. Once an occlusal problem is identified there are a number of techniques and materials that can be utilised to record occlusal relationships, subsequently analyse them and incorporate information obtained into the delivery of tooth restoration or replacement. This paper discusses the clinical and technical aspects of occlusal examination and analysis outlining contemporary and traditional techniques in their utilisation. Aspects of occlusal examination will be revisited; the identification and recording of centric occlusion as well as subsequent articulation will be discussed. The requirement for occlusal splint provision will also be discussed and illustrated.

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Introduction

In the first paper of this two part series a variety of occlusal issues that a general dental practitioner would commonly encounter in clinical practice were discussed [1]. The incorrect diagnosis of an occlusal condition and subsequent mismanagement may impact clinical outcome in terms of affecting the prognosis of the existing dentition and restorations whilst restricting general occlusal function which are not beneficial for the patient. It is the intention of these papers to guide the clinician to be able to implement a broad diagnostic strategy for occlusal management that can be applied in general practice. The following account will provide the clinician with a systematic method of approaching the examination and diagnosis of common occlusal issues within restorative dentistry and prosthodontics as described in Part I.

Occlusal examination

A thorough medical, dental and social history of the patient and a pain questionnaire should be completed before the examination of the patient is undertaken. The occlusal examination will be utilised to not only inspect the intra-oral tooth to tooth relationships, but also to take note of the extra-oral position of how the mandible relates to the maxilla without the influence of the dentition. Not all patients require a full comprehensive occlusal examination and it is the opinion of the authors that the depth and extent of occlusal examination and investigation undertaken for any patient should stay relevant to the specific occlusal complaints of the clinical situation.

A comprehensive occlusal examination should start with an extra-oral examination including an assessment of symmetry; the muscles of mastication and the skeletal base pattern. The extra-oral examination can then develop further to the inspection and palpation of the temporomandibular joint and associated orofacial musculature. The palpation techniques of the elevator and depressor muscles of mastication are beyond the remit of this article, however can be found described in other relevant texts [2].

The details of intra-oral occlusal examination should commence from as basic as possible and be in respect to what is deemed appropriate by the existing requirements for the patient in order to manage their presenting occlusal condition. The examination of a new patient at the initial consultation will require at least an inspection of the occlusal surfaces of the teeth, a recording of the incisal angle and molar relationships, and the nature of the tooth related mandibular guidance in both protrusive and lateral excursive movements. These observations can be identified and documented. An occlusal examination that is more exhaustive will include the diagnosis of centric occlusion (CO) which can be made by manipulating the patient's mandible using chin point guidance, but more favourably by a bimanual mandibular manipulation technique as described by Dawson [3]. If it proves challenging to carry this out due to resistance by the patient, the use of a Lucia jig as an adjunct for this purpose is

favoured by the authors. A Lucia jig is a removable custom made anterior flat plane bite platform deprogrammer first published by Lucia in 1964. It works by breaking the natural neuroceptive engram of the patient's habitual closure into maximal intercuspal position (MIP) [4]. It can be made of a variety of materials, commonly acrylic resin is used (e.g. Trim, Bosworth Company, U.S.A.).

CO to MIP relationship

The CO to MIP relationship maybe easier to diagnose in some patients than others due to the ability to manipulate the patient's mandible into the hinge axis position. The difficulty may be exacerbated by the existing level of parafunction and occlusal disharmony present. The diagnosis of CO may not be possible at the initial appointment and therefore it may be prudent to construct a removable occlusal appliance to allow a period of neuromuscular deprogramming before the diagnostic occlusal examination can be carried out at a later date. Occlusal appliances for this use could include a Lucia jig as a short term measure, or for a longer term period a removable occlusal splint may be used [4,5].

The diagnosis of CO is made when the mandible is manipulated into the hinge axis and the arch of rotation of the mandible occurs without anterior translation of the condyles occurring, this will take place as the condyles are seated and braced in their most superior anterior position within the glenoid fossa. As the mandible is closed towards the maxilla the identification of the first point of tooth contact can be confirmed by the patient as to which side it occurs, and the exact tooth to tooth contact can be marked using occlusal indicating paper. The majority of patients (approximately 90%) may demonstrate a discrepancy between the CO and habitual MIP [6], where MIP may lie anterior and superior to the CO by approximately 1.25 ± 1 mm [7]. The exact descriptive nature of the CO to MIP centric slide is not needed at this stage, but can be clinically assessed and a record of which can be detailed by means of clinical photographs or completion of an occlusal chart diagram, and confirmed later on a set of articulated diagnostic study casts. The use of GHM occlusal indicating paper (Hanel-GMH Dental GmbH, Nürtingen, Germany) of different colours (black and red) and Shimstock bite foil (Hanel-GMH Dental GmbH, Nürtingen, Germany) handled using Miller forceps and Artery forceps respectively, may be used to record this discrepancy.

The centric slide if present may exhibit three directional components, vertical (superior/inferior) and horizontal (anterior/posterior and medial/lateral). These components will vary in their degree and an attempt must be made to identify which is the most dominant component if adjustments are made to the CO. This relationship may be fully assessed and confirmed on a set of articulated study casts so that effects to mandibular movement are investigated which may have an impact upon the anatomical occlusal design of both posterior and anterior restorations.

For patients where the CO to MIP relationship has been diagnosed as being the identical, one may assume that either this has not been diagnosed correctly or the centric slide may

have been obliterated by means of tooth surface loss related to parafunction and bruxism.

Impressions and diagnostic study casts

Alginate impressions can be taken in metal rimlock impression trays, alternatively silicone impressions may be taken in plastic stock impression trays. Vacuum mixed gypsum is then used to pour the impressions for the fabrication of diagnostic study casts. The benefit of using a silicone material is that it allows the impressions to be poured again to make a duplicate set of casts without the need of agar or silicone duplication of the original set of diagnostic study casts.

Cast articulation and verification

It is necessary that accurate verified diagnostic study casts are mounted on an articulator in order to allow the clinician to closely duplicate the dynamic movements of the mandible outside of the clinical environment. An Arcon semi-adjustable articulator (e.g. Denar Mark II, Whip Mix Corporation, U.S.A) maybe used. Within this articulation arrangement the condylar elements are located on the lower member of the articulator which more closely represents the anatomical form of the temporomandibular joint (TMJ). The use of the semi-adjustable articulator allows the clinician to adjust the sagittal condylar inclination, progressive side shift (Bennet angle) and immediate side shift settings from average values which are pre-programmed at 27°, 7° and 0mm respectively. Changes can be made to the settings of the articulator by obtaining bite records made in protrusive movements and lateral excursions; this can be of particular use when designing the shape and anatomical form of posterior restorations.

Before mounting the diagnostic study casts to the articulator, the casts should be verified for their accuracy to ensure that the production process from impression taking to cast pouring has not introduced any dimensional errors to their shape. The first part of the verification process of both the maxillary and mandibular casts involves an initial visual assessment to confirm that no gross distortions have occurred.

A facebow record can then be taken and transferred to the articulator to mount the maxillary cast to the upper member of the articulator. Brown impression compound (Kerr, U.S.A) or a rigid silicone bite registration material (e.g. Blu Mousse, Parkell Inc., U.S.A) may be used as bite fork recording materials. The resultant cusp indentations produced in the recording material should be trimmed with a scalpel blade to expose shallow recordings of the cusp tip indentations. Verification of cast accuracy may be made by matching the cusp indentations of the teeth made in the bite fork recording material to the corresponding cusp tips of the diagnostic study cast. The casts being introduced to the cusp indentations should seat positively verifying their dimensional accuracy to the intra-oral recordings. If discrepancies are noted, a new impression should be made for production of a new

diagnostic cast which again will need to be verified for its accuracy in the same manner. Cast verification minimises discrepancies in diagnostic accuracy that may magnify through the diagnostic phase.

A separate bitefork may be used to record the cusp positions in the mandible for verification of the mandibular cast.

Centric relation record

Centric relation (CR) allows the mandible to position in the retruded arc of closure with the condyles acting in a purely rotational movement independent of tooth contact. A 'tooth apart' CR record captures this position and permits location of the mandibular cast to the maxillary cast whilst mounting to the lower member of the articulator. This procedure can be aided by means of a Luica jig for deprogramming the habitual closure of the patient into MIP and also act as an anterior vertical stop for the mandibular incisors [3,8,9].

The CR record can be made of a rigid double thickness of Moyco beauty wax (Moyco Industries, U.S.A) acting as a carrier for a low viscosity bite registration material in order to record the cusps of the opposing arches at the vertical height set by the anterior Lucia jig stop. A variety of bite registration materials can be used so long as when the CR is recorded, the registration material exhibits a low viscous fluid consistency, then allowed to completely polymerise to a rigid state and remain dimensionally stable over a period of time and easily adjusted with a scalpel blade [10,11]. A high value of Shore Hardness (scale 'D') of the polymerised bite registration material is preferred. The rigidity and resistance to deformation is also augmented by the hard Moyco beauty wax carrier. Examples of bite registration materials that can be used are TempBond (Kerr, U.S.A), Zinc oxide eugenol impression paste (Bosworth Company, U.S.A) or a silicone bite registration paste (e.g. Blu Mousse, Parkell Inc., U.S.A). Multiple CR records may be taken at this stage but are only useful for comparison to one another for accuracy if used in conjunction with a verification instrument.

Once the CR records have been recorded, the lower cast may now be located to the upper cast and mounted to the lower member of the articulator. It should be noted that both the maxillary and mandibular casts can also be verified at this stage using the CR record as an alternative to facebow bite fork impressions.

Verification of cast mounting

Before the tooth relationships of the casts are fully examined on the articulator, the positional mountings of the maxillary and mandibular casts must also be verified.

Verification of the cast mounting maybe carried out by use of an instrument such as the Denar Vericheck or its successor the Denar Centricheck (Whip Mix Corporation, USA). The recording of multiple (three or five) CR records will allow the clinician to compare the individual records to each other and allow the mounting of what is deemed to be the correct maxillary and mandibular positional relationship in CR. The

mandibular cast must be mounted as soon as possible after the registration is taken, as the centric relation record still may be susceptible to deformation due to adverse temperature changes or by mechanical stresses from transportation. It is common practice of the authors to mount the mandibular cast themselves after the CR record is taken.

Articulated study cast examination

Examination of the articulated casts should begin with correlating the occlusal findings detected clinically to what has been noted from inspection of the mounted casts. The occlusal markings on the articulated casts can be verified using occlusal charts or clinical photographs. Records of Shimstock holding tooth pairs can also be used and checked against the mounted casts. Shimstock bite foil is considered the thinnest for checking occlusal holding contacts; its thickness is 8 μm whereas commonly used occlusal marking papers can have a broad range of 18–70 μm thickness. It is important that the clinician is aware of the different thicknesses of occlusion indicating paper so that communication with technicians remain consistent.

If the diagnostic findings of the mounted casts do not correlate to intra-oral findings, the clinician must assume that the efforts to accurately record CR and mount the casts have been imprecise. The clinician must then go back to the patient to check the original occlusal findings and re-register the CR record for a remount of the mandibular cast.

The CO to MIP centric slide assessment can now be made by drawing a continuous pencil line between opposing maxillary and mandibular contacting teeth and viewing their relationship to each other after the centric slide has occurred.

Occlusal splints

The Glossary of Prosthodontic Terms defines an Occlusal Splint (Occlusal Device) as 'any removable artificial occlusal surface used for diagnosis or therapy affecting the relationship of the mandible to the maxilla. It may be used for occlusal stabilisation, for treatment of temporomandibular disorders or to prevent wear of the dentition' [12].

In general a hard acrylic full coverage maxillary splint may be used for a variety of clinical scenarios. The Michigan splint type design was first described by Ramfjord and Ash and is suitable for use in Class 1 and Class 2 patients [5]. In Class 3 patients the splint maybe made for the mandibular cover where it is referred as a Tanner splint. The Michigan type design prescription maybe indicated for a range of occlusal issues. The benefit of full occlusal coverage is that it does not allow the differential movement and migration of teeth that would be unopposed over a long period of time, thereby reducing the risk of iatrogenic tooth movement and occlusal instability. This type of occlusal splint is favoured by the authors as a protective measure for the prevention of further tooth surface loss (TSL) and further damage to teeth by parafunctional activity. It also may be used as a pre-treatment diagnostic aid for the recording of CR by acting as a muscle deprogrammer [5].

The design of the splint is paramount to its success and acceptability to the patient. It should allow the complete uninhibited movement of the mandible against its surface without being restricted in any motion. The optimal occlusal design of the splint should be a flat contacting surface allowing point contact of the opposing mandibular teeth. The number of contacting centric stops should correlate to the number of mandibular teeth. The anterior ramp should allow a path of shallow to steep guidance that is adequate enough to allow minimal disclusion of the posterior teeth against the surface of the splint on protrusive movements and lateral excursions of the mandible. This should be checked on both working and non-working sides.

Adjustments using the flat horizontal plane of an acrylic bud trimming bur can be used ensuring that no indentations are introduced to the contacting surface of the splint. If it is felt that the thickness of the splint is going to be compromised then it may be checked with thickness callipers. The ideal thickness of the splint should be at least 2 mm at the closest point of contact in the CR. The increase of thickness or relining localised areas may be made at a later stage after the splint has been processed by way of cold cure acrylic addition e.g. Simplex Rapid (Kemdent, Witlshire, U.K).

The occlusal markings on the splint may be highlighted by roughening the occlusal contacting surface by 50 μm alumina blasting. The other surfaces of the splint can be highly polished to allow added comfort to the patient.

Difficulties lie where the existing occlusal plane is severely altered by differential eruption and compensatory eruption of teeth whereby the occlusal plane in particular the curve of Spee is very uneven. This may prove technically challenging in the waxing and eventual production of an optimal occlusal design of the splint.

Planning restorations

Not all restorations that are planned may be designed to conform to the patient's existing occlusal scheme especially if there are attempts to reorganise the occlusion whilst providing multiple complex restorations. It was mentioned in the first article that a common treatment modality used in the U.K. is that of the Dahl concept [1,13]. This type of management strategy may be used with appropriate occlusal diagnosis and planning so that the design of the intended restorations is made considering an assessment of their aesthetic and functional requirements.

A type of restoration that is often cemented 'high in occlusion' is an adhesive resin bonded prosthesis (RBP). This type of restoration relies on enamel bonding for its retention and therefore no preparation to the proposed abutment tooth is made to accommodate for the thickness of the metal wing retainer [14,15,16]. If the design of the restoration allows, it is advised to provide this conforming to the existing occlusal scheme. However, the RBP restoration if effectively planned on articulated study casts will often allow subsequent occlusal adaptation by the intrusion of opposing teeth and the vertical migration of others, until a stable MIP has been re-established. The period of time of adjustment can vary between 2 and 6 months in the author's experience. If after

6 months no obvious occlusal compensation has occurred, one can assume that no further adaptation will occur and there must be an alternative treatment plan for the clinician to revert to for further management. Planned adjustment of the retainer and the opposing tooth can be made. The occurrence of this must always be initially anticipated and is mandatory to the treatment planning process and the patient fully informed of the consequences should intrusion or compensation of occlusion not materialise. The success of the occlusal compensation occurring is very dependent upon how much increase in the OVD that has occurred, the greater the OVD increase the longer the compensation adaptation will take.

When either conforming or reorganising the occlusion, the shape and form of the intended definitive restorations must be diagnostically waxed on the set of mounted study casts. This wax-up will allow the technician to design the aesthetic and functional form of the restorations by following the occlusal prescription determined by the clinician, the design

can be checked by the clinician and then shown to the patient before any decisions to carry on with treatment are made.

Case report

The following case report highlights relevant occlusal diagnostic procedures that are discussed in this article. Adherence to systematic clinical and laboratory procedures allowed the clinician to arrive to an accurate occlusal diagnosis for the restoration and conservative management of the dentition when faced with a patient that potentially may have required aggressive occlusal adjustments for occlusal stabilisation to be made pre-restoration.

A 58 year old woman was referred by her general dental practitioner for the provision of restorative care of a failing two unit fixed dental prosthesis in the fourth quadrant (Fig. 1).

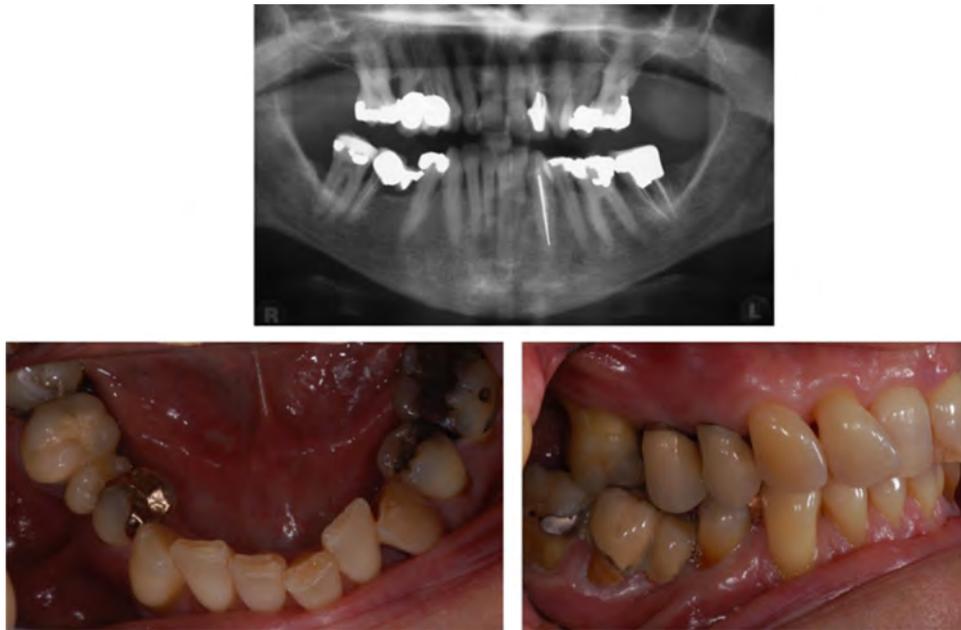


Fig. 1 – Pre-operative dental panoramic tomograph and right side lateral and mandibular occlusal views.

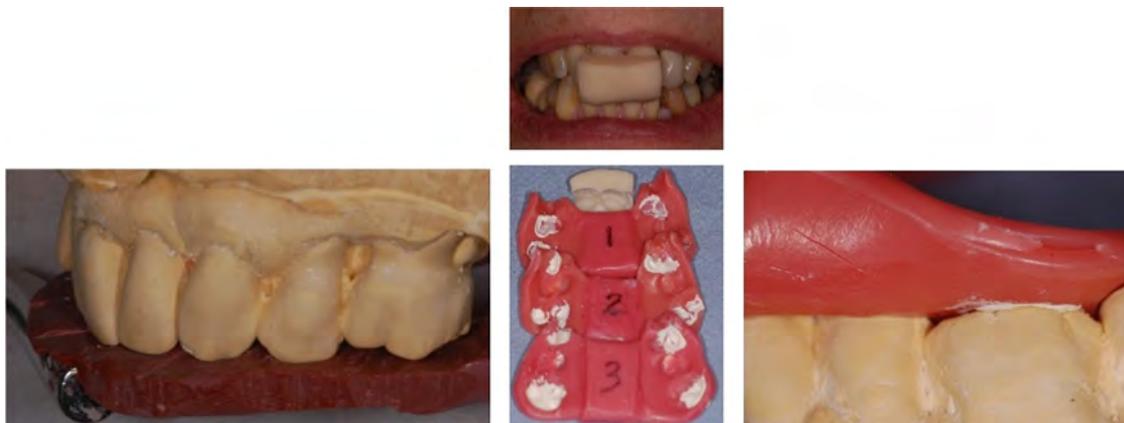


Fig. 2 – Facebow bitefork with impression compound verification of maxillary study cast. Lucia jig and multiple CR records. Verification of mandibular cast using a CR record.

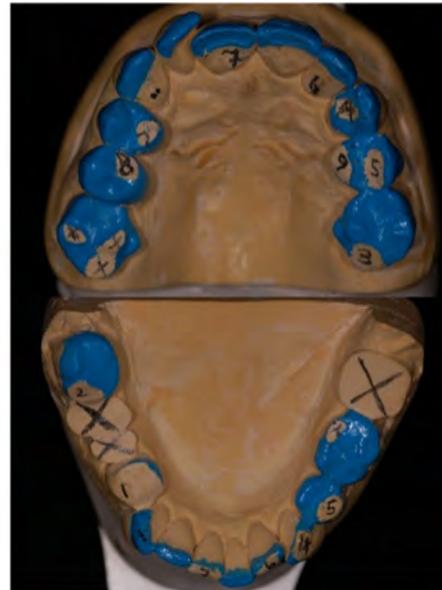


Fig. 3 – CO observed on 44 and mock occlusal adjustment for stabilisation with resultant contact between 43 and 13.

The fixed dental prosthesis restoration (teeth 46–45) was considered terminal and extraction was planned of the 46 abutment tooth. The adjacent teeth 47 and 44 were heavily restored and single cast restorations were considered, however the patient wished to replace the presenting 45 space. A new three unit conventional fixed dental prosthesis restoration was planned for teeth 47–44. It was felt that splinting the 47 and 44 would share the occlusal load imparted on that quadrant without affecting their prognosis. Radiographic generalised periodontal bone loss was evident (Fig. 1) but no clinical mobility was detected around the proposed abutment teeth. The generalised periodontal probing profile did not reveal any pockets over 3 mm and no furcation defect was detected on probing the 47. The patient's periodontal condition was stable as had been receiving regular periodontal maintenance at a specialist treatment centre.

Provision of the new three unit fixed dental prosthesis involved:

1. A comprehensive occlusal examination of the patient.
2. Alginate impressions taken in metal rimlock trays for the production of diagnostic study casts and subsequent duplication. A facebow record and clinical photographs were also taken. The impressions were poured in vacuum mixed Type III gypsum; the resultant maxillary cast verified for accuracy (Fig. 2) and mounted on a semi-adjustable articulator.
3. A Lucia jig was used to aid the recording of three CR records made of Moyco beauty wax and TempBond (Fig. 2).
4. The mandibular cast was verified for accuracy against the CR record (Fig. 2) and mounted against the maxillary cast on the semi adjustable articulator. The three CR records were then verified with a Denar Verichck instrument.
5. The CO had been identified intra-orally as being present between the 44 and opposing 14 (Fig. 3).
6. The 46–45 fixed dental prosthesis was then removed and the 46 root extracted under local anaesthetic. As the 46 socket was healing the 47 and 44 existing restorations



Fig. 4 – Fitted occlusal splint showing separation of posterior teeth on lateral movements.

were removed, the cavities cleaned and the teeth assessed for restorability using a Tooth Restorability Index [17]. Amalgam core restorations were then placed. The 37 was extracted by the general dental practitioner.

7. A mock occlusal adjustment for stabilisation was carried out on the mounted casts (Fig. 3) in order to determine where the CO would move to once removed from tooth 44 during the fixed dental prosthesis preparation. It was decided that the adjustments be carried on until the point where the CO landed on a tooth that was mechanically and periodontally stable for adequate occlusal loading. It was deemed after this diagnostic investigation that a large

amount of tooth tissue would need to be removed clinically in order to adjust the patient's occlusion to this point.

8. Consequently, occlusal splint therapy was provided for the patient to allow a longer period of deprogramming to see if there would be any change in the position of the mandible in relation to the maxilla and thereby a difference in where the CO was originally diagnosed. The splint was waxed, processed, polished and the occlusal surface alumina blasted.
9. The splint was fitted and adjustments were made, ensuring again that there was point contact with all the teeth and shallow protrusive and lateral guidance allowing separation of the posterior teeth (Fig. 4). A week later the splint was reviewed; all the contacts lateral and protrusive movements were checked again. Minimal adjustments were made to refine the protrusive guidance. The splint was reviewed over a period of time until there were no adjustments required over three consecutive weeks.
10. The occlusal splint had been worn for a period of 3 months after which mandibular repositioning had occurred and the CO was now identified intra-orally between the 43 and

14 (Fig. 5). A Lucia jig was again used to aid the recording of three CR records made of Moyco beauty wax and TempBond for remounting the mandibular cast. The three CR records were verified with a Denar Vericheck instrument, all of the three records were coincident with each other demonstrating accurate capture of CR (Fig. 5).

11. The CO was identified correctly again on the study casts between the 14 and 43, which correlated to the intra-oral findings (Fig. 5). The nature of the centric slide was then assessed (Fig. 6). From the subsequent findings, a confirmative occlusal approach to this case could be used without any planned occlusal adjustments made to any of the other teeth.
12. The palatal surfaces of the 13 and 23 were diagnostically waxed to steepen the canine guidance and improve separation of the posterior teeth in lateral excursions to allow a more anatomical occlusal design and form for the cusps of the fixed dental prosthesis. The 47-44 fixed dental prosthesis was then diagnostically waxed to full anatomical and functional form (Fig. 7).
13. The palatal surfaces of the 13 and 23 were recontoured with composite resin under rubber dam isolation as per

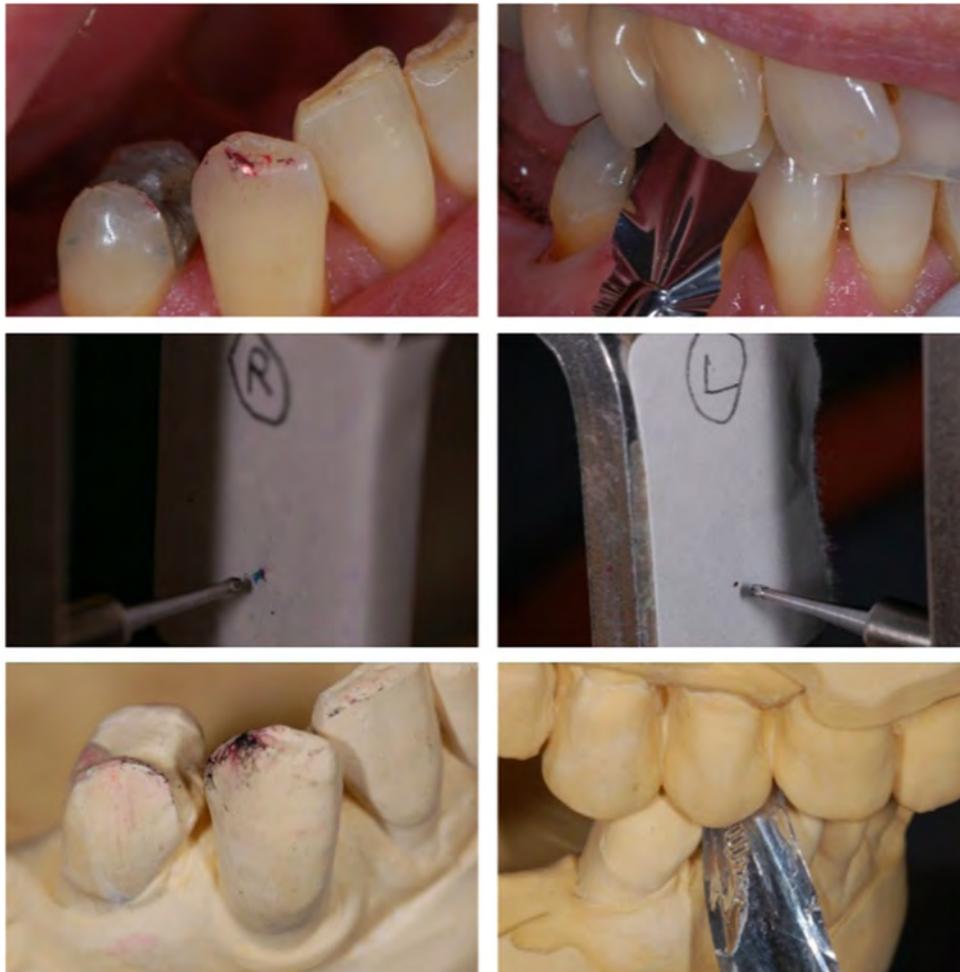


Fig. 5 – Post-occlusal splint therapy CO contact and shimstock bite foil hold between 43 and 14. Verification of CR records using blue, red and green coloured markings on a Denar Vericheck instrument. Intra-oral observations correlating to findings on diagnostic study casts. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

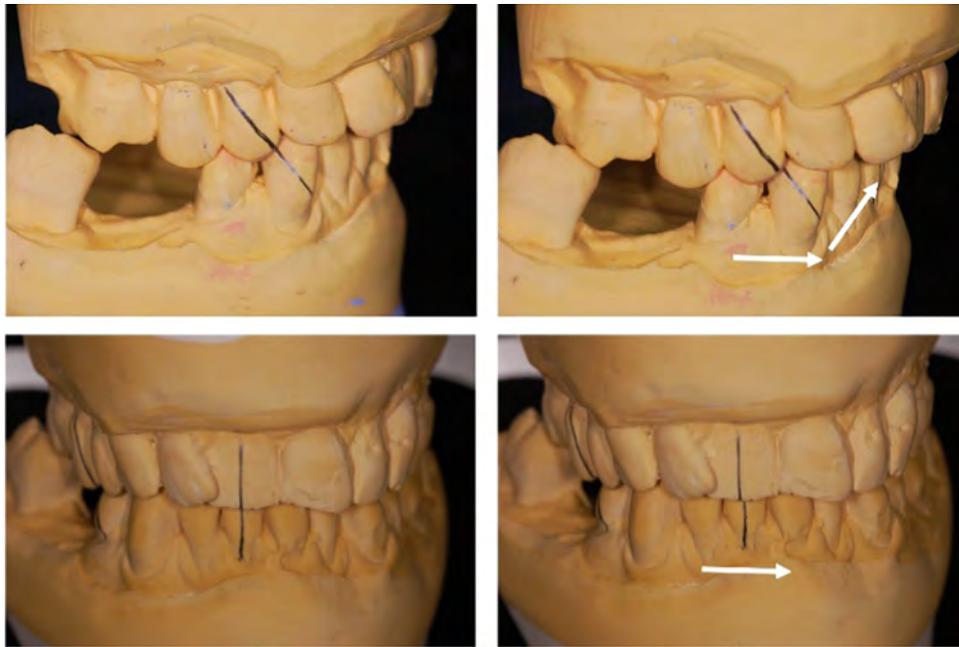


Fig. 6 – Diagnostic study casts mounted at CR showing horizontal and vertical components of centric slide from CO to MIP highlighted by pencil lines and white arrows.



Fig. 7 – Diagnostic waxing of 13 and 23 palatal surfaces and 47–44 prosthesis. Steepened canine guidance allows improved separation of posterior teeth on right lateral movement and anatomical cuspal build-up of prosthesis. Completed 13 and 23 palatal composite resin restorations showing static contacts and lateral excursive tracks.

the diagnostic waxing (Fig. 7). This was carried out to steepen and enhance the existing canine guidance offering improved separation of posterior teeth on lateral excursions, which in turn allows improved anatomical build-up of the new fixed dental prosthesis. Gold palatal backings may be adhesively cemented to the palatal surfaces of the 13 and 23 and used as an alternative which may prove more durable for restoration wear in the long-term. The occlusal splint had to be adjusted and relined in these areas with cold cure acrylic additions.

14. A preparation of the 44 and 47 on a duplicate cast was made and a heat cured polymethylmethacrylate acrylic shell provisional restoration was produced. The abutment teeth 47 and 44 were prepared for the fixed dental prosthesis and a silicone impression was made in a custom tray. A sectional Moyco beauty wax and Temp-Bond bite registration was taken over the prepared abutment teeth in the fourth quadrant with the patient closed in MIP. The shell provisional restoration was then relined with acrylic resin and fitted.

15. The silicone impression was poured for the production of a working model and dies. The working model was verified by using a bitefork recording of the occlusal surfaces of the mandibular teeth using impression compound TempBond before the provisional restoration was fitted (Fig. 8).
16. The working mandibular cast was mounted conforming to the existing occlusion using the sectional bite registration

made and the fabrication of 44-47 fixed dental prosthesis was carried out.

17. The 44-47 definitive fixed dental prosthesis was fitted (Fig. 9). The occlusal splint was subsequently adjusted accordingly to allow even contact of the mandibular teeth to it and the patient advised to wear it whilst sleeping (Fig. 9).

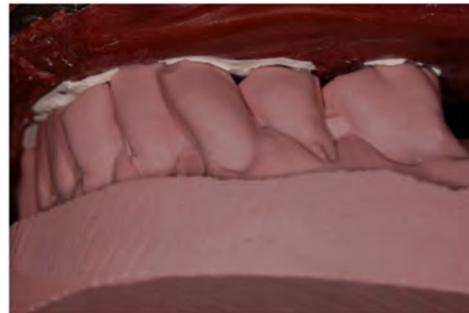


Fig. 8 – Facebow bitefork with impression compound and TempBond relines verification of mandibular working cast.



Fig. 9 – Fitted 44-47 definitive fixed dental prosthesis and post-operative occlusal splint after adjustment.

Table 1 – Summary of the stages of occlusal examination.

Extra-oral examination	Intra-oral examination
1. Assessment of the symmetry of the face	1. Charting of existing teeth and restorations
2. Assessment of skeletal base pattern	2. Assessment of existing removable prostheses
3. Palpation of TMJ on opening and closing	3. Inspection of occlusal surfaces of the teeth
4. Palpation of muscles of mastication	4. Assessment of incisal angle and molar relationships
	5. Assessment of the dynamic movements of the mandible and its guiding elements
	6. Diagnosis of CO
	7. Assessment of CO to MIP relationship

Table 2 – Summary of the stages of occlusal diagnostic phases.

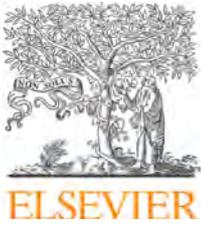
1. Occlusal Examination	<ul style="list-style-type: none"> • Extra-oral examination • Intra-oral examination
2. Impressions and Diagnostic Study Casts	<ul style="list-style-type: none"> • Alginate in metal rimlock tray • Addition-cured silicone putty/wash spacer technique in plastic stock tray • Vacuum mixed Type III Gypsum Dental Stone
3. Cast Articulation and Verification	<ul style="list-style-type: none"> • Arcon semi-adjustable articulator • 2 x Facebow biteforks • Facebow record transfer • Mounting of maxillary cast
4. Centric relation record	<ul style="list-style-type: none"> • 'Tooth apart' registration • Lucia jig • Moyco beauty wax rigid carrier • Low viscosity bite reg. material • Single or multiple registrations • Mounting of mandibular cast
5. Verification of Cast Mounting	<ul style="list-style-type: none"> • Multiple CR records (3 or 5) • Denar Vericheck / Denar Centricheck
6. Articulated Cast Examination	<ul style="list-style-type: none"> • Correlation to intra-oral findings • Occlusal markings • Shimstock holds • Centric slide assessment • Mock occlusal adjustment
7. Occlusal Splints	<ul style="list-style-type: none"> • Pre-restorative treatment occlusal stabilisation • Treatment of TMJD • Prevention of TSL and restoration protector
8. Planning Restorations	<ul style="list-style-type: none"> • Assessment of OVD • Diagnostic waxing • Production of the full desired anatomic aesthetic and functional form of the intended restorations.

Summary

The accurate and appropriate occlusal diagnosis for treatment planning is crucial to the management of any dental condition that may have adverse occlusal exacerbations. It was aimed that this article series shed light to the general dental practitioner for the correct recognition, diagnosis and selection of the applicable management strategy and thereby correct treatment of these cases (Tables 1 and 2).

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Review

Dry mouth – An overview



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ABSTRACT

This paper presents an overview of dry mouth, an important condition in the older population. Dry mouth will first be defined, followed by consideration of its occurrence. There will then be an overview of the leading causes of dry mouth. Next, the impact of dry mouth will be discussed in order to explain why it is a significant condition. Lastly, there will be a brief description of the diagnosis and management of dry mouth.

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Definition

There is some confusion about the definition of dry mouth in the literature because the terms “xerostomia” and “salivary gland hypofunction (SGH)” have been used interchangeably in relation to the subjective complaints and objective aspects of dry mouth [10,23,24]. Xerostomia is the subjective symptom of dry mouth (this could be a result of a qualitative change in saliva). It is a sensation that is assessed only by

directly questioning the individual [7]. On the other hand, the objective sign of dry mouth is salivary gland hypofunction, in which the quantity of saliva produced is lowered. It can be determined by sialometry [21].

Measuring dry mouth

Determining the epidemiology of dry mouth is complex due to (1) unclear definitions for dry mouth being used; (2) the

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different methods for measuring dry mouth; and (3) the samples used in most studies tending to be institutionalised older people, who are often on multiple medications (which can confound its investigation). The measurement of xerostomia and salivary gland hypofunction will be discussed separately.

Xerostomia is subjective, and therefore questions must be used to assess xerostomia. The subjective symptom of dry mouth, xerostomia, can be measured by a (1) single-item question, or (2) multi-item approaches, including (a) batteries of items, or (b) summated rating scales. An example of a single-item question is "Does your mouth feel dry?" [20]. There are limitations to this method in capturing the severity and variability of xerostomia. Such a single-item question inevitably categorises a patient as xerostomic or non-xerostomic according to an arbitrary cut-off point [10]. Moreover, the respondent will be likely to wonder whether the question refers to "now", or "usually?" [35]. A better example of a single-item question is "How often does your mouth feel dry?", with a range of possible responses from 'ever' to 'always'. It is used as a validity check in the Xerostomia Inventory (XI), a summated rating scale [31]. The multi-item approaches include (a) batteries of items; and (b) summated rating scales. Batteries are a list of items with a 'yes'/'no' response format. These items are usually questions asked about the experiences with regard to dry mouth-related problems or behaviours undertaken to alleviate dry mouth. For example, Locker used a list of seven questions and a simple 'yes'/'no' response format to group nursing home residents into three categories: no xerostomia (0 positive responses); mild xerostomia (1-2); or marked xerostomia (3-7) [15]. Batteries of items can be useful for exploring the determinants of xerostomia. However, they may not relate to the experience of dry mouth with just a 'yes'/'no' response. A summated rating scale is a multi-item scale that is a more sophisticated refinement of the item battery. For example, the XI comprises 11 items (each response is given a numerical value ranging from 1 to 5 according to its severity) aimed to capture the broad experience of xerostomia [31]. So far, the XI is the most comprehensive measure that addresses the individual awareness and the consequences of xerostomia. Moreover, it has been translated into several languages and recently shortened into a validated 5-item scale [34].

SGH is an objective sign that can be measured clinically. The normal daily production of saliva is between 0.5 and 1.5 l. The three major salivary glands (parotid, submandibular and sublingual) contribute to 90% of total salivary flow. The minor salivary glands contribute to the remaining 10% of salivary flow [22]. The secretions of the parotid glands contribute mostly to stimulated saliva that is in the mouth for about 2 h each day for alimentary functions [28]. The submandibular and sublingual glands are the main contributors to the unstimulated salivary flow that is present in the mouth for the majority of each day to lubricate and protect the oral mucosa [12]. SGH can be estimated by measuring stimulated or unstimulated salivary flow. Salivary stimulation is commonly achieved using citric acid or chewing of a piece of paraffin. Unstimulated salivary flow is more representative of the *in vivo* situation. Salivary flow can be evaluated by collecting saliva from individual glands or by assessing whole

salivary flow (total secretions of major and minor glands). Whole salivary flow (usually using the spit technique) is a more practical method to collect saliva [32]. Because salivary flow varies throughout the day [5], the objective of salivary flow measurement is to replicate consistency within the same patient. A base reference recording to compare within patient is ideal [11]. An unstimulated whole salivary flow rate of <0.1 ml/min or a stimulated flow rate of <0.5 ml/min is considered to be less than normal [27].

The epidemiology of dry mouth

Some studies assume that everyone who experiences xerostomia has SGH, and vice versa. The evidence suggests that the two are not necessarily concurrent. Prevalence estimates for dry mouth may vary and are dependent on factors such as the nature of the sample (age, gender, health etc.) and the case definitions used. The relationship between xerostomia and SGH is complex. Logically, xerostomia can occur due to a reduction in salivary flow in SGH, but both the subjective (xerostomia) and objective (SGH) components are known to occur independently of each other [14]. The few studies conducted on both xerostomia and SGH within the same population show that the two are largely separate conditions. In a systematic review, the prevalence of xerostomia prevalence ranged from 8% to 42%, while the prevalence of SGH prevalence ranged from 12% to 47%. The prevalence of both conditions existing together is only about 2% to 6% [10]. Similarly, in a longitudinal study of a population-based sample of 700 older South Australians, the prevalence of xerostomia was 21% and the prevalence of SGH was 22%, but only 6% of participants (or one in six of those with either conditions) had both conditions [30].

The variability in prevalence estimates for xerostomia due to different questionnaire formats and sample selection bias has been addressed in a systematic review by Orellana et al. (2006). Based on mainly elderly Scandinavian population samples, the reported prevalence of xerostomia has ranged from 0.9% to 64.8%. That variation may be explained as a consequence of differences in the measurement process and in case definitions. The review criticised the lack of consensus in the literature in the definition of xerostomia, and showed how the different types of single-item questions used may yield different prevalence estimates in the same population.

Even though it has been generally accepted that ageing has no significant impact on salivary flow rates, the prevalence of xerostomia is greater in older people. This may be at least partly due to the polypharmacy experienced with a concurrent increase in age-related medical conditions [37]. The misconception that xerostomia affects only older people has been challenged by findings from the Dunedin Multi-disciplinary Health and Development Study, a longitudinal study of health and behaviour in a complete birth cohort, where xerostomia was reported in 10% of the 972 participants at age 32 [33].

In older adults, there is a sex difference in xerostomia, whereby the reported prevalence of xerostomia is lower in men (10-26%) than in women (10-33%) [10]. There is no

apparent sex difference in younger adults, however [33]. This suggests that there may be some changes associated with menopause, resulting in a greater experience of dry mouth in older women [1].

In general, xerostomia and SGH affect a substantial minority of the population, especially in older people. As the global population continues to age [17], dry mouth will become an increasingly prominent problem in the future.

The aetiology of dry mouth

The common causes of dry mouth include xerogenic drugs, radiotherapy to the head and neck for cancer, and systemic diseases such as various connective tissue disorders [9]. Xerogenic drugs are the most common cause of dry mouth investigated in epidemiological studies, and it is an area which has been accompanied by the greatest number of avoidable mistakes [35]. A look at dry mouth-inducing medications reveals an almost inexhaustible list. These drugs usually have anticholinergic or sympathomimetic actions that affect the neural control of salivary glands, a cytotoxic effect on salivary glands, or a diuretic effect that depletes fluids [25]. Sreebny and Schwartz identified more than 400 drugs in 42 drug categories which they asserted were capable of inducing xerostomia or SGH [27]. The utility of such broad lists may be limited because most of the categories of medication included are based on case reports and clinicians' opinions instead of the findings of clinical or epidemiological studies. There is no indication of whether the medications listed cause xerostomia or SGH, and there is a lack of information on the xerogenicity of each specific medication, whether alone or in combination. Analysing the xerogenicity of medications is complicated by the difficulties of capturing information on medication exposure and choosing the analytical approach to be taken. Furthermore, polypharmacy is common in older people, and dry mouth may be a side-effect of the underlying medical conditions being treated [32].

Irradiation for malignant tumours in the head and neck region can cause dry mouth by direct damage to the salivary glands. Systemic diseases such as diabetes mellitus and chronic renal failure can result in dehydration and hence dry mouth. Systemic diseases that affect the salivary glands can cause salivary dysfunction, resulting in dry mouth. These include sarcoidosis, hepatitis C virus infection, and Sjögren's syndrome. The common aetiology of dry mouth is summarised in Table 1 [9].

In addition, there are physiological causes of dry mouth, such as anxiety (due to sympathetic activity), mouthbreathing, and (rarely) salivary gland agenesis [25]. Dry mouth in a patient can be due to more than one factor. For example, in a

patient with a chronic systemic disease such as Sjögren's syndrome, depression can be a commonly associated issue [38,39]. In such a scenario, dry mouth in the patient may be due to the salivary gland dysfunction, the anti-depressant-induced dry mouth, or the depression itself [2].

The impact of dry mouth

With an understanding of the prevalence and aetiology of dry mouth, this next section will discuss the effects of dry mouth. These include physical, emotional, and social impacts. The function of saliva needs to be explained in order to comprehend the effects of chronic dry mouth. In healthy adults, up to 1.5l of saliva is produced daily. Salivary function can be organised into five major categories that serve to maintain oral health and create ecologic balance: (1) lubrication and protection; (2) buffering action and clearance; (3) maintenance of tooth integrity; (4) antibacterial activity; and (5) taste and digestion. Unstimulated saliva keeps the oral mucosa moist and maintains oral health. Stimulated saliva that is produced in response to sensory stimuli (together with mechanical chewing) aids in the digestion process. Saliva also facilitates speech, cleanses food residues in the mouth, enhances taste, and neutralises potentially damaging food acids [11]. The physical impact of dry mouth is drastic and can manifest in a range of signs and symptoms. These are summarised in Table 2 (Soto-Rojas and Kraus, 2002).

The impact of dry mouth extends beyond the oral cavity into the daily lives of sufferers. One way of assessing this is by examining the effect of dry mouth on the oral-health-related quality of life (OHRQoL) of sufferers [16]. A study of 225 institutionalised older people in Toronto [15] used two different OHRQoL scales the General Oral Health Assessment Index, or GOHAI; [3], and the short-form Oral Health Impact Profile, or OHIP-14 [26]. It found xerostomia be an important influence on the rOHQoL. In a study of a Swedish older population [8], both xerostomia and SGH were found to be significantly associated with OHRQoL. In the Dunedin study, xerostomia was found to be strongly and independently associated with poorer OHRQoL among 32-year-olds. This finding suggested that xerostomia is not a trivial condition for anyone, whether relatively healthy young adults or institutionalised older adults ([33]a). More investigation aimed at improving the understanding of the impact of dry mouth on people's daily lives is essential. Qualitative research is one approach to improve knowledge in this area because this paradigm of research is based on the in-depth understanding of a phenomenon. The qualitative methods (such as diaries and interviews) employed allow for insight into the patient experience of dry mouth.

Table 1 – Causes of dry mouth (after [9]).

Medications	Antihistamine, Antihypertensives, Antidepressants, Anticholinergics, Antipsychotics, Sedatives, Analgesics, Muscle relaxants, Diuretics, Anticonvulsants, etc.
Sjögren's syndrome	Primary and secondary
Connective tissue diseases	Rheumatoid Arthritis, Systemic Lupus Erythematosus, Systemic Sclerosis, Mixed connective tissue disease
Other conditions	Radiotherapy, Chronic Active Hepatitis, HIV, Graft vs Host disease, Renal Dialysis, Anxiety, Depression, Diabetes Type 1 and 2

Table 2 – Signs and symptoms of oral dryness (after Soto-Rojas and Kraus (2002)).**Signs**

Dry, cracked, and peeling lips; dry and coarse tongue
 Cracks in the corners of the mouth
 Dental decay, cervical or atypical (such as in incisal and cuspal areas)
 Dental erosion
 Erythematous tongue
 Swelling of the salivary glands
 Mucositis
 Oral candidiasis
 Oral ulcers

Symptoms

Difficulties while swallowing and chewing dry foods
 Sensitivity to spicy foods
 Altered, salty, bitter, and metallic taste in mouth
 Burning sensation
 Lack of (or diminished) taste perception
 Pain in salivary glands
 Coughing episodes
 Voice disturbances/speech difficulties
 Increased liquid intake
 Nocturnal discomfort

Diagnosing dry mouth in the clinical setting

As mentioned, dry mouth has both a subjective (xerostomia) and an objective component (SGH), which are assessed using questionnaires and salivary measurements respectively. A recent Dutch study has shown that it does not seem possible to diagnose oral dryness by the mere visual inspection of photographed tongues. It recommended that the correct diagnosis of dry mouth required further clinical investigation of the oral cavity, along with saliva measurement [4].

The management of dry mouth

Dry mouth is not an easy condition to manage. The management of dry mouth and its consequences will be discussed in this section. In general, the goals in managing dry mouth are to deal with the underlying systemic condition(s), alleviate symptoms, and institute preventive measures. This may involve increasing the amount of existing saliva or replacing lost secretions in order to control the development of caries and treat specific oral infections such as candidiasis [36].

In order to manage dry mouth, the underlying cause needs to be understood (and rectified if possible). For example, patients taking xerogenic medications may have the drugs changed for an alternative if possible. However, this may be impractical in view of the wide range of medications that induce dry mouth, and the polypharmacy that is especially common in the older population. Should the underlying cause of dry mouth be a systemic disorder (such as diabetes mellitus), treatment should be aimed at the systemic disease.

Synthetic saliva substitutes (such as dry mouth gel or sprays) contain carboxymethylcellulose, a mucopolysaccharide, glycerate polymer base or mucins; all of these can provide temporary mucosal wetting. More recently, 1% malic acid spray

has been shown to be an effective topical sialogogue to improve xerostomia in patients who are on antidepressants and anti-hypertensive medications [18]. Furthermore, an intra-oral electrostimulation device was found to alleviate oral dryness, discomfort, speech and sleeping difficulties, and to increase salivary output in Sjögren's patients [29]. However, this can work only with patients who have residual salivary gland function, and the comfort and practicality of using such devices need to be considered. Sugar-free candies and chewing gums that contain xylitol can be used to stimulate salivary flow. Patients with dry mouth can also make adjustments to their diet in order to avoid dry or acidic food, and they can sip water with (and between) their meals. Raising patient awareness is also important, so that they can avoid factors that may increase oral dryness (such as caffeine or alcohol), and keep the mouth moist. Sialogogues that are cholinergic drugs (such as pilocarpine) can be prescribed to promote saliva production [6,19]. These are effective only in patients with sufficient exocrine tissue, and may have adverse effects such as nausea, vomiting, and affect pulmonary and cardiac functions [37].

There are measures which can be taken to prevent the adverse consequences of dry mouth. These include adopting a non-cariogenic diet, a high level of oral hygiene, and the regular use of topical fluoride agents (toothpaste, gels, rinses, varnishes), and casein phosphopeptide-amorphous calcium phosphate. Dental examinations every 4-6 months (with accompanying radiographs) are also recommended, followed by any required treatment.

There is no cure for dry mouth; rather, there is only palliative management to alleviate the symptoms. Although acupuncture has been noted to be effective in the treatment of dry mouth after head and neck radiotherapy [13], further research needs to be done in this area. The measures to manage dry mouth are summarised in Table 3 [19].

Table 3 – Overview of the management of dry mouth (after [19]).**Manage underlying systemic conditions**

Multidisciplinary management with other healthcare providers

Management of symptoms**Diet and habit modifications**

Frequent and regular sips of water
 Avoidance of dry, hard, sticky, acidic foods
 Avoidance of excess caffeine and alcohol

Salivary substitutes and lubricants

Artificial saliva, gels, rinses, sprays, bedside humidifier (sleeping hours)

Sialogogues

Pilocarpine 5-10 mg orally TDS
 Cevimeline 30 mg orally TDS

Acupuncture**Management of the consequences of dry mouth****Prevention**

Increased frequency of dental examination
 Topical fluoride application

Treatment of oral conditions

Dental caries – Restoration, topical fluoride
 Oral candidiasis – Chlorhexidine rinse and antifungal medication
 Poor-fitting prosthesis – Denture adhesives.

In Table 3, the management is divided into the underlying cause of dry mouth, the symptoms of dry mouth (diet and habit modifications, salivary substitutes, sialogogues, acupuncture) and the underlying consequences of dry mouth (prevention and treatment). The items in the Table act as a general guideline only, because there are different brands and medications available in different countries. Many of these strategies to alleviate the symptoms of dry mouth may only have a short-term effect. Moreover, it is imperative for clinicians to understand that each individual needs to tailor the management of dry mouth to suit their lifestyle and preferences.

Conclusion

In conclusion, dry mouth is a complex condition that will become increasingly prevalent in view of the aging population. Much research has been done to quantify and understand the cause of dry mouth. Its impact on sufferers is pertinent in view of its negative effect on OHRQoL and the lack of cure. It is crucial for clinicians to recognise that dry mouth is not a trivial condition, and it is especially relevant to the older population.

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Review

MicroRNAs as biomarkers for dental diseases



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ABSTRACT

MicroRNAs (miRNAs) are short, noncoding RNAs that act as key regulators of diverse biological processes by mediating translational repression or mRNA degradation of target genes. Recent studies discovered miRNAs in saliva, and these miRNAs are promising candidates for use as biomarkers of dental diseases. In this review, the results of miRNA studies in the dental field are presented, and a brief overview of the current progress, limitations, and perspectives regarding miRNA biomarkers for dental diseases is given.

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MicroRNAs

MicroRNAs (miRNAs) are a class of small single-stranded noncoding RNAs that were first discovered in *C. elegans* and later shown to be evolutionarily conserved across many animal species, including humans [1–3]. MicroRNAs, which

are approximately 22 nucleotides in length, act as key regulators of diverse biological processes by mediating translational repression or mRNA degradation of their target genes [4,5]. The mode of action of these regulators is through imperfect complementary binding to the 3' untranslated region (3' UTR) of target mRNAs [4,6]. Typically, a single

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Table 1 – Differential expression of miRNAs in oral cancers (Human model).

miRNA	Sample source	Disease	Expression	Reference
miR-211	Tissue	OSCC	Increased	Chang et al. [45]
miR-125a, miR-200a	Saliva	OSCC	Increased	Park et al. [20]
miR-21, miR-155, let-7i, miR142-3p, miR-423, miR-106b, miR-20a, miR-16	Tissue	HNSCC	Increased	Hui et al. [46]
miR-125b, miR-375, miR-10a			Decreased	
miR-24	Plasma	OSCC	Increased	Lin et al. [47]
miR-31	Plasma	OSCC	Increased	Liu et al. [22]
miR-99a, miR-100	Tissue	HNSCC	Decreased	Chen et al. [48]
miR-9	Saliva	HNSCC	Increased	Salazar et al. [49]
miR-134, miR-191			Decreased	
miR-21	Whole blood	OSCC	Increased	Ren et al. [50]
miR-155	Tissue	OSCC	Increased	Shi et al. [51]
miR-27b	Saliva	OSCC	Increased	Momen-Heravi et al. [38]

* Head and neck squamous cell carcinoma (HNSCC), oral squamous cell carcinoma (OSCC).

miRNA has the potential to simultaneously control the translation of hundreds of genes [5,7]. To date, more than 2500 genes encoding miRNAs have been identified in the human genome [8,9].

The biogenesis of miRNAs begins with the production of mRNA-like polyadenylated primary transcripts (pri-miRNA) by RNA polymerase II. Subsequent miRNA maturation requires two RNase III proteins, Drosha and Dicer. These two proteins may collaborate in the stepwise processing of miRNAs, and also have key roles in the process of miRNA-mediated gene regulation. The mature single-stranded miRNAs are eventually incorporated into a ribonucleoprotein complex, the RNA-induced silencing complex (RISC). RISC acts to downregulate gene expression via mRNA cleavage or translation repression: the miRNA component acts as a guide [10-14].

Circulating microRNAs

Serum and plasma contain large amounts of stable miRNAs, and these therefore have potential to serve as biomarkers for specific physiological and pathological conditions such as cancer, transplant rejection, cardiac injury, infection, and others [3,15-18]. The salivary transcriptome, which contains more than 3000 RNA species, including miRNAs, was recently released, and salivary miRNA biomarkers are emerging as tools for the detection of oral cancer and systemic diseases [19-23]. The miRNAs in saliva have advantages for biomarkers compared with other salivary biomarkers like proteins, mRNAs, DNAs and bacterial products. Even aside from the distinctive function of miRNA as post-transcriptional regulator, miRNAs are stably present in saliva and the similarity between miRNA profiles of saliva and other body fluids provide high availability as biomarkers for various human diseases [21,24,25].

Saliva sampling is a non-invasive, cheap, easy-to-access alternative to traditional tissue and blood sampling [26,27]. Saliva is an accurate indicator of bodily conditions, and salivary biomarkers may serve as early diagnostic tools. Saliva diagnostics is considered to be a highly promising alternative to classic environmental epidemiology [28,29]. The ease of sampling and cost effectiveness of saliva-based tests provide

advantages over traditional techniques for large scale population-based screening studies and also in situations where repeated sampling is required, such as for monitoring and managing disease progression [30]. Lab-on-a-chip (LOC) technologies are beginning to be used in clinical settings for point-of-care (POC) diagnostics [31]. Saliva samples have been used successfully for POC detection of multiple disease entities, including some that cause dental disease [32,33].

MicroRNAs as biomarkers for oral cancers

MicroRNAs are important in tumourigenesis due to their proximity to chromosomal breakpoints and their dysregulated expression levels in many malignancies [34-36]. Overexpression of certain miRNAs might result in the downregulation of tumour suppressor genes, while underexpression of other miRNAs might cause oncogene upregulation [37,38]. Consequently, several studies evaluated the potential of miRNAs as diagnostic and prognostic biomarkers for cancers [20,34,39,40].

Approximately 90% of head and neck cancers are oral squamous cell carcinomas (OSCC). OSCC is an aggressive and lethal malignancy that is a major worldwide problem due to its extremely high prevalence and very poor prognosis [41,42]. The average 5-year survival rate for patients with diagnosed OSCC is approximately 50% [43,44]. Therefore, an early detection method is needed for OSCC to improve treatment and long-term patient survival [20]. A number of studies have evaluated miRNAs as diagnostic biomarkers for OSCC. Differentially expressed miRNAs discovered by these studies are listed in Table 1.

MicroRNAs as biomarkers for periodontitis

Periodontal disease is characterised by inflammation of tooth-supporting structures. Periodontitis, which is a typical manifestation of periodontal disease, involves progressive loss of the alveolar bone around the teeth. If left untreated, periodontitis can lead to tooth loosening and subsequent tooth loss [52-55]. Associations between periodontal disease and other general health problems, such as diabetes, cardiovascular disease, rheumatoid arthritis and adverse

Table 2 – MicroRNA research related to periodontal disease.

Target diseases	Sample source	Methods	Results	Reference
Periodontitis	Healthy and diseased gingival tissues	miRNA PCR array	6 miRNAs up-regulated	Lee et al. [64]
Periodontitis	Healthy and diseased gingival tissues	miRNA Microarray	91 miRNAs up-regulated, 34 miRNAs down-regulated	Xie et al. [58]
Periodontitis and obesity	Gingival biopsy samples	miRNA PCR array	11 miRNAs up-regulated	Perri et al. [59]
Periodontitis	Healthy and diseased gingival tissues	miRNA Microarray	4 miRNAs up-regulated, 7 miRNAs down-regulated	Stoecklin-Wasmer et al. [61]

pregnancy outcome, have been reported in recent years, indicating the importance of early detection and treatment of periodontal disease [56]. The development of diagnostic tools to detect the presence and activity of periodontal disease is therefore of high importance.

Periodontal disease severity has traditionally been assessed using clinical parameters like pocket probing depth, clinical attachment loss, bleeding on probing, and radiographic determination of alveolar bone loss. Most of these techniques were established more than five decades ago, and lack the capacity to identify highly susceptible patients at risk for disease progression [28,57]. Periodontitis is a highly complex disease, which hampers the development of rapid, accurate, diagnostic and prognostic tests. Nevertheless, the development of innovative diagnostic tests for periodontal disease remains a high priority.

A small number of miRNA studies related to periodontal disease have been performed (Table 2). Xie et al. [58] used microarray analysis to examine miRNA expression, and transcript levels of selected inflammatory-related miRNAs were confirmed by quantitative reverse transcription polymerase chain reaction (qRT-PCR). The study used gingival tissues from ten healthy subjects and ten patients with periodontitis. Levels of some miRNAs were more than five-fold higher in tissues from periodontitis patients than in control tissues. In addition, the possible regulation of Toll-like receptors (TLRs) in periodontal inflammation by miRNA pathways was also proposed.

A pilot investigation was conducted to determine whether miRNA expression was altered by obesity or periodontal disease, and whether there were any potential interactions between obesity and periodontitis that could involve miRNA modulation [59]. In this study, gingival biopsy samples were obtained from 20 patients, ten of who were non-obese (BMI < 30 kg/m²) and ten of who were obese (BMI > 30 kg/m²). Each group of ten patients contained five patients with chronic periodontitis and five periodontally healthy patients. This was the first trial to assess the mechanisms underlying the pathogenesis of periodontitis and a common chronic condition (obesity), as well as the interaction between the two diseases [60].

Stoecklin-Wasmer et al. [61] examined the occurrence of miRNAs in healthy and diseased gingival tissues and validated the *in silico*-predicted targets through mRNA profiling using whole-genome microarray analysis of the same specimens. Four miRNAs were significantly overexpressed, and seven significantly underexpressed, in gingival tissues compared to controls. Gene Set Enrichment Analysis (GSEA) identified 60 enriched miRNA gene sets with target genes involved in immune/inflammatory responses and tissue

homeostasis. This was the first study to examine concurrent mRNA and miRNA expression in the same gingival tissues.

Only a handful of studies investigating miRNAs in gingival tissues have been reported to date. Studies of miRNAs and their relationships to periodontal disease will be improved in the near future by the use of diverse samples, including saliva, and this will allow the inter-relationships of periodontal disease with other systemic diseases to be ascertained. In addition, some studies using animal periodontitis models and dental stem cells have been conducted [62,63], and these will help determine the mechanisms underlying the modulation of specific candidate miRNAs.

Limitations of miRNAs as biomarkers

Although the exploitation of miRNAs as biomarkers for dental diseases is promising, some constraints should be considered.

First, differentially expressed candidate miRNAs identified through pilot studies need to be validated. Most previous studies using tissues were performed with samples from small numbers of individuals without matching for potential confounding factors known to influence periodontitis susceptibility such as age and gender. Further validation studies using large well-characterised cohorts are required [60].

Second, although recent advances in molecular biology and high-throughput screening techniques have enabled researchers to characterise miRNA patterns in body fluids such as serum, plasma, and saliva on a large scale, this is limited by the lack of suitable endogenous controls for normalisation of salivary miRNAs. Recent research attempted to identify endogenous control miRNAs displaying minimal expression variability between samples [38], but endogenous salivary miRNA controls are required for future exploitation of miRNA datasets. In addition, saliva samples collected from the same individual can display considerable heterogeneity according to the collection method used, and standardised methods for sample collection should therefore be considered.

Third, although biomarker development is paramount, the development of suitable treatment and prevention methods for patients testing positive for these biomarkers is also required. Effective, focused treatments are needed for highly susceptible patients in order to capitalise on early diagnosis, and without such treatments a clear cost-benefit advantage cannot be realised [28].

Future directions

The availability of novel genetic testing technologies such as RNA sequencing will allow current technical limitations to be circumvented and will increase test accuracy when extremely small samples are used. Fundamental research into the mechanisms underlying control and activity of miRNAs will facilitate the identification of links between various diseases. In addition, more efficient computational prediction models and improved bioinformatic pipelines will allow optimal use of miRNA datasets [65-67].

The combination of new diagnostic tests with saliva sampling will provide easy, rapid, testing, and will enable large scale and follow-up studies to be conducted at lower costs than when using traditional blood or tissue samples. With the introduction of new and improved techniques, more individuals susceptible to periodontal disease and with poor prognosis for other conditions will be detected early, allowing patient-focused clinical treatments. This first step will lay the groundwork for the future development of personalised dentistry using genetic information.

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Case report

Utilization of extracted teeth as provisional restorations following immediate implant placement – A case report

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ABSTRACT

This case report utilized a patient's natural teeth as provisional restorations supported by immediately placed implants to provide a seamless transition from hopeless teeth to implant supported restorations.

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Introduction

Patients facing the unexpected loss of a tooth in the esthetic zone in an otherwise healthy dentition may feel psychologically distressed. The placement of an implant into a fresh extraction socket followed by an immediate provisional restoration supported by the implant can help alleviate an upsetting experience. The utilization of a patient's own teeth can further provide a seamless transition from hopeless teeth to implant supported restorations.

Immediate implant placement and immediate provisionalisation (IIP) of a single anterior tooth have been documented to have high success rates ranging from 93.5% to 100% [1–4]. The results are comparable to implants placed in healed sites with immediate provisionalisation [5,6] or delayed loading approach [7,8] with reported success rates of 100% and 97% respectively.

In addition to shortened treatment time and smooth conversion, the flapless approach of IIP which maintains the blood supply to the buccal bone plate could help minimize changes in the facial–palatal contour [9–11]. Although bone

remodeling cannot be halted by the immediate placement of the implant [12,13], the immediate provisionalisation acts as a scaffold to support the existing soft tissues from flattening [1,11].

Various techniques have been described for the construction of implant supported provisional restorations with the aim to support the peri-implant tissues [1,9,11]. Provisional shells made with auto-polymerizing acrylic resin are the most commonly prescribed methods, however, much chair-time is required to accurately reproduce the interproximal contacts and identify the location of the cervical margin. Furthermore, the provisional materials are vulnerable to staining and fracture with time.

This case report utilized a patient's natural teeth as provisional restorations supported by the immediately placed implants.

Case report

A twenty-six year old male patient was referred for the management of the symptomatic maxillary left central and lateral incisors. The incisors were diagnosed with external root

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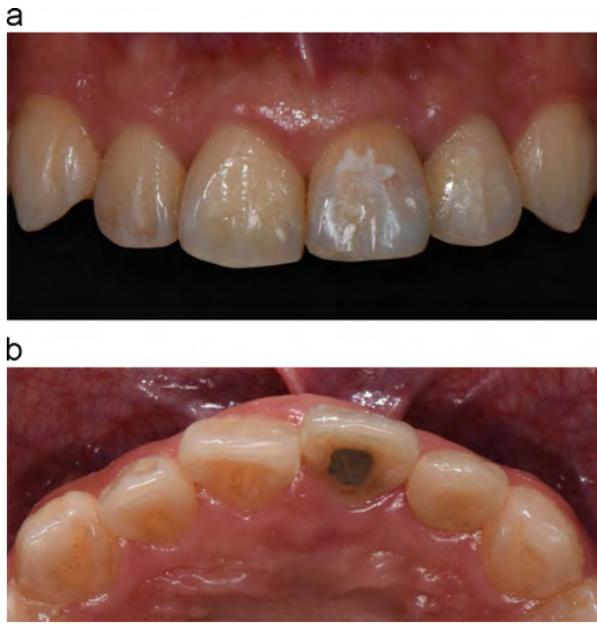


Fig. 1 - (a) Labial view of the pre-operative clinical condition. (b) Palatal view of the pre-operative clinical condition.



Fig. 2 - Pre-operative periapical radiograph showing external root resorption of maxillary left central and lateral incisors.

resorption due to history of trauma. The long-term endodontic prognoses were assessed to be poor (Figs. 1a, b and 2).

Cone beam computed tomography (CBCT) revealed the presence of buccal plate and the patient was treatment

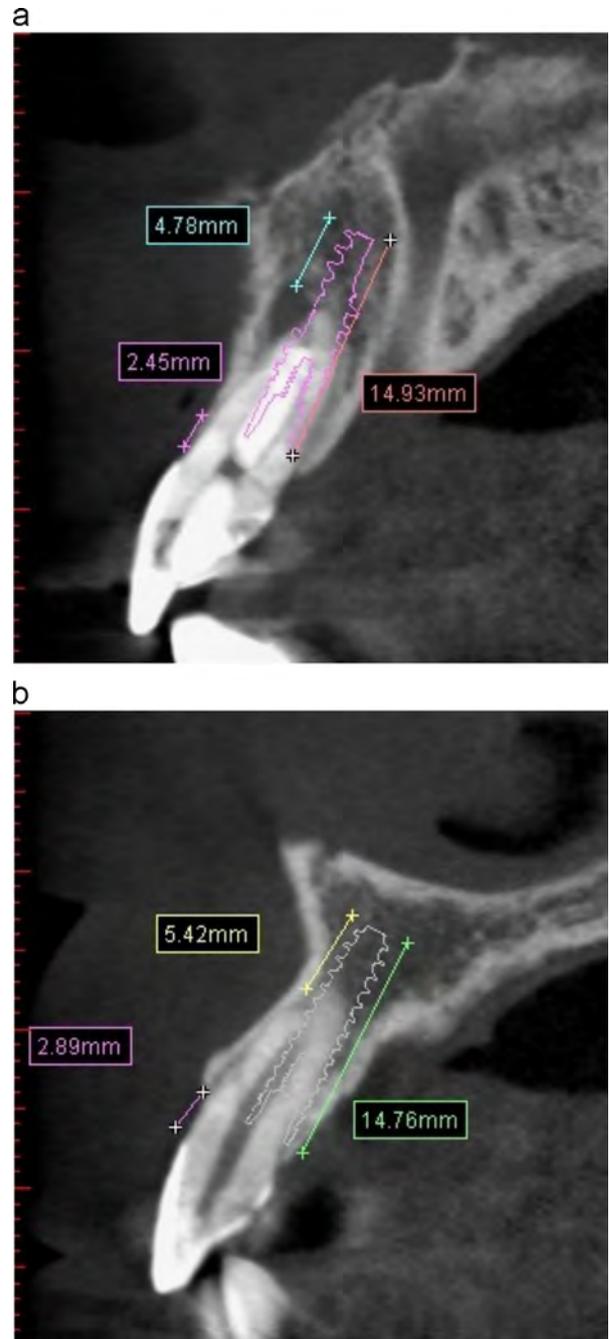


Fig. 3 - (a) CBCT showing intact buccal plate and a 3.5 mm Nobel Active implant of 15 mm length was planned for the replacement of central incisor. (b) CBCT showing intact buccal plate and a 3 mm Nobel Active implant of 15 mm length was planned for the replacement of lateral incisor.

planned to receive immediate implant placement and immediate provisionalisation for both the central and lateral incisors (Fig. 3a and b). The IPIP procedures for the two teeth were performed on two separate visits to maintain the integrity of interproximal bone. The IPIP of lateral incisor was carried out six weeks following IPIP of central incisor when the peri-implant tissues have stabilized (Fig. 4a and b).

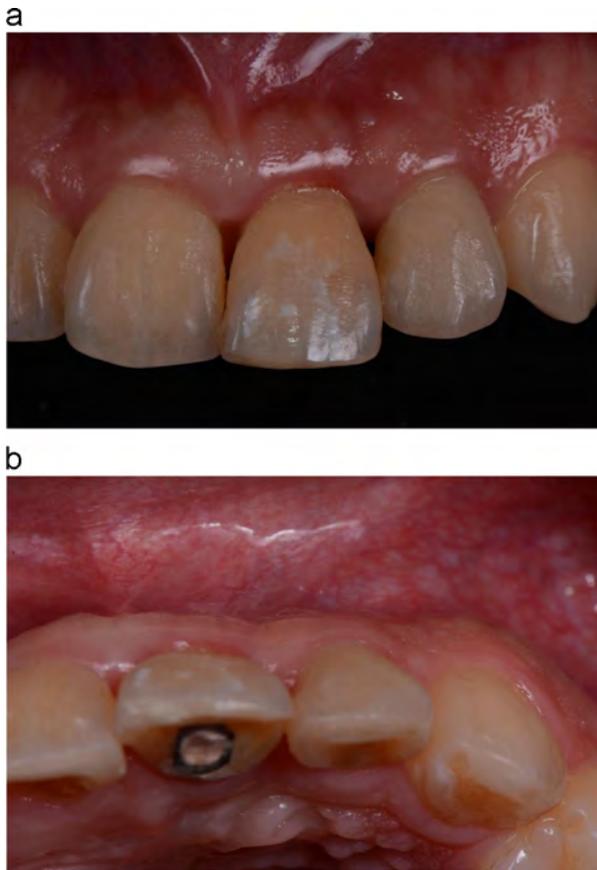


Fig. 4 – (a) Labial view of soft tissue healing 6 weeks after IPIP of central incisor. (b) Screw access hole on the palatal surface of implant supported natural crown of left central incisor.

Following local anesthesia, sharp dissection of the supra-crestal fibers with a 15c scalpel blade was performed and the tooth was removed carefully with extraction forceps (Fig. 5a and b). The socket was thoroughly debrided with a surgical excavator and rinsed with saline. The integrity of the buccal wall was verified (Fig. 5c). Two 15 mm threaded and textured implants with diameters of 3.5 mm and 3 mm (Nobel Active, Nobel Biocare) were placed at central and lateral incisor sites respectively on two separate visits. The implants were placed toward the palatal aspect of the extraction sockets to a depth of 3–4 mm from the free gingival margin (Fig. 6a and b). A minimum torque value of 30–35 N cm upon implant placement was confirmed prior to immediate provisionalisation.

The anatomical crown of the extracted tooth was sectioned off and the screw access hole was created on the palatal surface of the crown (Fig. 7). A screw retained provisional abutment was placed onto the implants. The natural crown was steam cleaned, treated, and connected to the temporary abutment with flowable composite resin intra-orally with an aid of a position index (Fig. 8a and b). The connected provisional restoration was then removed from the implant and composite resins were used to contour the sub-gingival portion (Fig. 9a and b). It is crucial the subgingival contour supported the peri-implant tissue.

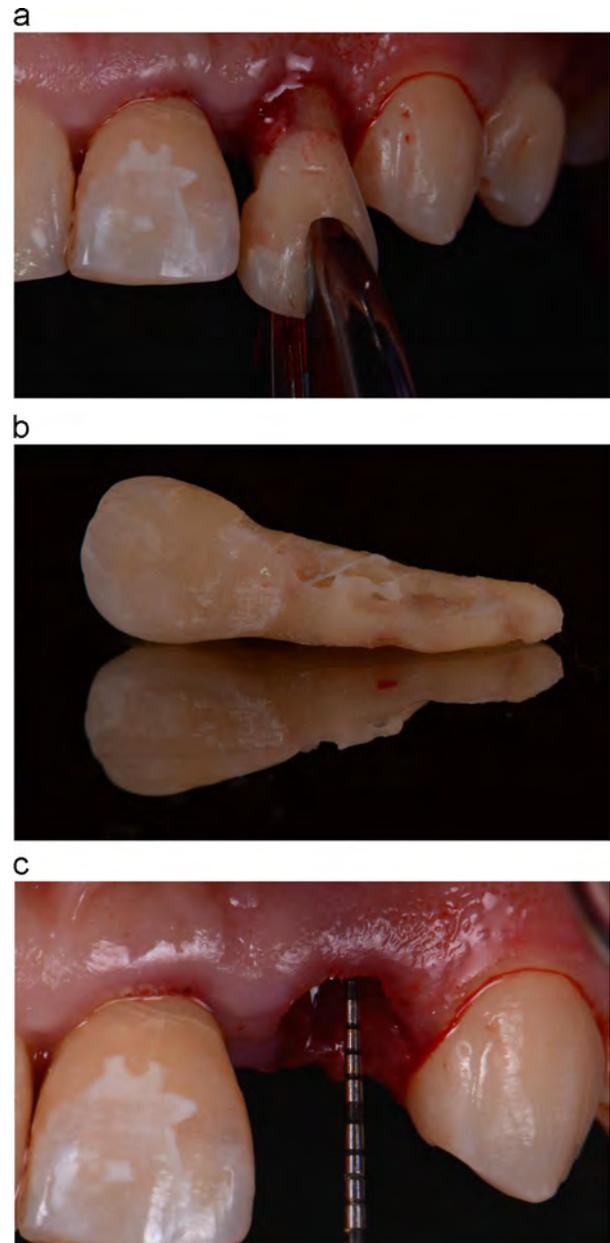


Fig. 5 – (a) Removal of maxillary lateral incisor with forceps. (b) Extracted maxillary left lateral incisor showing extensive area of external root resorption. (c) Presence of buccal bone verified at 3 mm below the free gingival margin at extracted site.

Upon completion of the screw retained provisional restoration, a tall, flat-contoured healing abutment was placed onto the implant prior to the placement of bone graft materials. The healing abutment allowed the grafting materials to be placed and packed against it at the same time prevented the excess from entering the screw channel. A xenograft bone graft material (Bio-Oss, Geistlich Pharma AG) was used to fill the gap between the implant and the buccal wall as well as the space above up to the most coronal aspect of the free gingival margin (Fig. 10). The healing abutment was then removed, leaving the bone graft material intact. The prepared provisional restoration was subsequently

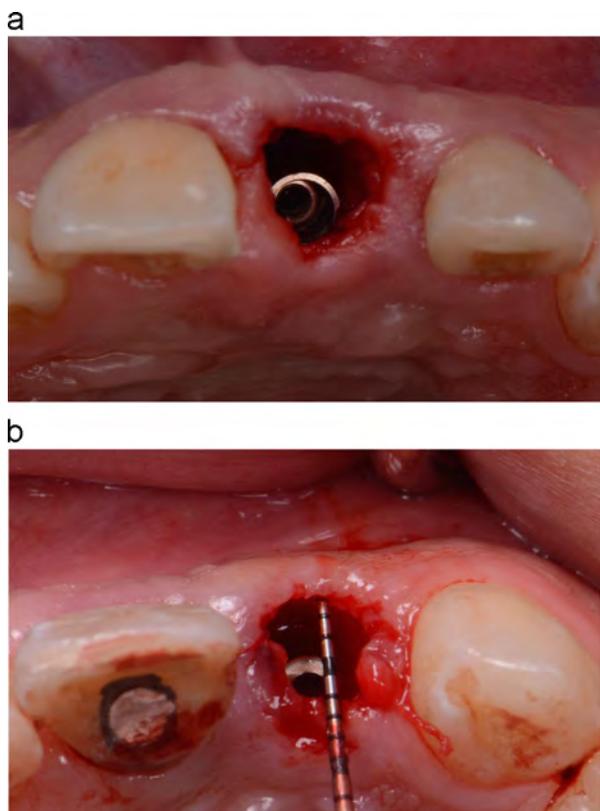


Fig. 6 – (a) Implant (3.5 mm × 15 mm) placed at extracted socket of central incisor. (b) Implant (3 mm × 15 mm) placed at extracted socket of lateral incisor.



Fig. 7 – Screw access hole created on the palatal surface of the sectioned anatomical crown of lateral incisor.

screwed onto the implants and the access was sealed with a temporary material (Cavit temporary filling materials, 3M, ESPE). The occlusion was adjusted to clear all static and dynamic occlusal contacts (Fig. 11). The technique resulted in minimum alteration of the patient's esthetics (Fig. 12).

Discussion

Tooth removal results in marked reduction in buccal–lingual alveolar bone width [14,15]. Araujo and Lindhe showed that

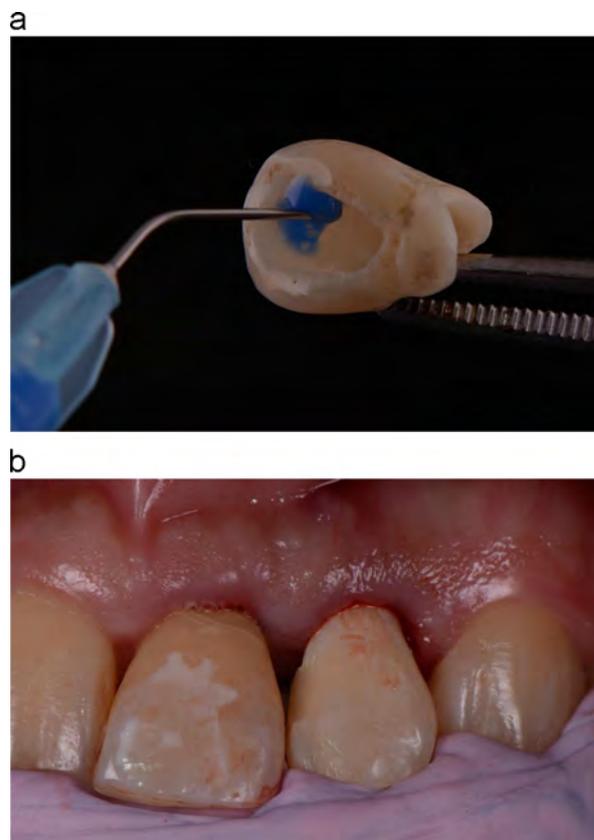


Fig. 8 – (a) Provisional crown was etched and primed. (b) The crown was repositioned with an aid of a matrix.

the reduction of the dimension of an extraction site was due to the replacement of bundle bone with woven bone from the inner portion of the socket and the resorption of the outer and crestal portions of the buccal–lingual socket walls [16].

Various techniques have been proposed to place implants immediately following extraction [17]. Assessment of the morphology of the pre-extraction socket is essential. Elian et al. classified the extraction site based on the presence or absence of the labial and interproximal bone, and its overlying gingival tissue and papilla surrounding the compromised tooth to be extracted [18]. When a socket is not compromised, described as a type I socket, the use of bone graft coupled with flapless surgery can help limit the amount of buccal contour change [11,19,20]. The grafting materials are then contained by the provisional restoration.

The use of a position matrix is an effective method to reposition the sectioned natural crown back to its pre-extracted spatial position. The use of the patient's own tooth simplified the provisionalisation procedure as no modification was required for cervical margins and interproximal contacts. Furthermore, the tissue response to the patient's own tooth could be expected to be more superior than other provisional materials, which tends to promote plaque accumulation if it is porous or unpolished.

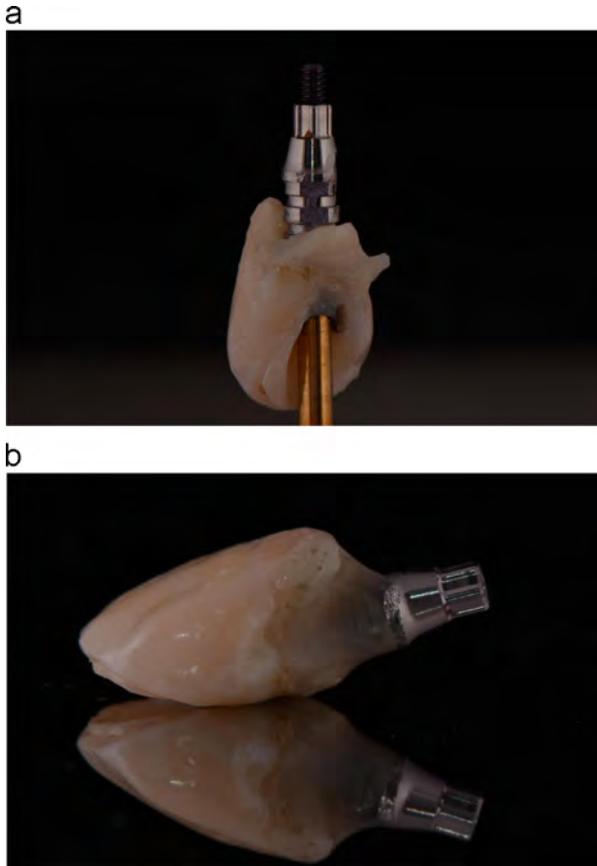


Fig. 9 – (a) The crown connected to the temporary abutment. (b) Composite resin used to contour the tissue surface.



Fig. 10 – Bone grafting materials packed against the healing abutment.

Conclusion

The patient's extracted teeth can be used as provisional restorations following immediate implant placement for a seamless transition from hopeless teeth to implant supported restorations.



Fig. 11 – Occlusion cleared of any static and dynamic contacts.



Fig. 12 – Post-operative clinical view of IPIP of left lateral incisor on the day of surgery (IPIP of central incisor was completed 6 weeks prior).

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Research paper

Comparison of incidence of dentinal defects after root canal preparation with continuous rotation and reciprocating instrumentation



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ABSTRACT

Biomechanical preparation is one of the most important steps in endodontic therapy. Rotary instrumentation has facilitated this step. Nowadays the market is flooded with different types of rotary instruments. The present study compared the root dentinal crack formation with continuous rotating versus reciprocating root canal preparation methods. One hundred and fifty freshly extracted teeth were used for the study. They were divided into 5 groups with 30 teeth in each group. Thirty teeth were kept under control group A and no root canal preparation was done for this group. Another 30 teeth were prepared with hand files which were kept under control group B. In the experimental groups (sample size, $n=30$ each) root canals were prepared with ProTaper, K3XF rotary system and WaveOne. Sectioning of these teeth was done at 3, 6 and 9 mm from the apex and were evaluated for the presence of any defects. Root dentinal cracks were produced with each type of rotary instruments. Statistical analysis showed no significant difference in root dentinal crack formation between control groups and WaveOne system. There was statistically significant difference in root dentinal crack formation when the canals were prepared with ProTaper and K3XF rotary system. So it was concluded, that continuous rotating instruments could produce dentinal crack formation. Root canal instruments with reciprocating movement appear to be a better option than continuous rotation movement.

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Introduction

The main goal of cleaning and shaping the root canal system is to prepare the root canal, thus creating adequate space for

copious irrigation and three dimensional obturation [1,2]. Use of inflexible stainless steel instruments in curved canals can cause iatrogenic damage to the original shape of the root canal [3]. This damage can be in the form of canal

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transportation, ledge formation or perforation [4]. To avoid this damage, nickel titanium (NiTi) instruments with shape memory and superelasticity were developed [5]. But NiTi instruments carry inherent risk of instrument fracture and root dentinal crack formation [6,7]. These root dentinal cracks can further progress to root fractures resulting in failure of root canal treatment [8].

Most commonly NiTi instruments are used with two types of movement: first is continuous rotating full sequence and second is reciprocating. Torsion and flexion occur with continuous rotating NiTi instruments while preparing root canals, which can lead to instrument fracture. To avoid this, reciprocating movement was proposed [9]. This movement minimizes the stresses on instrument by counterclockwise (cutting action) and clockwise (release of instrument) movements [10]. Reciprocating movement claims to mimic manual movement and reduces various risks associated with continuous rotating file systems. But reciprocating systems with small and equal Clockwise (CW)/Counterclockwise (CCM) angles have decreased cutting efficiency, thus making progression into canal more laborious [11].

WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) is a single instrument NiTi file system to shape the root canal completely from start to finish. These specially designed NiTi files work in a reverse 'balanced force' action using a pre-programmed motor to move the files in a back and forth reciprocal motion. As WaveOne utilizes CCW (counterclockwise) movement greater than CW (clockwise) movement, it is claimed that it requires less apical pressure for its advancement into the canal [12]. It was also thought that reciprocation might decrease the incidence of dentinal cracks formation. But this speculation is not supported by literature.

Thus, the present study was taken up to compare the incidence of generation of dentinal defects after canal preparations with continuous rotating instruments (ProTaper and K3XF system) and WaveOne (reciprocating motion).

Materials and method

One hundred and fifty freshly extracted human mandibular premolars were selected for the study. Mature root apices and single straight root canals with single apical foramen were main considerations for the sample selection. Single rooted premolars were verified by taking their buccal and proximal radiographs. The coronal portions of all the teeth were removed with diamond disks, (Jiangyin Rongmai international trading Co. Ltd., China) leaving roots 16 mm in length. All roots were observed under a stereomicroscope (12x magnification, Trinocular Stereo Zoom Microscope Nikon SMZ- 745T) to exclude the presence of any cracks. Access cavity was prepared for each tooth and patency of canal was checked with ISO No. 10 K file (Dentsply Maillefer Ballaigues, Switzerland). Working length was measured with ISO No. 15 K file (Dentsply Maillefer Ballaigues, Switzerland) keeping it 1 mm short of the apical foramen.

For continuous rotating instrumentation – Protaper (Dentsply Maillefer, Ballaigues, Switzerland) and K3XF systems (SybronEndo 1717 West Collins Avenue, Orange, CA 92867) were used.

For reciprocating instrumentation a WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) system was used. For ProTaper and WaveOne 6:1 reduction handpiece (X-smart plus, Dentsply Maillefer Ballaigues, Switzerland) with individual torque limit and rotational speed programmed in the file library of the motor was used. For a K3XF system torque limit and rotation speed as specified by manufacturer was used.

After each continuously rotating instrument or after 3 pecks while using the reciprocating files, irrigation was done with 5 ml of 3% sodium hypochlorite solution (Septodont) using 27 gauge needle (Romsons Juniors India Unit-II C-1, Foundary Nagar, Agra).

Sample size of 150 teeth was randomly divided into five groups with 30 teeth in each group.

Control group A: Teeth left unprepared.

Control group B: Hand instrumentation was done using a step back technique. After coronal enlargement with Gates Glidden burs, apical preparation to the desired master apical file ISO size 40 was commenced with K files to working length. Then the working length was progressively decreased by (modified step back technique) 1 mm to create a tapered

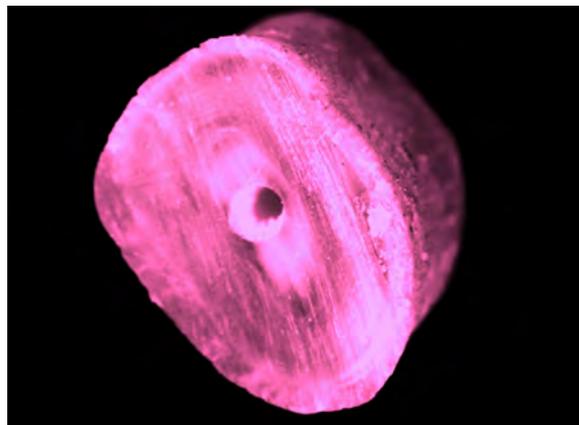


Fig. 1 – Craze line i.e. line extending from outer surface into dentin but does not reach the canal lumen.



Fig. 2 – Partial crack i.e. line extending from canal walls into dentin without reaching outer surface.

shape. After each step recapitulation was done with a smaller number K-file.

Group C: A ProTaper rotary system (Dentsply Maillefer, Ballaigues, Switzerland) using a crown down technique was used to prepare samples of this group. The instrument sequence used was SX instrument at two third of the working length, S1 and S2 at working length minus 1 mm. Further F1 (20/.07), F2 (25/.08), F3 (30/.09) and F4 (40/.06) were used at working length.

Group D: Samples were prepared using the K3XF rotary system (SybronEndo 1717, West Collins Avenue, Orange, CA 92867) using a crown-down technique. Canal preparation was done with the K3XF technique with file No. 40/.06 at working length.

Group E: WaveOne file was used in a reciprocating working motion generated by torque control motor using a WaveOne technique. A reciprocating WaveOne file No. 40/.08 was used in a reciprocating slow in and out pecking motion till working length.

One examiner completed all root canal preparations and cross sectioned all samples. These cross sectioned samples were examined by another two experienced examiners having minimum of five years post PG experience, who were not



Fig. 3 – Fracture: line extending from root canal space all the way to outer surface of root.

given any information about the specimens they were examining. This was to rule out any operator bias. Sectioning of prepared teeth was done at 3, 6 and 9 mm from the apex using 0.1 mm low speed diamond disc (Jiangyin Rongmai international trading Co. Ltd., China). Water was used as coolant during this process to avoid any artefacts because of dehydration. Teeth were kept moist in distilled water throughout the study. Digital stereomicroscope (Nikon Model SMZ- 745T) with cold light source was used to observe the sectioned samples and digital photographs were taken. Results from the two examiners were compiled and statistically evaluated.

A scoring system used according to the type of defects present [13]

No Defect (Score 0): Root dentin devoid of any lines or cracks where both external surface of root and internal root canal wall does not present any evident defects.

Craze line (Score 1): Line extending from outer surface into dentin but does not reach the canal lumen (Fig. 1).

Partial crack (Score 2): Line extending from canal walls into dentin without reaching outer surface (Fig. 2).

Fracture (Score 3): Line extending from root canal space all the way to outer surface of root (Fig. 3).

The incidences of root dentinal defects among various groups were compared by using a Chi square test.

Results

Roots were classified as 'defective' if at least one of three sections showed either a craze line, partial crack or a fracture. Results were expressed as number and percentage of defective roots in each group (Table 1). A complete crack was present in only one (3.3%) sample prepared with the ProTaper rotary system.

The data collected was statistically analyzed to compare the presence of defective roots between various experimental groups. Each group was compared with control groups and it

Table 1 – Comparison of number and percentage of teeth showing defects between various groups at coronal, middle and apical third.

Dentinal damage	Control group (A)	Control group (B)	Protaper rotary	K3XF rotary	WaveOne	Total
At coronal third						
Score 0	30 (100%)	30 (100%)	22 (73.3%)	25 (83.3%)	28 (93.3%)	135
Score 1	–	–	6 (20%)	3 (10%)	2 (6.7%)	11
Score 2	–	–	1 (3.3%)	2 (6.7%)	–	3
Score 3	–	–	1 (3.3%)	–	–	1
At middle third						
Score 0	30 (100%)	30 (100%)	24 (80%)	29 (96.7%)	27 (90%)	140
Score 1	–	–	3 (10%)	1 (3.3%)	2 (6.7%)	6
Score 2	–	–	2 (6.7%)	–	1 (3.3%)	3
Score 3	–	–	1 (3.3%)	–	–	1
At apical third						
Score 0	30 (100%)	30(100%)	30 (100%)	30 (100%)	30 (100%)	150
Score 1	–	–	–	–	–	–
Score 2	–	–	–	–	–	–
Score 3	–	–	–	–	–	–
Total	30	30	30	30	30	30

was found that WaveOne did not produce any significant dentinal cracks. ProTaper and K3XF rotary systems produced significant dentinal cracks as compared to control groups but when were compared with each other no significant difference was found (Tables 2 and 3).

Discussion

Rotary endodontics was developed with the aim of reducing the treatment time, increasing efficiency and accuracy of root canal preparation. Currently, there are many different NiTi rotary systems available in the market. Root canal preparation with different rotary NiTi endodontic instruments may cause stress and strain which can lead to micro cracks or craze line formation in root dentin [14]. Tip design, cross-sectional geometry, taper, pitch and flute form of NiTi instruments may contribute to the extent of these defects [15].

The total volume of dentin removed from root canals is significantly greater with NiTi engine driven systems when compared to hand filing, this may contribute for the formation of the defects. These small defects can extend to the external surface thus breaching the intact root dentin. Also defects shown in one section might communicate with defects in another section [16].

Control group A samples showed no cracks on external surface when observed under stereomicroscope before sectioning. Even after sectioning no cracks were found. This means that the sectioning method used in the study did not induce any cracks. So cracks if present in other groups should be due to the technique of root canal preparation.

Control group B samples also showed no crack formation, even after using Gates Glidden burs for coronal flaring as their use was limited to coronal one-third only. This was in accordance with the earlier studies which concluded that use of Gates Glidden burs for coronal flaring does not induce cracks in the root dentinal wall [17]. Less crack formation with hand filing can be because of the slower speed, better tactile sensation and less stress generated as compared to rotary instruments. However, this must be balanced against

the better efficiency of motor driven systems in cleaning and shaping the root canal.

Group C samples prepared with ProTaper files showed the most root dentinal crack formation among all the groups, in 33.3% of samples. This could be attributed to continuous rotating motion and design of the file having triangular or modified triangular cross section resulting in less space for collection of dentine chips, thus generating stresses on the root dentinal wall. Its 7–9% taper of various files from F1 to F3 can also cause more stresses. Bier et al. also found cracks in horizontal section of 16% of roots instrumented with the ProTaper system [18]. Liu et al. observed cracks at apical root surface in 25% of roots instrumented with the ProTaper system [19].

Group D samples prepared with K3XF files showed crack formation in 16.7% of samples. Decrease in incidence of crack formation with this continuous rotating system could be due to its peripheral blade relief design of the file which claimed to reduce friction, facilitating its smoother operation. This feature controlled the depth of cut which prevented the files from over-engagement thus, protecting the root dentin from getting more damaged [20].

Present study found that WaveOne file produced significantly less cracks i.e. only 10% of group E samples. It was found that the single file (WaveOne) system caused less damage as compared to multiple files used by the ProTaper or K3XF system. This might be due to the reciprocating motion, the difference in file design in this single file system and shorter root canal preparation time.

The present study showed more crack generation at coronal third as compared to middle or apical third. Versluis et al. also concluded that the stresses generated at 1 mm short of the apical foramen were one third of stresses at more coronal levels. This may be due to increase in taper of various files towards the coronal third [21].

Other reasons that can contribute to the root dentinal crack formation beside different type of systems are operator skill, storage conditions and the absence of periodontal cushioning in prepared samples. Clinical procedures that can further lead to propagation of these cracks are stresses induced by obturation methods or postspace preparation techniques [22, 23]. In addition, simple masticatory forces, parafunctional habits like bruxism and occlusal loading can also contribute to progression of incomplete cracks to complete fracture of root.

One main shortcoming of this study was that we could not match the roots for root dentine thickness amongst all groups. Although we have used only mandibular premolars in all groups, there would still be differences in dentine thickness. Thickness variation would give rise to significant changes in strength and hence its response to stresses during instrumentation, we must interpret the results of this study with some caution.

Table 2 – Comparison of number and percentage of teeth showing defects between control and experimental groups.

Defect	Control group (A)	Control group (B)	Protaper rotary	K3XF rotary	WaveOne
Absent	30 (100%)	30 (100%)	20 (66.7%)	25	27 (90%)
Present	–	–	10 (33.3%)	5	3 (10%)
Total	30	30	30	30	30

Table 3 – Basic statistical values and level of significance of comparison between control and experimental groups.

Group comparison	Chi square value χ^2	Degree of freedom (df)	'p' Value	Level of significance
Control groups Vs Protaper	12	1	0.001	Significant
Control groups Vs K3X rotary	5.455	1	0.020	Significant
Control groups Vs WaveOne	0.00	1	1.000	Not significant

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Case report

Necrotizing periodontitis in a heavy smoker and tobacco chewer – A case report



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ABSTRACT

Necrotizing periodontitis is a distinct and specific disease characterized by rapidly progressing ulceration of the interdental gingiva and then spreading along the gingival margins and leading to acute destruction of periodontal tissues. Necrotizing ulcerative gingival lesions are common in developing countries because of poor nutritional status, poor oral hygiene and debilitating conditions. In the developed world it is mostly seen in patients with the HIV infections and other immune system dysfunctions. The exact etiology of the necrotizing lesions is still unknown; however a fusio-spirochaetal infection along with weakened host immune system seems to play a major role in the pathogenesis of these diseases. Presented is the case of acute necrotizing periodontitis in a 21 year old male patient with no systemic disease but a history of tobacco use (chewing and smoking) since 7 years. The patient was managed by conservative treatment followed by surgery for the correction of gingival defects.

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1. Introduction

Necrotizing lesions of the oral cavity generally involve the periodontium. Necrotizing periodontitis (NP) is a destructive periodontal disease mostly associated with the characteristics of necrotizing gingivitis (NG) clinically. These lesions manifest with areas of necrosed gingiva, spontaneous bleeding, intense pain and alveolar bone attachment loss. Factors causing NP are little understood. It may be a consequence of

NG lesions or as a result of previous occurring periodontitis. Periodontal pathogens treponema, fusobacterium and prevotella are implicated in the disease. Host immune deficiency as in HIV, diabetes, leukemia, poor oral hygiene, nutritional deficiency, stress and smoking predisposes to this condition [1].

This report describes a very aggressive case of NP in a heavy smoker and tobacco chewer and its successful management.

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2. Case report

2.1. Clinical presentation

A 21 year old male patient reported to the Department of Periodontology of Dr. Z.A. Dental College, A.M.U. Aligarh, with chief complaint of severe pain and bleeding in the gums along with difficulty in eating since one week. There was history of swelling of gums three months back for which no treatment was undertaken. There was a history of pan chewing along with tobacco since 5 years. Also the patient was a heavy smoker since 7 years (more than 20 cigarettes/day). The patient was systemically healthy and there was no medical history contributory to the dental problem. The patient stopped brushing since the pain started. Earlier the patient used his fingers to clean his teeth. Extraorally, the patient presented with enlarged lymph nodes and slight fever. On intraoral examination, poor oral hygiene was noticed with gross accumulation of dental plaque especially along the gingival margin (Fig. 1). A thin whitish film (pseudomembrane) covered part of the attached gingiva. Examination of the gingiva revealed necrosis of the papillae, causing it to separate into one facial and one lingual portion with an interposed necrotic depression producing considerable tissue destruction leading to the formation of characteristic punched out crater like depressions. Heavy stains were present.

Radiographic examination demonstrated horizontal bone loss in the lower anterior region. (Fig. 2) A diagnosis of necrotizing ulcerative gingivitis with periodontal involvement in lower anterior region was made.

2.2. Case management

After explaining the condition to the patient a written informed consent was taken and a two step treatment plan was designed comprising of conservative and surgical phase.

In the conservative phase, on the very first appointment, after the application of topical anesthesia the acutely inflamed areas were swabbed with a moistened cotton pallet to remove the sloughed tissue and non-attached surface debris along with irrigation with 3% H₂O₂ and sterile warm water. Suprapericardial scaling was attempted as thoroughly as the condition allowed. Patient was prescribed metronidazole 250 mg QIDS for seven days. A small gingival tissue from the posterior was taken and sections were prepared to evaluate histopathologically. Histopathological



Fig 1 – Clinical view showing the gingival lesions.



Fig 2 – Intra oral peri-apical radiographic view showing horizontal bone loss in lower anterior region.

report further confirmed our diagnosis. Nonspecific infiltrate comprising of areas of ulcerated squamous epithelium with abundant neutrophils and fibrin pseudomembranes with fragments of necrotic epithelium were seen (Fig. 3a and b). Patient was advised to rinse with 3% H₂O₂ and sterile warm water (1:1 dilution) four times a day and with 0.12% chlorohexidine twice a day. The patient was instructed to avoid tobacco as well as pan chewing, to take adequate rest and take proper diet. Proper oral hygiene instructions were given.

After 2-3 days the patient was re-evaluated and again supragingival scaling was performed. At every re-evaluation phase oral hygiene instructions were reinforced.

After five days the patient was almost symptom free, so thorough scaling and root planning was done. At this time 3% H₂O₂ rinses were discontinued but 0.12% chlorohexidine rinses were continued. Patient was again instructed to avoid tobacco as well as pan chewing.

The patient was recalled after four months and gingivoplasty was done in lower anteriors under local anaesthesia.

2.3. Clinical outcomes

The patient was very responsive to the treatment provided. After the very first appointment there was decrease in pain and gingival inflammation. After complete debridement, there was complete remission of inflammation but the gingival contour remained affected. Gingivoplasty corrected this defect but as there was bone loss in the lower anteriors, there was apical shift of gingiva. The patient's condition responded to the therapy given, with a complete resolution of the lesion (Fig. 4).

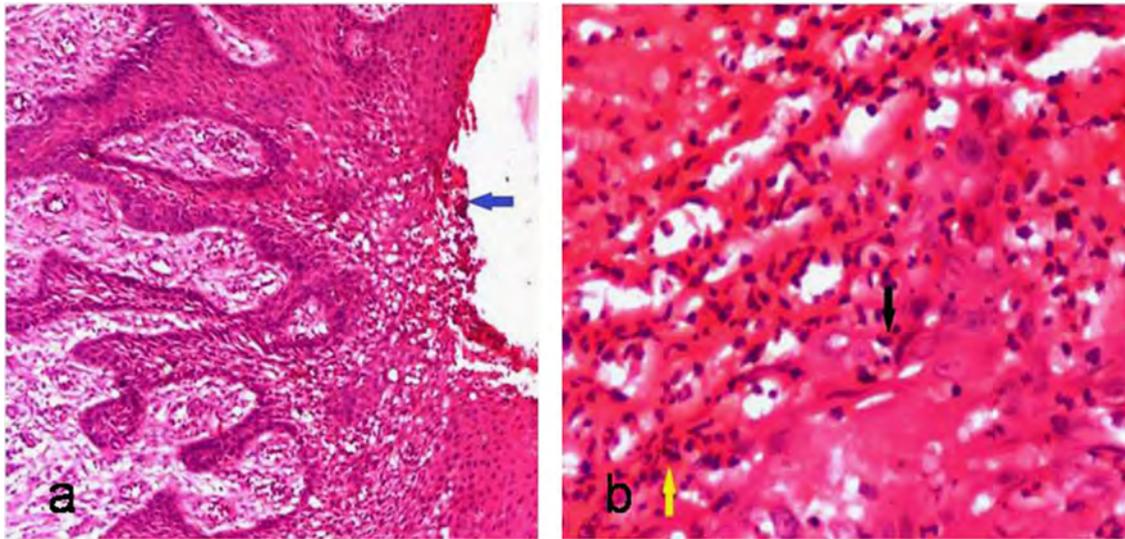


Fig 3 - Histological view under 100X magnification (3a) and 400X (3b).



Fig 4 - Post operative view.

3. Discussion

Necrotizing periodontitis is now a rare disease in developed countries but yet found in developing countries due to existing poor nutritional status, stressful living conditions, poor oral hygiene and state of debilitation often resulting from endemic contagious diseases. Diagnosis of this disease is made on clinical signs and symptoms [2]. Early diagnosis and prompt treatment of the disease prevents the progression and cellular destruction and results in resolution of the disease.

Our case presented the classical picture of necrotizing lesions localized to the anteriors and not involving the lingual and posterior regions. Massive destruction may be associated with poor oral hygiene and tobacco use in either chewable form or as cigarettes. It is a known fact that the pathogenic processes involved in any periodontal diseases are modified by environmental factors such as smoking [3]. This may be the result of thousands of chemicals present in cigarette smoke which are powerful inducers of inflammatory responses and are toxic to multiple cell types [4]. Nicotine present in the tobacco causes release of local and systemic catecholamines leading to increase in gingival papillary flow and resulting in papillary necrosis. Also nicotine disrupts the balance of MMP/TIMP ratio thereby resulting in increased collagen and periodontal destruction [5]. Tobacco consumption has direct effect on homeostatic

mechanism in the periodontium as well as influences periodontal microflora. Changes in tissue vascularity, alteration in fibroblast attachment and function, suppression of osteoblast proliferation, stimulation of osteoclasts and alteration in PMNL function leading to impaired phagocytosis, superoxide and hydrogen peroxide generation, integrin expression and protease inhibitor production are some of the consequences of tobacco use [6]. Studies demonstrate that smokers have higher plaque levels, more pathogenic flora and less favorable response to periodontal treatment [7]. In majority of the published cases necrotizing lesions have been rarely attributed to tobacco chewing and smoking. Poor oral hygiene may have facilitated the penetration and pathogenicity of the microbes but not necessarily be the predisposing factor to NUP as stated by Taiwo [8] not all with poor oral hygiene may develop necrotizing lesions.

Treatment of necrotizing lesions includes effective removal of local irritating factors that is the plaque and calculus. Hydrogen peroxide mouthwash is advocated to increase the supply of oxygen to the anaerobic microbes thereby inhibiting their growth. Chlorhexidine gluconate mouthwash has antiplaque effects. Prompt periodontal therapy and oral hygiene reinforcement and patient compliance are essential in treatment of such lesions.

In our case the sudden amount of destruction noted is a grave sign of negative consequences of tobacco on oral health. Of importance is that this destruction is in absence of any other immunocompromised conditions like HIV, diabetes and leukemia. This paper highlights the imminent danger faced by the populations where tobacco and its products are not only accessible but quite inexpensive.

4. Conclusion

The case reports the massive periodontal destruction that occurred in a patient consuming tobacco and its successful management. Therefore, it is highly recommended for those with habit of smoking and tobacco chewing should be made

aware of its negative impact on oral health and be regularly monitored to aid in early detection and to provide proper management of periodontal inflammatory conditions to minimize its destruction.

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Conflict of interest

There is no conflict of interest among authors.

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Case report

Application of platelet rich fibrin for management of an electrosurgery induced osteonecrosis involving maxillary alveolus



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ABSTRACT

Background: Application of principles of electrocautery for hemostasis dates back to prehistoric times. Its modern implementation in various fields of general and head and neck surgeries have been well documented. However its usage in minor oral surgical procedures has gained popularity only recently.

Complications associated with electrosurgery in the dental field are relatively rare and there is insufficient literature on its management.

Case report: We present a case report on management of an electrosurgery induced osteonecrosis involving maxillary alveolus of left premolars.

Discussion: Inadvertent contact of the electrosurgery tip on bone can result in necrosis making it necessary to remove the sequestrum and graft the defect. Platelet rich fibrin in combination with bone grafts have been well documented to provide successful periodontal regeneration.

Clinical implications: Our aim of presenting this report is to create awareness among the health care providers regarding electrosurgical injuries. To our knowledge, this is the first time platelet rich fibrin has been used in the management of intraoral electrosurgical injury. Combining bone grafts with platelet rich fibrin is a good alternative as it can be done with relative ease and predictable outcome.

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Introduction

“A smile is a curve that sets everything straight”. The underpinning of dentistry relies on bringing out this social attribute

in its superlative semblance. The quality of smile should not be measured only by its aesthetic value but also by its health status. However, common dental diseases such as caries and periodontitis threaten to disrupt this if not addressed early.

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Surgical management of dentition and its associated structures becomes imperative when diseases affecting them cannot be addressed through conservative measures alone. Surgical techniques involving cutting procedures although still performed with the surgical scalpel, has number of drawbacks. Pertaining to this, a search for alternatives led to the introduction of diathermy that provides more precision, effective and effectual hemostasis with reduced operating time and faster healing with minimal scarring [1,2]. Though the principles of cauterizing for achieving hemostasis dates back to prehistoric times, the major breakthrough in this field is correlated with the discoveries of d'Arsonval and Franz Nagelschmidt who coined the term "Diathermy" and it's inception in its contemporary form by William T. Bovie in 1928 [3-5].

Today there are an increasing number of applications for electrosurgery in general surgery and head and neck surgery [6-9]. However its usage in minor oral surgical procedures such as frenectomy, gingival depigmentation, gingivectomies, excision of soft tissue overgrowths has gained popularity only recently. Despite of many advantages when properly used, this technique still can cause hazards to the patient, operating surgeons and assistants. Although various complications caused by electrosurgery such as burn injuries, electrocution, operating room fire, smoke inhalation have been reported in the literature its depiction in minor oral surgical procedures are rare [3]. Also management of the ensuing complications has very limited literature support making it difficult for the general practitioner to handle such situations. Hereby we present a case report involving surgical removal of hyperplastic tissue in relation to maxillary left second premolar region using electrocautery with its adverse outcome and management.

Case history

The 43 year old female patient presented with carious, non-vital tooth 25 and gingival overgrowth into the cavity. Since the gingival tissue obscured the placement of rubber dam it was removed using electrosurgery (Parkell Sensimatic™-600 SE), following which pulp extirpation, cleaning and shaping was done and the cavity temporized with intermediate restorative material. After a month, she returned with grade I and II mobility in relation to 24 and 25 respectively with sequestrum formation near the cauterized site.

(Figs. 1 and 2). Under local anesthesia the sequestrum was removed (Fig. 3) and the bone defect between 24 and 25 filled with allograft (Puros®) and platelet rich fibrin (PRF) membrane was adapted over it (Figs. 4 and 5). Review after a week showed satisfactory healing and endodontic treatment was completed. The patient was reviewed for the next six months (Fig. 6) during which satisfactory bone fill was observed in radiographs (Fig. 7) with decrease in mobility from grade II to I in 25.

Discussion

The discovery and implementation of modern, sophisticated tools such as electrosurgery and lasers have led to a



Fig. 1 – Pre-operative photograph showing bone sequestrum between teeth 24 and 25.



Fig. 2 – Pre-operative radiograph showing PDL widening and bone loss between teeth 24 and 25.

revolution in today's surgical practices. These have found a special place beside the scalpel and have become indispensable within a surgeon's kit. Electrosurgical units have been improvised since their discovery to counter some of their earlier complications such as patient burn, conductivity, etc. Despite its many advantages, iatrogenic and patient related factors can sometimes hamper their outcome and injury may occur in the following situations: direct application, insulation failure, direct coupling, and capacitive coupling, and so forth [10]. In this particular case, limited access and prevention of blood contamination made it essential to choose electrosurge over the surgical scalpel to excise the gingival overgrowth.

Electrosurgery refers to the passage of high frequency electrical current through the body to achieve a desired effect [11]. When applied through the active electrode, current gets concentrated at its tip and arcs across the tissue, thereby rapidly



Fig. 3 - Excised bone sequestrum.



Fig. 4 - Flap elevation with bone defect seen between teeth 24 and 25.

elevating its intracellular temperature causing vaporization [12]. Two types of electrosurgical instruments are currently available namely the monopolar and the bipolar. Parkell Sensimatic™ 600 SE Electrosurge which is of monopolar type was used in this patient. It is a dental electrosurgery unit which employs a low-impedance, high frequency current that has multimodal settings such as cut, cut and coagulate and coagulation. In our case we selected the cut with balanced coagulation mode (RF Mode No. 2) which offers both cutting and coagulation to reduce bleeding.



Fig. 5 - Platelet rich fibrin membrane over bone graft.

The hyperplastic tissue was severed using a Bent straight wire loop (T2) dental electrode held near to the tissue. Though direct contact on bone was avoided as far as possible, formation of sequestrum occurred after a month. Such electrosurgical injuries can be minimized by following certain guidelines such as guiding the electrode over the tissues at a rate of 7 mm/s, reducing contact time with the tissues to 1–2 s followed by a 10–15 s cooling interval, using thinner diameter electrodes to reduce lateral dissipation of heat, avoiding contact of the non active end of the electrode against tooth surface [13,14].

In our case the sequestrum might have resulted from accidental contact of electrode with the bone which was very near to the operating area of interest. Studies have shown that marginal alveolar bone touched by an activated electrosurgery electrode produced bone destruction in a time dependant manner as a result of thermal necrosis without ablation and the damaged area was not replaced by new bone [15,16]. Since the sequestrum formed in relation to maxillary left first and second premolar teeth resulted in bone loss and ensuing mobility we decided to graft the site. The reason for choosing Puros® allograft is germane to the fact that allografts are next best only to autografts and have the advantage of avoidance of a second surgical site to harvest them. In addition we decided to conjoin a material that would provide both synergistic and ameliorating effect to the bone graft. The most positive outcome of periodontal regeneration process has been achieved with a combination of bone grafting and guided tissue regeneration [17]. Platelet rich fibrin (PRF) is a newly discovered bio-material that can be obtained in a membrane form and used along with bone grafts. PRF being a reservoir of growth factors such as Platelet derived growth factor (PDGF) and Transforming growth factor (TGF) has inherent osteoconductive and osteoinductive properties that can enhance periodontal and bone regeneration in the recipient site. Its innate fibrin network can prevent the growth factors from proteolysis thus prolonging the activity of the later. The fibrin matrix is also capable of

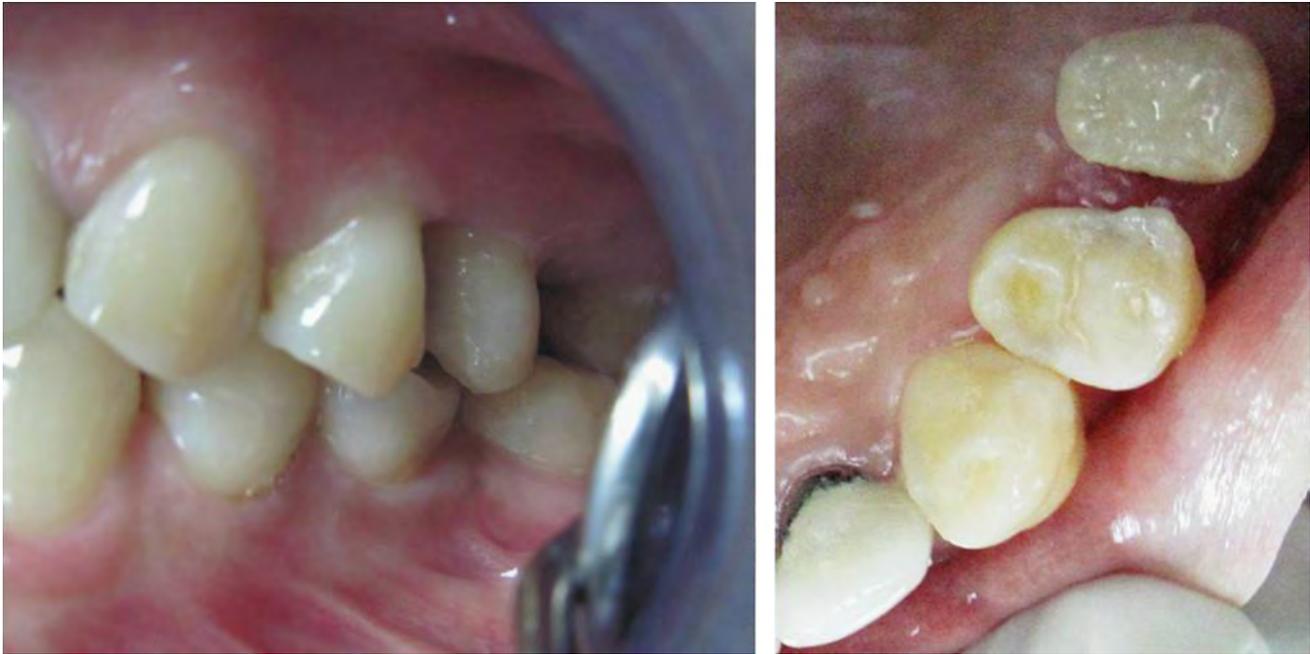


Fig. 6 – Six months postoperative photograph of teeth 24 and 25.



Fig. 7 – Six months radiograph showing bone fill in relation to tooth 24.

promoting wound healing, reducing the inflammatory process and can lead to angiogenesis [18].

All the above factors led to our decision of combining PRF along with Puros to achieve a predictable and stable outcome of the treated site which was achieved on six months follow up of our patient.

Conclusion

Our aim of presenting this report is to create awareness among the dental fraternity regarding electrosurgical injuries. Although the incidence of electrosurgical injuries is relatively uncommon in the dental operatory, if such injuries occur, dentists should be knowledgeable enough to handle such situations. In our report we have highlighted an injury caused

by electrosurgery, with its management. To our knowledge, this is the first time platelet rich fibrin has been used in the management of intraoral electrosurgical injury. The authors feel that combining bone grafts with PRF is a good alternative as it can be done with relative ease and predictable outcome.

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Case report

Rapid fabrication of a digital prosthesis



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ABSTRACT

Finger prosthesis often needs refabrication due to its discoloration following use. This article presents a novel, economical, and cost-effective technique to duplicate the patient's existing prosthesis to obtain a new wax replica, which is then clinically tried and processed to obtain new silicone finger prosthesis. This technique requires comparatively less clinical and laboratory steps as to fabricate an entirely new prosthesis. The newly fabricated silicone finger prosthesis has the fit and marginal adaptation of the patient's existing prosthesis but the esthetics is improved.

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Introduction

Fingers or digits have an important role in the function and aesthetics. The loss of the digits leads to functional and psychological problems [1–3]. Silicone finger prostheses have lifelike appearance [4]. Finger or digital prosthesis have been also used to prevent and protect ulcerated finger tips in patients with microangiopathy of fingers [5].

Finger prosthesis often has low durability when compared to facial prosthesis. It needs to be frequently replaced as it can be irreversibly stained or discolored due to repeated insertion and removal. Fabrication of new finger prosthesis is time consuming and requires several clinical and laboratory steps [6]. Even after fabrication of the finger prosthesis, intricate adjustments are necessary during the delivery visit to obtain a retentive fit and proper marginal adaptation. In some scenarios, a well-fitted prosthesis may need to be replaced due to discoloration or wear of the existing prosthesis.

This article presents a novel cost-effective technique to fabricate new finger prosthesis by duplicating the patient's

existing prosthesis to obtain a wax replica that has the fit and marginal adaptation of the patient's existing prosthesis. The wax replica needs fewer adjustments to obtain a comfortable and retentive fit as compared to fabricating an entirely new wax up, reducing the overall fabrication time. The newly fabricated prosthesis has improved esthetics and the fit and marginal adaption as that of the patient's existing prosthesis.

Technique

1. Make impression of the patient's existing finger prosthesis with irreversible hydrocolloid impression material (Jeltrate Regular Set; Dentsply) in a small container (Jeltrate Regular Set; Dentsply) and make key groove at the edge of the impression for orientation of the stone stump in the later stage (Figs. 1 and 2).
2. Box with tape (Fig. 3) and pour the inner surface of the silicone prosthesis and over the hydrocolloid impression with Type IV dental stone (Nok Stone; Lafarge) to get the

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Fig. 1 – Patient's existing finger prosthesis.



Fig. 2 – Irreversible hydrocolloid impression of patient's existing prosthesis.



Fig. 3 – Boxing the hydrocolloid impression.

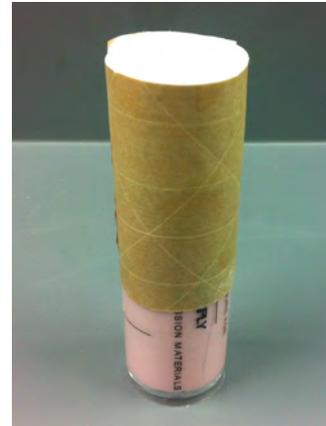


Fig. 4 – Pouring the impression with Type IV dental stone.



Fig. 5 – Removed stone finger stump.



Fig. 6 – Pouring the hydrocolloid impression with molten baseplate wax.

stone stump with base (Fig. 4). Gently remove the stone digit stump from impression after the stone sets so that the impression remains intact (Fig. 5). Apply thin layer of separating medium (Tinfoil substitute; Factor II Inc) over the stone stump.

3. Pour the hydrocolloid impression with molten baseplate wax (TT 100 soft; Cavex) to obtain a wax replica of the patient's existing finger prosthesis (Fig. 6). Place the stone stump over the hydrocolloid impression filled with wax and allow the wax to set (Fig. 7). Gently remove the wax replica of finger prosthesis by tearing the hydrocolloid impression (Fig. 8).
4. Try in the wax replica and do necessary adjustment and final texturing (Fig. 9). Fabricate a 3-piece mold from Type

- IV dental stone (Nok stone; Lafarge). Eliminate the wax from the mold and apply tinfoil-separating medium (Tinfoil substitute; Factor II Inc).
5. Mix room temperature vulcanizing silicone (MDX 4-4210; Factor II Inc) according to the manufacturer's recommendation with intrinsic stains to match the shade of the patient's skin and pack the silicone into the mold.

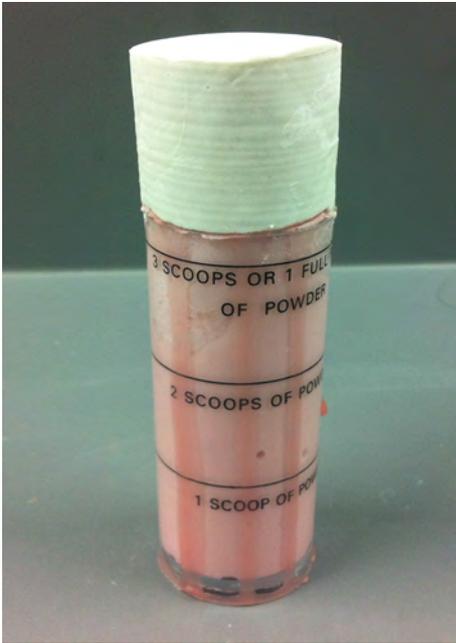


Fig. 7 – Placing the stone finger stump over the impression filled with wax.



Fig. 8 – Removed wax replica of finger prosthesis from the hydrocolloid impression.



Fig. 9 – Try in of the wax replica of finger prosthesis.



Fig. 10 – Try in and delivery of the silicone finger prosthesis.

6. After complete polymerization of the silicone, evaluate the prosthesis to verify the fit. Extrinsically stain the finger prosthesis and deliver it (Fig. 10).

Discussion

Unlike other extraoral prosthesis, finger prostheses are commonly retained with the friction-fit or with implant [2,6,7]. The use of friction-fit is a common and economical method of retention for finger prosthesis, and is useful when a part of the stump is remaining [2,6]. Although digit prosthesis often has a high patient acceptance, retention, marginal adaptation, and color matching are important aspects that should be considered during the fabrication.

In scenarios that warrants a rapid replacement of finger prostheses, this technique can be useful as the described technique allows the fabrication of a new wax replica with relative ease. Fabrication steps are considerably reduced as the obtained wax replica has the fit and marginal adaptation as that of the patient's existing prosthesis. Minor adjustments to the wax replica can also be made to improve the fit and adaptation, as it can be clinically evaluated before processing.

However, the impression material should be properly mixed to prevent porosities and the impression should be carefully poured to obtain an accurate working cast. A key groove or an anti-rotation feature should also be incorporated in the impression for the proper orientation of the stone stump during the duplication process. Before removal of the working model from the impression, sufficient time should be given for the wax to set in order to prevent distortions of the wax. There may be loss of some anatomical details during the duplication process and the wax replica may need minor adjustments and texturing. A ring can also be worn to hide the margins (Fig. 10). In case the previous prosthesis is significantly damaged, the duplication of previous prosthesis might not be a good option.

Conclusion

The patient was satisfied with the overall retention and esthetics of the new silicone finger prosthesis. The described technique provides the clinician with a novel, cost-effective

technique for the fabrication of finger prosthesis with the fit and marginal adaptation of the patient's existing prosthesis.

Acknowledgment

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