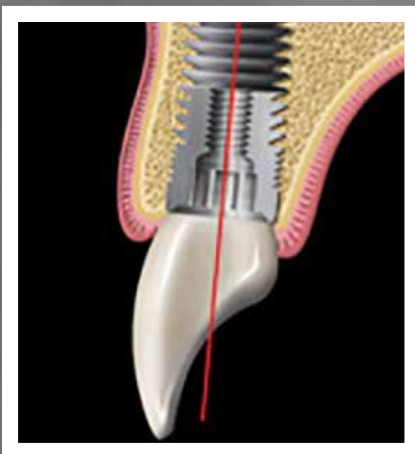


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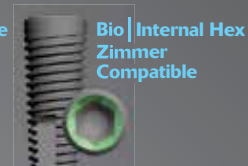
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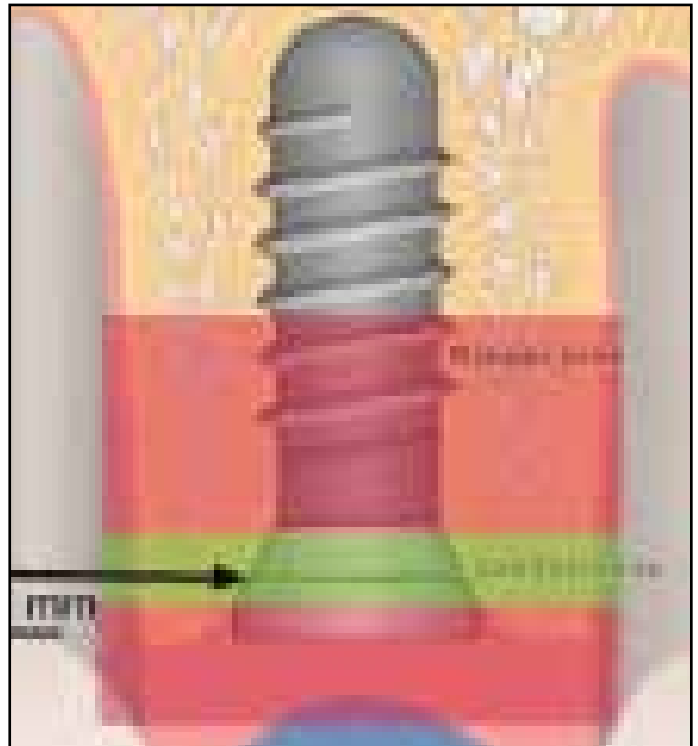
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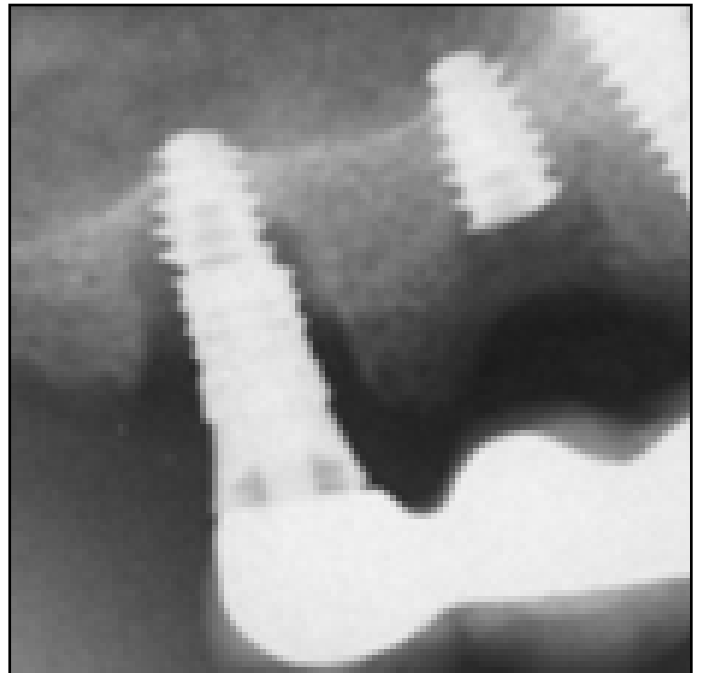
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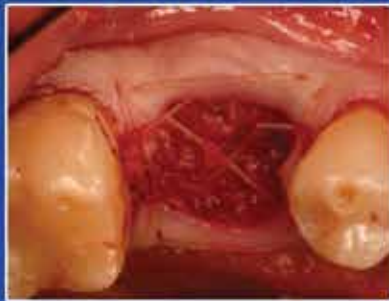
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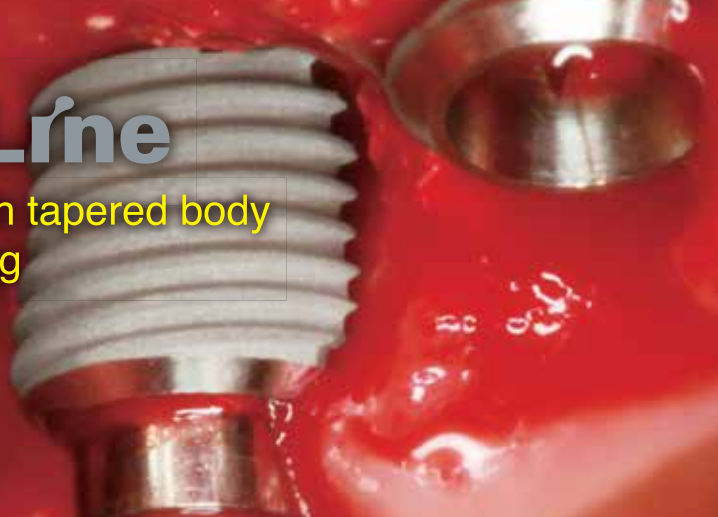
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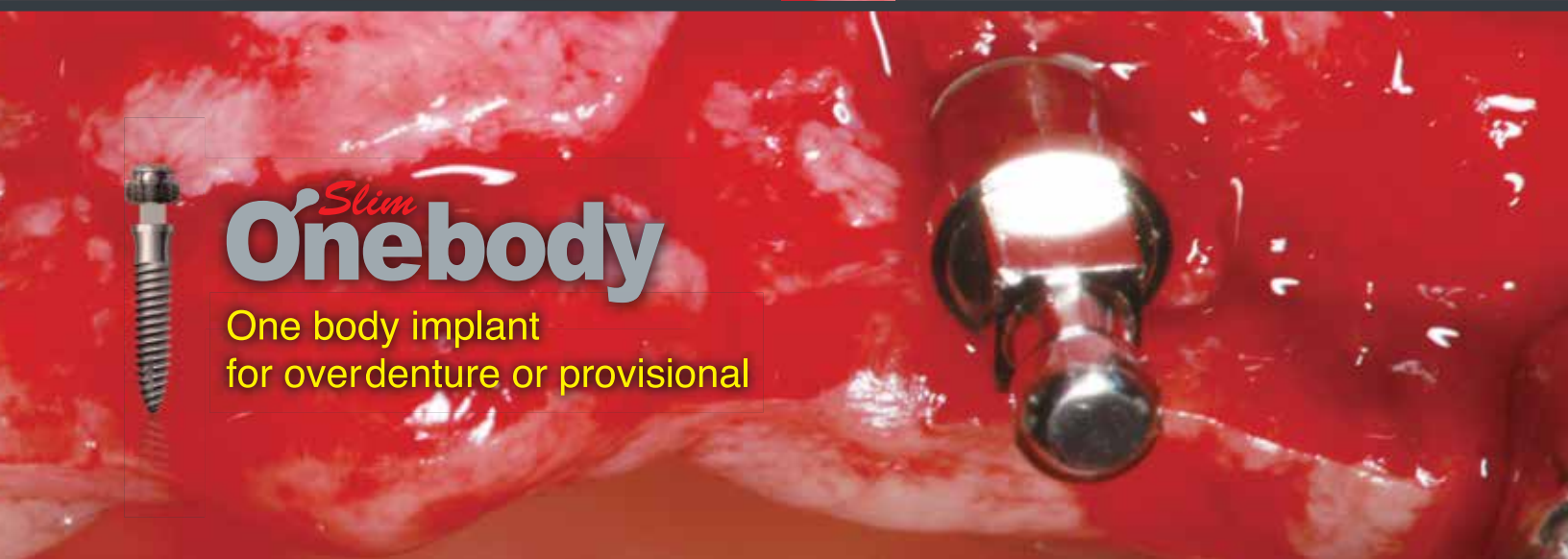
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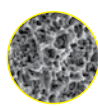
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Immediate Placement of Mandibular Molar Dental Implants: Case Report

**Dr. Mohit Zamad¹ • Dr. Aakanksha Zamad²
Dr. Akshay Daga³ • Dr. Pankaj Akhare⁴**

Abstract

Commonly, immediate dental implants have been reserved for the single rooted anterior tooth and single or bi-rooted premolar tooth. Perhaps the most important aspect of any implant surgery in accordance with the successful procedure is implant stability and bone to implant contact (BIC). Immediate dental implant placement has been an acceptable procedure for at least the past two decades. Removal of molar teeth provides a challenging and intriguing dilemma due to multiple root morphology. In the case of extraction and immediate placement of dental implants preserving alveolar bone proper, particularly that of the labial and lingual plates

of bone is essential in providing the optimal environment for maximizing BIC and implant stability. Also, the position of the final restoration must be considered, in relation to intra and inter arch position, occlusion, function and esthetics. Thus, minimal alveolar bone removal should be considered and attained to aid in the above factors in order to provide an acceptable surgical site for successful placement of the dental implant. Finally, and perhaps most importantly when considering immediate molar implant placement, removal of the intra-alveolar septum should be avoided to aid in increasing BIC and allowing the attainment of initial implant stability at the time of placement.

KEY WORDS: Dental implants, immediate placement, mandible, molars

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4. Department of Orthodontics, VSPM Dental College and Research Center, Nagpur, India



Figure 1a: Pre-operative radiograph.

INTRODUCTION

Immediate implant placement following tooth extraction in appropriately selected cases can be considered an optimal procedure for the following reasons: the natural healing process is mobilized to the maximum, no bone resorption, drilling is reduced, number of surgical stages are eliminated, design and construction of prosthesis is simplified, and positive psychological effect on the patient.^{1,2} As per previous studies, immediate dental implant placement was carried out in single rooted teeth more successfully. The posterior mandible can be considered for implant placement because of the premature loss of molars and it is always a challenging task to place implant in multi-rooted teeth as there is discrepancy between size of implant and socket. However, their use is complicated by the anatomic obstacles of the inferior alveolar nerve and the presence of softer bone.^{3,4} The implant diameter is often smaller than the diameter of the root of the extracted tooth. In cases where the distance between the implant and the extrac-



Figure 1b: Atraumatic extraction of mandibular first molar.

tion socket is less than 2mm, spontaneous bone healing can be expected without the necessity for additional grafting procedures.^{5,6,7} However, if the gap is more, then augmentation procedures are carried out by using synthetic bone graft followed by non-resorbable expanded polytetrafluoroethylene (ePTFE) membrane for soft tissue augmentation.^{8,9,10}

CASE REPORT ONE

A 30 year old, non-smoker visited the Department of Oral & Maxillofacial Surgery, VSPM Dental College & Research Centre, Nagpur. Tooth #30 was vertically fractured (Fig.1a) and was



Figure 1c: Placement of barrier membrane.



Figure 1d: Abutment placement.



Figure 1e: Final prosthesis.



Figure 1f: Post-operative radiograph after prosthesis delivery.

not associated with any infection. All the available treatment options were discussed with the patient which involves the hemisection of lower right 1st molar with extraction of the distal root and tooth segment and metal ceramic bridge fabrication; extraction of lower right 1st molar and fabrication of a metal ceramic bridge, extraction of lower right 1st molar, followed by a delayed implant placement, or an immediate implant placement. The patient opted for immediate implant

placement for which the patient consented. All the necessary blood investigations were carried out and radiological investigations were evaluated for the selection of implant size.

A crevicular incision extending to the adjacent teeth was made and a full thickness envelope flap was reflected and the molar was atraumatically extracted. The socket was curetted and irrigated with saline solution (Fig.1b). The dimension of the socket was measured



Figure 2a: Pre-operative radiograph showing mandibular molar.



Figure 1d: Pre-operative radiograph showing mandibular molar.



Figure 2c: Clinical photo of extraction socket following mandibular molar removal.



Figure 2d: Immediate dental implant placement into molar socket.

with a periodontal probe (UNC 15, Hu Friedy, Germany) after tooth extraction. The mesiodistal distance was 9mm, buccolingual distance was 8mm and the depth in the mesial side was 8mm. A 4.2x11.5mm dental implant was placed into the interradicular bone. A pilot drill (2mm) was used for initial preparation and was followed by sequential drilling along the implant axial line to allow the implant to have adequate

bone contact and implant placement. Synthetic bone graft was used to cover the implant into the remaining socket and a non-resorbable ePTFE membrane was then secured over the socket for regeneration of soft tissues and bony augmentation (Fig 1c). The patient was then prescribed an appropriate antibiotic and analgesic and chlorhexidine mouthwash.

The membrane was removed 4 weeks after



Figure 2e: Abutment placement.



Figure 2f: Final prosthesis.

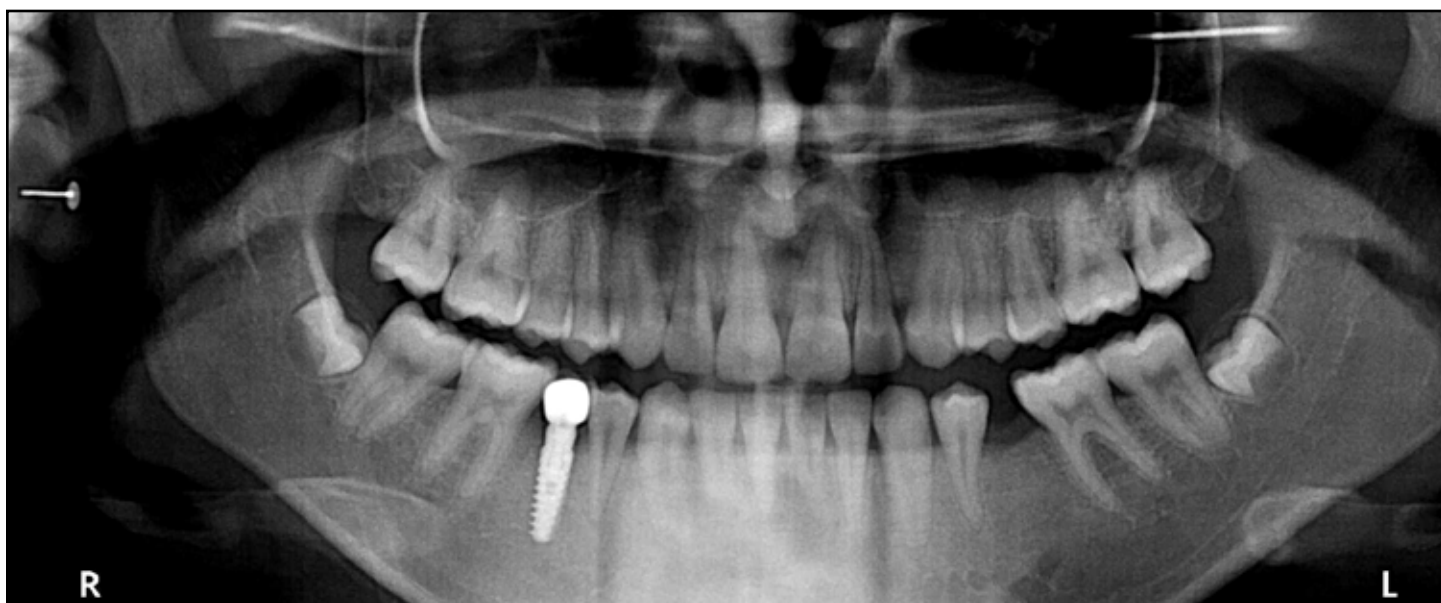


Figure 2g: Panoramic radiograph of final prosthesis.

surgery and a healing cap was placed 6 months after surgery. Two weeks after this, the healing cap was removed and implant was loaded with a single ceramic crown (Figs. 1 d, e, f).

CASE REPORT TWO

A 17 year old female reported in our depart-

ment with a complaint of retained lower right deciduous molar (Figs. 2a,b) and wanted to replace it. All the treatment options as for Case 1 were given and patient opted for immediate implant placement. All the pre-operative investigations were within normal limits. The same surgical procedure was carried out for



Figure 3a: Pre-operative radiograph.



Figure 3b: Post-operative radiograph following dental implant placement.

implant placement as in the previous case (Figs. 2c,d). In this case, no bone graft was required as the gap between implant the socket was wall was less than 2mm and primary stability immediately after implant placement was satisfactory. A prosthesis for this patient was given after 3 months (Figs. 2e, f, g).

CASE REPORT THREE

A 23 year old male patient reported in our clinic for extraction of his carious right mandibular first molar (Figs. 3a, 3b). The patient opted for immediate implant placement.

RESULTS

Clinical evaluation was performed at one, two and three months preloading, then at one, three and six months after loading including following parameters: Probing depth, bleeding index and gingival index, except for Case 1 in which preloading follow up was 6 months as the primary stability was average. Radiographic evaluation was done for all cases

at same follow up post loading periods using periapical and panoramic radiographs to assess marginal bone height and bone density mesial and distal to implant fixture.

Postoperative follow up visits for all three patients were made every week during the first 4 weeks and then followed by a maintenance program consisting of semi-annual follow up appointments for 2 years. Results of our study are reported in Table 1.

PRE-LOADING CLINICAL EVALUATION

All three patients were followed up at one, two and four months post operatively. At the first week postoperative, some discomfort was reported without any complaint of severe pain or edema. All wounds healed properly during follow up period.

POST-LOADING EVALUATION

This was done one, three and six months post loading as implant mobility was tested using the Miller Mobility Index (MI) scores.¹¹

Two of our cases showed no mobility during the follow up period. The remaining one case showed decline in mobility index scores through the follow up period. Probing depth¹² was measured for each implant for the four surfaces collectively (buccal, lingual, mesial and distal). There was gradual decrease in probing depth measurement during the study period. Bleeding index¹² were measured from the four surfaces collectively around the implant. At the three months follow-up period the bleeding index value showed a decline and a further decline was apparent at the six months follow-up period. Gingival index¹² scores were measured of the four surfaces collectively for all implant surfaces. At three months follow-up period a decline in the gingival index score was noticed. At six months follow up period, further decline in gingival index score was shown.

RADIOGRAPHIC EVALUATION

Both marginal bone height and bone density were evaluated for all cases throughout the post-loading follow up period. For the marginal bone height measurements, there was decrease in the marginal bone height around all implants at the three months post-loading period and then increase in the six months post-loading period.

DISCUSSION

All the 3 patients were very pleased with the functional outcomes of their treatment. A main factor determining the success of immediate placement is the initial stability of the implant. The extraction site must be evaluated to see whether it is suitable

for immediate implant placement. Micromovements between implant and surrounding bone should be avoided to allow successful healing to occur. In the present case reports, the interradicular septum of extraction socket was used to anchor the implant. Therefore, sufficient height and width of the interradicular septum should be considered serious selection criteria for this treatment modality. Further selection criteria include the following: (1) absence of clinical signs of acute periodontal or endodontic abscess formation²; (2) establishment of healthy periodontal conditions before surgery; (3) patient compliance.

It has been suggested that the implant should be placed into a minimum of 3 mm of solid bone apical to the extraction site.^{13,14,15,16} The observation of a crestal gap between the implant shoulder and the socket wall is a common finding and in such cases augmentation procedures are indicated.¹⁷ All the 3 extraction sockets had intact socket walls after extraction. Following placement of the implants, primary stability of all cases were good except in the first case where primary stability was not achieved. All the cases had good soft tissue architecture preservation at one week post surgery with minimal edema and there were no complaints of pain nor discomfort during early post operative healing period. All the implants achieved successful osseointegration after a healing period of between 3 and 6 months. The residual peri implant socket spaces were found to be well healed exhibiting no implant thread exposure at the end of healing process. In our study, two cases have showed no mobility throughout the post-loading follow-up period and one

Table 1: Study Results

Patient No.	Age/Sex	Extracted tooth and implant replacement site	Reason for extraction
1	32/Male	Mandibular right first molar	Non-restorable tooth structure secondary to vertical tooth fracture
2	17/Female	Manibular over retained primary first molar	To replace the missing tooth
3	23/Male	Mandibular right first molar	Non-restorable tooth secondary to caries

case showed gradual decline in the Mobility Index scores and decrease in Gingival bleeding indices as well as Probing depth during the follow-up period. This indicated healing of soft tissue attachment around the implant and absence of peri-implant disease due to extensive oral hygiene instructed to the patients. This is in agreement with Linkow et al.¹⁸ who stated that periodontal indices were not directly related to the success or failure of osseointegration of implants. They are used for monitoring peri-implant soft tissue.

CONCLUSION

The above findings suggest that in cases of immediate implant placement in molar region, a sufficient interradicular bone width can be uti-

lised for primary retention of immediate implant successfully. The long term stability of immediate implant placement in the molar region has been demonstrated previously; however, the existing data is not sufficient for determination of treatment guidelines. More extensive and long term study is further motivated. ●

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Table 1: Study Results

Inter radicular bone after extraction	Labial peri implant socket gap distance	Primary stability	Peri implant socket grafting	Healing period before final prosthesis (in months)
Intact	> 2mm	Average	Yes	6 months
Intact	< 2mm	Good	No	3 months
Intact	< 2mm	Good	No	3 months

Disclosure

The authors report no conflicts of interest with anything mentioned in this article.

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Treatment Planning Considerations for Cemented Versus Screw-Retained Single Tooth Dental Implant Restorations in the Aesthetic Zone – Advantages, Disadvantages and Maintenance Issues: A Literature Review

Kenneth K.H. Cheung, BDSC, MSC¹

Abstract

Background: The use of a single implant retained crown to replace a missing tooth has gained popularity since 1990. There are two design options for the implant supported crown: the crown can be cemented onto an implant supported abutment (be it pre-fabricated or custom designed, as would be done if the crown were tooth supported) or the crown can be a screw-retained, direct-to-fixture crown (provided that the implant has been placed at the correct axial inclination). Different philosophies exist regarding the best type of implant restorations in the aesthetic zone. The literature details the advantages and disadvantages for both screw- and cement- retained implant prosthesis.

Methods: Treatment planning, including restorative, surgical, occlusal, and maintenance aspects will be reviewed using a review of the literature. The search was restricted to English-language publications from 1990 to pres-

ent. Giving preference to systematic reviews and long-term, patient-based outcome data, prospective longitudinal studies and retrospective studies were included in the search.

Results: There is no clinical evidence to suggest that one type of restoration yields superior clinical outcomes than the other. It has been reported that cement-retained prosthesis exhibited more biological complications but less technical problems; whereas screw-retained prosthesis exhibited more technical issues but less biological complications.

Conclusion: For the reasons described in the literature, it is the author's preference to use screw-retained implant restorations in the aesthetic zone. However, the implant angulation during placement is more technique-sensitive when a screw-retained prosthesis is used. Proper diagnostic workups, and the use of a surgical guide are necessary in order to achieve an ideal result.

KEY WORDS: Dental implants, literature review, aesthetics, maintenance

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Figure 1a: Average smile line (87% of population).



Figure 1b: High "gummy" smile line (4% of population).



Figure 1c: Low smile line (6% of population).

EVALUATION OF AESTHETIC COMPONENTS

A systematic analysis that progresses from facial, dentofacial, and dentogingival to dental is mandatory for a successful aesthetic outcome in the aesthetic zone. The use of a smile evaluation form proposed by Calama can assist in developing an organised approach to treatment planning.³

Dentofacial analysis - smile evaluation

The amount of exposed tooth and supporting gingival tissue displayed during function and facial expression is associated with an increase in aesthetic risk (Figures 1a-c). Passia described the relationship between the smile line and the category of a person's smile.⁴

Dentogingival analysis - soft tissue and tooth morphology

Olsson outlines the relationship between tooth morphology and soft tissue quality.⁵ A triangular shaped tooth is generally associated with a scalloped, thin periodontium whereas a square shaped tooth is usually associated with a thick, flat periodontium (Figures 2a, 2b). Kois stated

BACKGROUND

Treatment planning for single tooth implant restoration in the aesthetic zone involves a comprehensive work-up which should include a medical and dental examination, smile assessment, diagnostic models, and special tests. Tischler proposed the guidelines for implant placement in the aesthetic zone; which include: proper evaluation of the existing hard and soft tissues, correct implant placement and proper loading and unloading time, visualisation of a three-dimensional position, assessment of the emergence profile and proper selection of the abutment and design of the final restoration.^{1,2}



Figure 2a: Thin biotype.



Figure 2b: Thick biotype.

that soft tissue biotype can influence the aesthetic outcome of the final implant restoration.⁶ A thin scalloped biotype reacts to periodontal disease or surgical insult by facial and interproximal recession. In contrast, a thick, flat biotype is relatively resistant to surgical trauma.^{5,7}

Dentogingival analysis - Osseous architecture and anatomical topography

Failure of the final outcome may be due to a failure to recognise the discrepancy between the osseous anatomical form and the final restoration. Schroeder estimated that the width of the bundle bone may vary between 0.1 and 0.4 mm. By using a cone-beam CT, Araujo found that 50% of the facial bone wall examined had a thickness of less than 0.5 mm, and may solely be comprised of bundle bone.⁸ As the bundle bone is a tooth-dependent tissue, it will lose its function and disappear following the removal of a tooth, and result in a ridge defect.⁹ Studies by Schropp found a 30% reduction after three months, and over 50% reduction after 12 months in the buccal-palatal width of the ridge.^{10,11} A ridge defect would have an

adverse effect on the emergence profile and soft tissue aesthetics around an implant crown.

Dental analysis - Three dimensional positioning

An optimal aesthetic implant restoration depends on proper three-dimensional implant positioning. The evolving concept is known as restoration-driven implant placement, or a “top-down planning approach.”¹² A diagnostic wax-up on articulated models is required in aesthetic cases as it assists in treatment planning. It also previews the future restoration, helps assess the occlusion, helps decide on implant location, and forecasts any potential difficulties.¹³ A duplicate of the wax-up can be used to create a surgical guide (Figure 3). Studies claimed that the use of three-dimensional imaging together with a stent was a more efficacious technique than using two-dimensional images and a diagnostic model.^{14,15} Once planning for the crown has begun, the type of implant and the orientation of implant axis can be determined.¹⁶ A screw-retained single tooth implant restoration offers the advantages of absence of residual cement,



Figure 3: Example of dental implant surgical guide.

retrievability and serviceability. The crown can be removed, repaired, cleaned, and replaced.^{17,18,19}

IMPLANT ANGULATION

Correct angulation of the implant (Figure 4a) is a key factor for a screw-retained restoration in the aesthetic zone.⁷ It should have the long axis of the implant body exiting at the cingulum of the tooth in order to allow for a screw access angle that does not compromise the incisal edge of the restoration.

Labio-palatal position

Proper labio-palatal positioning of the implant (Figure 4b) is a function of the design, size of the implant and abutment, and the orientation and morphology of the final restoration.

An implant shoulder placed too far labially will result in the potential for gingival recession, leading to the loss of a harmonious gingival margin; whereas too far palatally can reduce the running room to develop a proper emergence profile.

Mesiodistal position

Proper mesiodistal positioning of the implant (Figure 4c) is a function of the horizontal dis-

tance available, the size of implant selected and its planned position. It is correlated to the amount of crestal bone loss and the maintenance of the interdental papillae.²⁰

Loss of crestal bone height after implant placement due to routine circumferential bone saucerization (1.0–1.5 mm) around the implant shoulder will result in further reduction of papillary height. A study performed by Tarnow examined 288 sites in 30 patients, and reported that if the distance from the base of the contact point to the crest of the bone is less than 5 mm, the papilla will fill the embrasure almost 100% of the time.²¹

Apicocoronal position

Proper apicocoronal positioning of the implant (Figure 4d) is a function of the size of the implant selected, the amount of countersinking, and the cemento-enamel junction location of the adjacent teeth. Inadequate apical positioning of the implant can result in the risk of a visible metal margin through the gingivae and an abrupt emergence profile. Ridge-lap design may be required to compensate for the inadequate running room from the implant platform to the gingival margin in order to satisfy aesthetic demand. In contrast, the more apical the placement of the implant, the more running room there is for the emergence profile. However, the deeper the microgap is positioned the higher the risk of undesirable crestal bone loss and subsequent gingival recession.

OCCLUSAL CONSIDERATIONS

The occlusal scheme

A review found that implants are more susceptible to occlusal overload than natural teeth due to their narrower size compared to a natural root, and the absence of a periodontal ligament.¹³

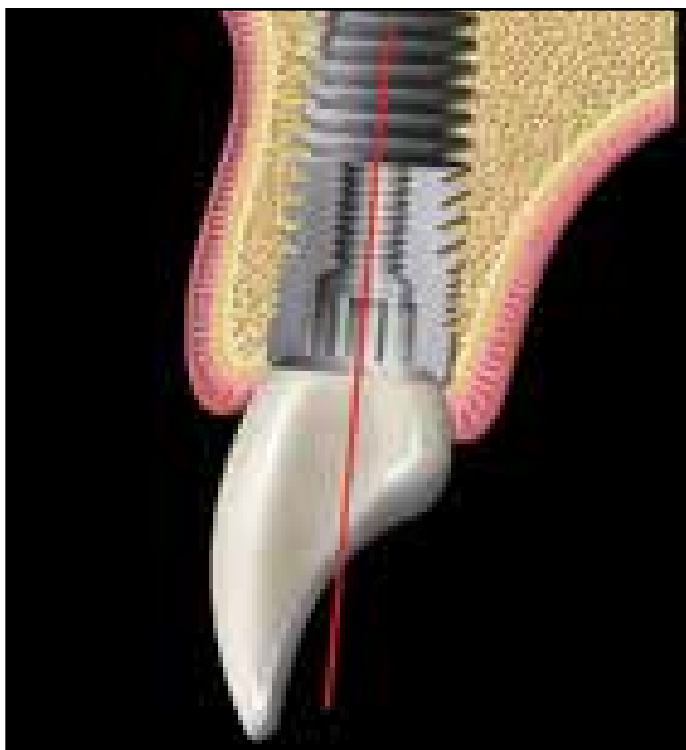


Figure 4a: Ideal dental implant angulation.

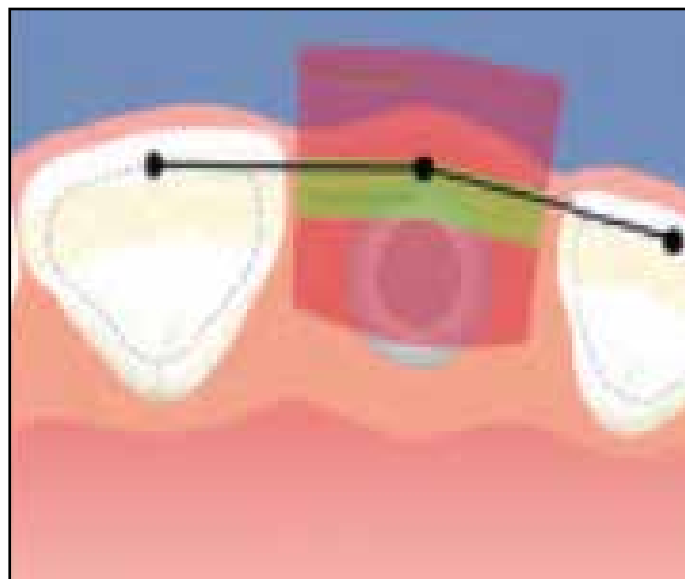


Figure 4b: Labio-palatal position of dental implant.

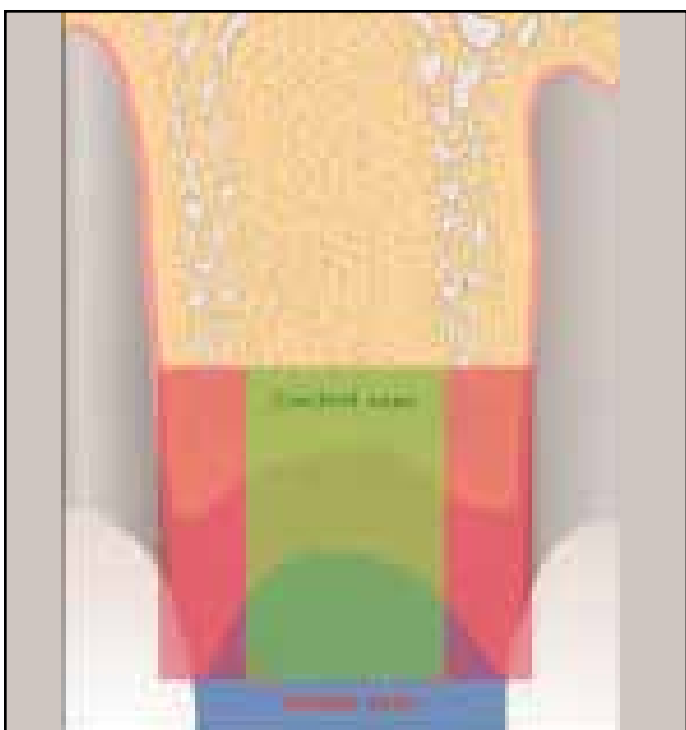


Figure 4c: Mesiodistal position of dental implant.

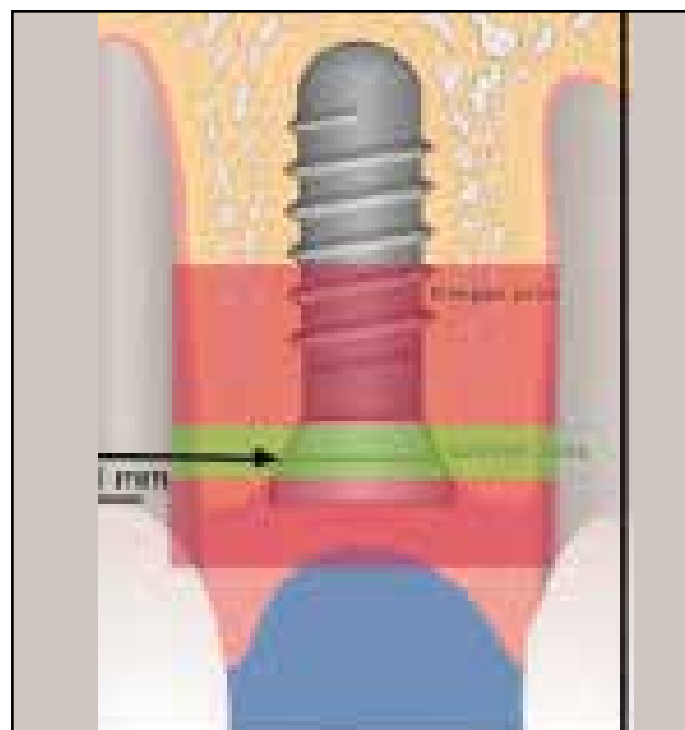


Figure 4d: Apicocoronal of dental implant.

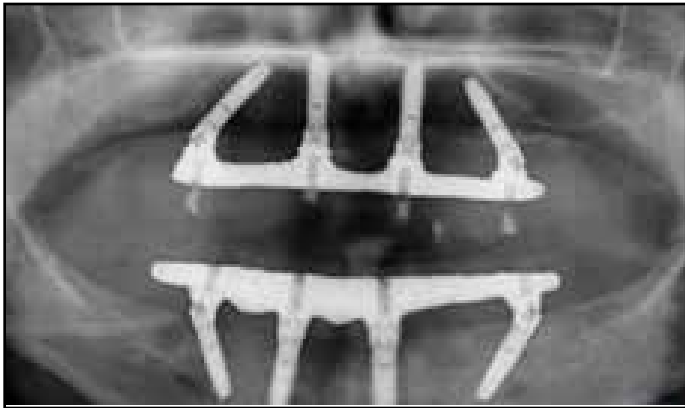


Figure 5: Example of tilted implants used in edentulous arches.

Osseointegrated implants have a limited capacity to axial displacement (3–5 μm), and consequently have a lower adaptive capability. It was found that proper occlusal management can help reduce unnecessary functional and non-functional loads on implant supported restoration in the anterior region.²² Recommendations from Fenton and Schmitt stated that implant supported restorations should make light contact with the opposing natural dentition in the intercuspal position, while remaining free from contact in all excursive movements.²³ It has been proposed that single tooth implant crowns should demonstrate 30 μm light contact with opposing natural dentition, and with shimstock (8–10 μm) clearance at the intercuspal position.^{13,24} A systematic review investigated whether the occlusal design of fixed and removable prosthesis has an influence on diet, parafunction and quality of life.²⁴ From the review of 1315 studies, it was observed that there is no scientific evidence specifying an ideal occlusal and superstructure design in fixed prostheses for optimising clinical outcomes. It was stated that complex neurophysiological mechanisms allow the masticatory system to adapt to subtle or gross

changes in the oral and dental status. Based on a review of finite element analysis data in 2012, it was further explained that an optimum restoration design is significant for bone remodeling and bone load around implants with occlusal loading. Klineberg concurs with Davies that contact in centric occlusion with minimal lateral loading in function and parafunction is recommended.²⁵

Non-axial loading in the maxillary anterior region

Implants in the aesthetic zones are subjected to a non-axial protrusive force. Literatures have stated that the application of non-axial loading onto dental implants should be avoided whenever possible, as non-axial forces can create high stress concentration areas, which can induce a greater risk of mechanical complications and implant failure.^{26,27} The use of tilted implants has become popular in the rehabilitation of edentulous jaws, and on patients with maxillary atrophy. Several recent literature reviews compared the use of axial implants, tilted implants, or a combination in rehabilitating edentulous and partially edentulous patients (Figure 5). High success rates and no significant difference in marginal bone loss have been found between tilted and axial implants in the reviewed studies.^{28,29,30} There is little evidence to demonstrate a negative effect on peri-implant bone loss after extended periods of non-axial loading.³¹ Another study compared the success rate and marginal bone loss between straight implants and tilted implants.^{32,33} Both studies found that there is no significant difference in mean marginal bone loss between the axial and tilted implants. There is inadequate scientific evidence to show a higher incidence of biomechanical complications in tilted implants.

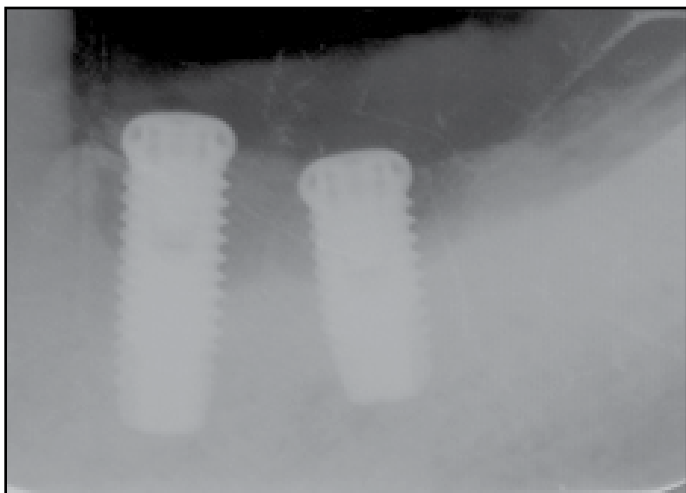


Figure 6a: Radiograph of peri-implantitis.

MAINTENANCE ISSUES

Complications (biological and technical) have been reported in both screw-retained and cement-retained implant restorations. A high risk of technical complications is reported with screw-retained crowns, while a higher biological complication is observed with cement-retained crowns.

Biological complications

The consensus report of the Sixth European Workshop on Periodontology reported that peri-implant mucositis occurs in about 80% of subjects restored with implants, and peri-implantitis (Figures 6a, 6b) occurs in 28 to 56% of subjects restored with implants.³⁴

Excess cement

Strong evidence in the systemic review showed that poor oral hygiene, history of periodontitis, diabetes, and smoking are the risk factors for peri-implant disease.³⁵ Other factors that may contribute to the progression of peri-implant disease include inadequate abutment seating, screw loosening, and fractured abutment screws.



Figure 6b: Clinical photo of peri-implantitis.

One of the most commonly reported factors is the presence of excess cement (Figure 7) in the soft tissue around cement-retained crowns.³⁶ A systematic review examined data from 46 studies in 2012 and reported a cumulative five year biological complication rate of 5.2%.³⁷ Another recent review on data from 59 clinical studies, comparing cemented to screw-retained restorations found that the biological complications of marginal bone loss greater than 2 mm occurred more frequently with cemented crowns (five year incidence 2.8%) than with screw-retained crowns (five year incidence of 0%).³⁸ Equally, a meta-analysis reported a 7.1% cumulative soft tissue complication rate over five years, and a 5.2% cumulative complication rate for implants with bone loss over 2 mm.^{37,38} Like Jung, Sailer investigated the biological complications with marginal bone loss greater than 2 mm. Data from their systematic review reported 2.8% for a five year incidence with cemented crowns compared with 0% with screw-retained crowns. Several articles have reported the clinical significance of residual cement that can lead to gingival inflam-

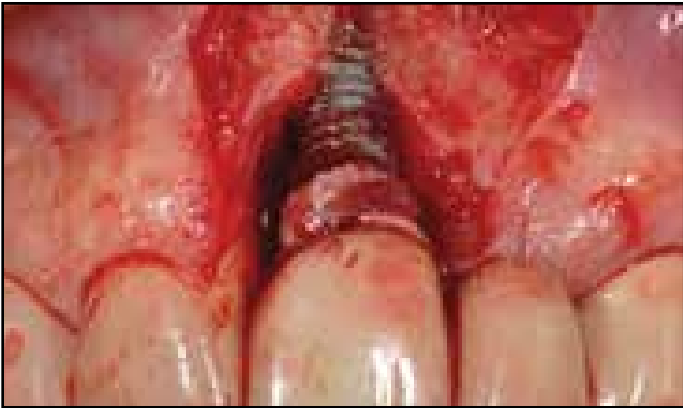


Figure 7: Peri-implantitis due to excess cement.

mation, suppuration and crestal bone destruction. An investigation on the predisposing factors that can lead to retained excess cement, included: the presence of a circular connective tissue cuff around the implant collar and abutment, a less than ideal positioning of the implant, a deep sub-gingival restorative margin, and the type of cement used.³⁶ Compared with a cement-retained restoration, the fabrication of screw-retained restorations may require additional components (impression transfers, analogues and screws) and higher initial costs. However, the main advantage of a screw-retained restoration is its predictable retrievability, without damaging the restoration or fixture. It allows easy adjustment, easy access to refasten loose screws and easy retrieval of the crown for repairing fractured porcelain. It has a lower maintenance cost and requires less treatment time than that of cement-retained restorations.¹⁷ Also, it has the ability to allow for modification to accommodate any future tooth loss.¹⁸

Crown retention

Most prefabricated implant abutments have a six-degree taper, which is based on the design retention of a conventional tooth supported

crown.³⁹ For the cement retained restoration, a minimum of 5 mm abutment height is required to ensure adequate retention. It can be difficult to achieve such abutment height on the palatal aspect in the maxillary anterior region, unless it is extended 2 to 3 mm sub-gingivally, which in turn increases the risk of peri-implant problems when cement-retained restorations are used. A recent prospective clinical study on 53 subjects measured the influence of the restorative margin on the amount of undetected cement and found a similar result to Shapoff.⁴⁰ Both studies agreed that the deeper the position of the margin, the greater the amount of undetected cement. The use of a screw-retained restoration can provide adequate retention where there is limited interocclusal space, without the risk of excess cement.

The UCLA abutment solves the problem of limited interocclusal space by eliminating the use of the transmucosal abutment cylinder. The implant restoration was simplified by retention with one screw directly fitted to the implant fixture.⁴¹ This also improved aesthetics by creating a better emergence profile.

Screw loosening

Screw loosening or fracturing has been reported as one of the most common technical complications with screw-retained restorations. Meta-analysis reported an 8.8% cumulative incidence for screw loosening and 4.1% for loss of retention.³⁷ Likewise, a systematic review of a five year cumulative incidence of technical complications, reported 11.9% with cement-retained restorations, and 24.4% with screw-retained restorations.³⁸ Chaar assessed the prosthetic outcome of cement-retained restora-

tions.⁴² The report included 15 studies with less than five year observation periods and 17 studies with over five year observation periods. The most common technical complications found in cement-retained restoration were loss of retention, porcelain chipping, and abutment screw loosening. Abutment screw loosening occurs in both screw-retained and cement-retained restorations and can be caused by prosthetic misfit, insufficient clamping force, screw settling, biomechanical overload, heavy occlusal forces, or non-axial forces.⁴³ It was a common problem with early screw designs due to the lack of devices that could deliver a specified torque during screw tightening. In order to achieve sufficient clamping force to retain the implant prostheses, it is important that all screws be tightened to manufacturers' specifications using a torque wrench to deliver an initial preload.¹⁷ Preload is a compressive force generated across a joint that keeps the screw threads secure to the mating counterpart, and holds the separate parts together. The elongated screw places the shank and threads in tension. It is the elastic recovery of the screw that generates the clamping force that holds the prostheses and the implant together.^{44,45} It is limited by the frictional resistance of the contacting screw threads, the flange and the opposing joint surfaces.⁴⁶ Torsional relaxation of screw shaft, embedment relaxation of the screw threads and localised plastic deformation will occur shortly after screw tightening. During function and biomechanical overload, both compressive and tensile forces will cause disengagement of the mating threads when the amount applied is greater than the preload, and the tensile forces may cause plastic deformation of the screw,

resulting in a reduction of the clamping force that holds the joints together.¹⁷ An in-vitro study demonstrated that 42% of preload reduction occurs within ten seconds of tightening with a 24.9% reduction over 15 hours.⁴⁵ Preload must be maintained in order to prevent joint separation, and hence to prevent screw loosening. Various reports suggested techniques to prevent screw loosening, for example, retightening abutment screw at various intervals to offset decay in preload.^{44,45} It has been shown that abutment screw loosening can result in peri-implant disease. The treatment of peri-implant disease caused by abutment screw loosening with screw-retained restorations will be more straightforward, less time consuming and less expensive than cement-retained restorations.

Technical complications - porcelain fracture

Meta-analysis parallels Pjetursson's data which reported a 3.5% cumulative incidence of fracture of veneering material with implant-supported single crowns over a five year period.³⁷ An in-vitro scanning electronic microscopic (SEM) fractographic study evaluated the fracture resistance of 40 samples for both screw- and cement-retained porcelain fused to metal single crowns⁴⁷ and reported no significant differences between the two groups. Likewise, an in-vitro study performed on 40 crowns showed that the cement-retained group had a higher mean fracture resistance than the screw-retained group.^{48,49} It was believed that the presence of the screw-access hole of the screw-retained restoration disrupts the structural continuity of the porcelain, weakens the porcelain around the opening and at the cusp

tip, and results in porcelain fracture. Despite their similar conclusions, it has been reported that normal masticatory forces range from 2 to 46.8 kg in incisor regions and 6.8 to 81.8 kg in molar regions. The amount of force required to cause the porcelain fracture recorded in the above in-vitro experiments are much higher than normal masticatory forces. A multicentre retrospective analysis comparing porcelain fracture resistance between two groups of implant restorations carried out by a group of dental specialists examined 471 patients with a total of 675 implants in the posterior region,⁵⁰ the study demonstrated statistically less complications with cement-retained restorations when comparing with screw-retained restorations. However, the data could be biased as only ten percent of the participants were restored with screw-retained restorations. These preliminary findings need to be confirmed with more robust and better design studies, ideally with similar size of participants between study groups, and with longer follow-up. Repair of a porcelain fracture will be more straightforward with a screw-retained restoration. On the other hand, cement-retained

crowns are unlikely to be retrieved intact; hence the only option is to cut the restoration off, or to access the abutment screw by cutting into the restoration. The use of screw-retained restorations has a significant long-term cost saving.

CONCLUSIONS

For the reasons described in the literature, it is the author's preference to use screw-retained implant restorations in the aesthetic zone. However, the implant angulation during placement is more technique-sensitive when a screw-retained prosthesis is used. Proper diagnostic workups, and the use of a surgical guide are necessary in order to achieve an ideal result. ●

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Disclosure

The author reports no conflicts of interest with anything mentioned in this article.

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Ultraviolet Photofunctionalization of Dental Implant Surfaces: A Review

Dr. Suraj Khalap¹ • Dr. Ajay Mootha² • Dr. Ramandeep Dugal³

Abstract

Ultraviolet photofunctionalization of titanium implants has shown promising results for treatment outcomes. Photofunctionalized dental implants have shown promising findings in regards to bone implant contact, osteoblast response, and dental

implant stability, hence opening up the avenue to be incorporated in daily implant practice. This article summarizes the findings of all the recent in vivo & in vitro research conducted regarding UV photofunctionalization of titanium implants.

KEY WORDS: Dental implants, UV photofunctionalization, osseointegration, reveiw

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INTRODUCTION

Dental implants have become the treatment modality of choice in the recent past and titanium is the material of choice. Physicochemically, it is well known that titanium constantly absorbs organic impurities such as polycarbonyls and hydrocarbons from the atmosphere, water, and cleaning solutions.¹⁻³ The results of different studies indicate that the bioactivity of dental implant titanium surfaces is affected by the level of surface hydrocarbons.⁴⁻⁶ Fresh titanium surfaces have a positive charge and are cell and protein attractive. As the surface ages, the negatively charged hydrocarbons will deposit onto the surface, cover the cationic sites and convert the surface charge of titanium to negative.⁷ Thus, the surface will become cell-inert or even cell-repellent.⁸ Various techniques have been tested to overcome these difficulties and one recent technique showing promise is ultraviolet (UV) photofunctionalization.

AGING OF TITANIUM

The biomechanical strength of bone-implant integration was substantially impaired depending upon the age of the implants. X-ray photoelectron spectroscopy revealed significantly higher levels of oxygen-containing hydrocarbons on old titanium surfaces than on newly prepared surfaces. Indeed, the atomic percentage of carbon continued to increase, from 16% to 62%, as the titanium surfaces aged.⁷ Four-week-old titanium surfaces showed only 20% to 45% of the albumin adsorption of the newly prepared surfaces with different surface topographies. UV treatment of the 4-week-old titanium surfaces increased the rate of albumin adsorption to the equivalent level (for the machined surface) or

an even higher level than the new surfaces (for acid etched and sandblasted surfaces). Similarly, cell attachment to 4-week-old titanium surfaces was less than half of that observed for the new surfaces, whereas more cells attached to the UV-treated 4-week-old surfaces than to the new surfaces.⁹ Accordingly, alkaline phosphatase activity on the UV-treated 4-week old surfaces was higher than that on the new surface, which was two times greater than that seen on the 4-week-old surface. The push-in value for newly prepared acid-etched implants at the early stage of week 2 was 2.2 times greater than that for 4-week-old acid-etched implants.⁷ Notably, the push-in value for the newly prepared implants at week 2 of healing was even higher than that of the 4-week old implants at week 4 of healing. The bone formation at week 2 was contiguous and extensive around the new implants, but it was localized and fragmented around the 4-week-old implants, leaving a large area covered by soft tissue.

CONCEPT OF PHOTOFUNCTIONALIZATION

UV photofunctionalization is defined as an overall phenomenon of modification of titanium surfaces occurring after UV treatment, including the alteration of physicochemical properties and the enhancement of biologic capabilities. UV light-induced superhydrophilicity of titanium dioxide was discovered in 1997.¹⁰ UV light treatment of titanium surfaces has been found to remove deposited hydrocarbons^{11,12} and converts the titanium surface from hydrophobic to superhydrophilic. When oxygen-containing hydrocarbons are removed, Ti⁴⁺ sites are again exposed, thereby enhancing surface bioactiv-

ity.^{8,13} UV-treated titanium surfaces also manifest a unique electrostatic status and act as direct cell attractants without the aid of ionic and organic bridges, which imparts a novel physicochemical functionality to titanium, which has long been understood as a bioinert material.

MATERIALS AND METHODS

This literature review was based on the Pubmed database using the key words “photofunctionalization” and “photofunctionalized implants.” The search was limited to articles written in English. No exclusion/inclusion criteria were used as limited data were available. Fourteen articles were found using the key words as mentioned in Table 1.

RESULTS

WAVELENGTHS OF UV LIGHT

Gao et al¹⁴ treated micro-arc oxidation (MAO) titanium samples were pretreated with UVA light (peak wavelength of 360 nm) or UVC light (peak wavelength of 250 nm) for up to 24 hours. UVC treatment promoted the attachment, spread, proliferation and differentiation of MG-63 osteoblast-like cells on the titanium surface, as well as the capacity for apatite formation in simulated body fluid (SBF). These biological influences were not observed after UVA treatment. The enhanced bioactivity was substantially correlated with the amount of Ti-OH groups, which play an important role in improving the hydrophilicity, along with the removal of hydrocarbons on the titanium surface. Yamada et al.¹⁵ concluded that regardless of topographies, the amount of bacterial attachment and accumulation was lower on ultraviolet-C pre-irradiated surfaces than on the non-irradiated

surface through 8 hour incubation. Thus UVC has shown more promising results than UVA.

CONTACT ANGLE

Att et al.¹⁶ assessed the hydrophilic status of different surfaces by means of contact angle measurements of a water droplet showed that all newly prepared titanium surfaces were superhydrophilic (contact angle < 5 degrees). As the titanium disks aged, the surface property changed from hydrophilic to hydrophobic (contact angle > 50 degrees).^{7,27,28} Interestingly, after UV treatment, the contact angle of the 4-week-old titanium surfaces decreased to < 5 degrees, indicating that the superhydrophilic status of these aged surfaces had been restored.

OSTEOBLAST RESPONSE

Variations in the chemical and topographic properties of implant surfaces result in different osteoblastic responses.²⁹ On acid-etched titanium surfaces, degradation of the albumin adsorption rate after 4 weeks of storage was substantial, compared with the rate seen on new surfaces. The reductions were approximately 70% for a machined surface, 60% for an acid-etched surface and 50% for a sandblasted surface.³⁰ Similarly, a significant degradation in the adsorption capacity of fibronectin was observed on aged titanium surfaces. With respect to osteoblast behavior and function, a surface age-dependent degrading property of osteoblast attachment and proliferation was also confirmed. The number of attached osteoblasts and the proliferative activity during certain time periods of incubation were reduced by 50% to 75% on 4-week-old acid-etched surfaces as compared to new acid-etched surfaces.^{7, 27} Osteogenic functional phe-

Table 1: Articles Reviewed and Type

Authors	Study	Type
Aita et al¹²	Integration of bone with UV functionalized titanium	In-Vitro
Gao et al¹⁴	Different wavelength for UV photofunctionalization	In-Vitro
Yamada et al¹⁵	Biofilm formation	In-Vitro
Att et al¹⁶	Biologic aging of implants & Osseointegration	Review
Miyauchi et al¹⁷	Osteoblast adhesion to photofunctionalized TiO₂	In-Vitro
Aita H et al¹⁸	Human mesenchymal stem cell migration, attachment & differentiation	In-Vitro
Pyo et al¹⁹	Bone implant contact, Interfacial osteogenesis, Marginal bone seal & Removal torque	Animal Study
Iwasa et al²⁰	Micro-nano-hybrid surface to alleviate biological aging	In-Vitro
Ikeda et al²¹	Fluoride treated nanofeatured titanium	In-Vitro
Minamikawa et al²²	Bioactivity & osteoconductivity of titanium alloy	In-Vitro
Ohyama et al²³	Bone implant contact	FEA Study
Suzuki et al²⁴	Implant stability change & Osseointegration speed	In-Vivo
Funato et al²⁵	Success rate, healing time & implant stability	In-Vivo
Ueno et al²⁶	Bone titanium integration profile	In-Vitro

notypes such as alkaline phosphatase activity and mineralization were substantially (by approximately 50%) reduced on 4-week old acid-etched titanium surfaces compared with the newly prepared acid-etched surfaces.^{7, 28} Moreover, the expression levels of collagen I and osteocalcin, as evaluated by reverse-transcriptase polymerase chain reaction, were also not significantly different among the groups of different ages.⁷

Miyauchi et al.¹⁷ determined adhesion of a single osteoblast is enhanced on UV-treated nano-thin TiO₂ layer with virtually no surface roughness or topographical features were determined. The mean critical shear force required to initiate detachment of a single osteoblast was determined to be 1280 ± 430 nN on UV-treated TiO₂ surfaces, which was 2.5-fold greater than the force required on untreated TiO₂ surfaces. The total energy required to complete the detachment was 37.0 ± 23.2 pJ on UV-treated surfaces, 3.5-fold greater than that required on untreated surface. The level of hydrocarbon, and not hydrophilicity level, strongly correlated with rates of protein adsorption and cell attachment. The study demonstrated that bone-titanium contact can be increased up to nearly 100% by treating titanium implants with UV light.

MESENCHYMAL STEM CELLS

Aita H et al.¹⁸ cultured human mesenchymal stem cells (MSCs) on acid-etched microtopographical titanium surfaces with and without 48 hour pretreatment with UVA (peak wavelength of 360nm) or UVC (peak wavelength of 250 nm). The number of cells that migrated to the UVC-treated surface during the first 3 hours of incubation was eight times higher than those that migrated to the untreated surface. After 24 hours

of incubation, the number of cells attached to the UVC-treated surface was over three times more than those attached to the untreated surface.

BONE IMPLANT CONTACT (BIC)

Aita et al.¹² reported a remarkable increase of 55% to 98.2% was achieved in BIC due to UV photofunctionalization. The result was based on the histology within the bone marrow, where bone deposited around implants was all de novo. BIC and bone area were significantly increased in the cortical bone by photofunctionalization also. Cortical bone around untreated implants contained voids and gaps near the interface, probably because of microgaps and tissue damage that occurred during drilling and insertion, and an inflammatory reaction and remodeling after surgery. It was notable that the cortical zone BIC, which was as low as 70% for untreated implants, increased to 95%, at its approximately highest level.

Pyo et al.¹⁹ intensively stained the bone integrated to photofunctionalized surfaces with Calcein and tetracycline. Bone tissues that were very sensitive to both types of labeling at the very interface of photofunctionalized surfaces suggested; early-onset, more intimate, long-lasting, robust peri-implant osteogenesis. Consequently, the interthread spaces were all filled with the labeled tissues exclusively around photofunctionalized surfaces, whereas the early bone formation around untreated implants, as labeled with Calcein, occurred remotely outside the thread peak line. Surprisingly, bone around photofunctionalized implants was strongly positive to tetracycline, which indicated the long-lasting osteogenesis for these surfaces.

IMPLANT TOPOGRAPHY

Iwasa et al.²⁰ evaluated the behavior of biological aging of titanium with micro-nano-hybrid topography and with microtopography alone, following photofunctionalization. Rat bone marrow-derived osteoblasts were cultured on fresh disks (immediately after UV treatment), 3-day-old disks (disks stored for 3 days after UV treatment), and 7-day-old disks. The rates of cell attachment, spread, proliferation and levels of alkaline phosphatase activity and calcium deposition were reduced by 30%–50% on micropit surfaces, depending on the age of the titanium. In contrast, 7-day-old hybrid surfaces maintained equivalent levels of bioactivity compared with the fresh surfaces. Both micropit and micro-nano-hybrid surfaces were superhydrophilic immediately after UV treatment. However, after 7 days, the micro-nano-hybrid surfaces became hydrorepellent, while the micropit surfaces remained hydrophilic. Ikeda et al.²¹ also achieved similar results with fluoride treated nanofeatured implants.

PHOTOFUNCTIONALIZATION VS SURFACE ROUGHENING

Minamikawa et al.²² tested two different surface morphology, a roughened surface (sandblasted and acid-etched surface) and relatively smooth surface (machined surface). The strength of bone-implant integration examined using a biomechanical push-in test in a rat femur model was at least 100% greater for photofunctionalized implants than for untreated implants. These effects were seen on both surface types. The strength of bone-implant integration for photofunctionalized machined implants was greater than that for untreated roughened implants, indicating that the impact of photofunctionalization

may be greater than that of surface roughening.

LENGTH OF IMPLANTS

Ohyama et al.²³ demonstrated that photofunctionalized implants of 40% shorter length showed an equivalent strength of osseointegration to untreated implants with a standard length. A rat study addressed how much decrease in the strength of osseointegration is caused by the use of short implants.³¹ Implants with 40% shorter length decreased the implant anchorage by 50%. More importantly, when the shorter implants were photofunctionalized, the strength of osseointegration doubled and the disadvantage of the use of short implants was eliminated.³¹ This was reasonably explained by the expanded area of the load-bearing interface and bone volume around photofunctionalized implants.^{12,31}

IMPLANT STABILITY

Suzuki et al.²⁴ evaluated the level, change and rate of osseointegration of photofunctionalized dental implants under the immediate loading condition by using the Implant Stability Quotient (ISQ) values. One of the hypotheses tested was whether clinical effects of photofunctionalization similar to those found in animal studies can be obtained in humans. The following were the 3 major findings (1) a greater increase between the initial and secondary ISQ values in photofunctionalized implants than in literature; (2) the majority of Osseointegration speed index (OSI) in literature was lower than 1.0 and the OSI of photofunctionalized implants was notably higher than those in literature; and (3) the ISQ values at secondary time points obtained in this study between 77.5 and 78.1 were higher than any values in literature, even within a shorter heal-

ing time of 1.5 months. Another important result was the elimination of the stability dip or significant decrease of total stability throughout the healing period for photofunctionalized implants.

STRESS

Ohyama et al.²³ evaluated the effects of different BIC and lengths of implants on the distribution and concentration of peri-implant mechanical stress. The results indicated that the stress pattern fluctuated more substantially responding to the degree of BIC than to the different length of implants. Under vertical load, 98.2% BIC eliminated the high-stress area even around 7-mm implants. Increase in the implant length from 7 to 13 mm helped to reduce the stress level by only 15% under vertical load, whereas elevating BIC from 53.0% to 98.2% reduced stress by 50%. Also, the high-stress area around the implant neck was reduced more effectively by increasing BIC than by increasing the implant length.

PUSH IN VALUES

Aita et al.¹² concluded that biomechanical anchorage of acid-etched implants increased up to more than threefold at the early-stage of healing at week 2. This threefold increase of the push-in value was obtained at week 8 of healing in the same animal model.³² In other words, the push-in value obtained by the UV-treated acid-etched implants at week 2 was equivalent to that obtained by untreated acid-etched implants at week 8, indicating that the UV-treated surface accomplished bone – titanium integration 4 times faster.

Funato et al.²⁵ proved against the common understanding, that photofunctionalized

implants showed a significant ISQ increase in compromised bone, supporting the application and successful outcome of early loading within 3 months in a large number of cases.

GAP HEALING

Ueno et al.²⁶ proved that the strength of bone-titanium integration in the gap healing model was one-third of that in the contact healing model. However, UV-treated implants in the gap healing condition produced a strength of bone-titanium integration equivalent to that of untreated implants in the contact healing condition. Bone volume around UV-treated implants was 2- to 3-fold greater than that around the untreated implants in the gap healing model.

DISCUSSION

The bone formation around photofunctionalized implants was significantly improved. Cellular response followed by osseointegration also showed an improvement. The implant surface and topography are not a hindrance in the photofunctionalization treatment. According to the limited number of clinical reports, photofunctionalized implants placed in fresh extraction sockets showed high survival rate. Also, none of the photofunctionalized implants showed destructive changes in peri-implant bone during the initial healing stage

CONCLUSION

These in vivo accomplishments originated the following biological processes on UV-treated titanium surfaces: (1) increased adsorption of protein, (2) increased osteoblast migration, (3) increased attachment of osteoblasts, (4) facilitated osteoblast spread, (5) increased proliferation of

osteoblasts, and (6) promoted osteoblastic differentiation. However, these processes should not be considered as independent from each other.

No surgical complications were observed in relation to photofunctionalization, and surprisingly, the percentage of surgical complications was lower with the use of photofunctionalization suggesting the practicality and safety of this technology ●

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Disclosure

The authors report no conflicts of interest with anything mentioned in this article.

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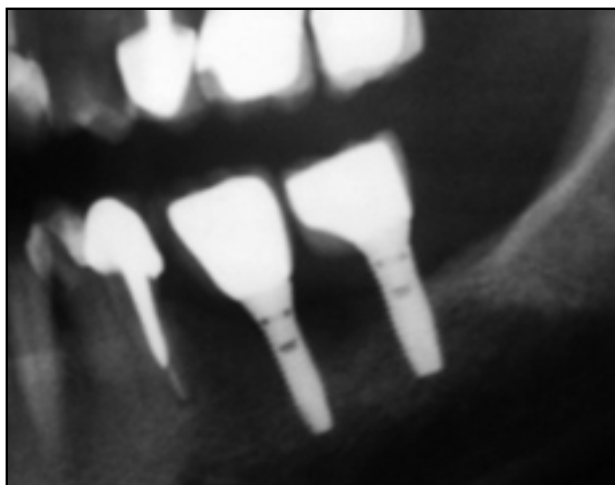
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A Report of Three Dental Implant Fractures with Literature Review

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Abstract



Dental implant fracture is one of the rare complications in implant dentistry. Such fractures pose important problems for both the patient and the dental surgeon. According to most literature sources, the prevalence of dental implant fractures is very low with approximately 2 fractures per 1000 implants placed. Considering that implant placement is becoming increasingly popular, an increase in the number of failures due to late fractures is to be expected. Clearly, careful treatment can contribute to reduce the inci-

dence of fracture. An early diagnosis of the signs alerting to implant fatigue, such as loosening, torsion or fracture of the post screws and prosthetic ceramic fracture, can help prevent an undesirable outcome. Also it is important to know and apply the measures required to prevent implant fracture. This article presents three cases with fractured dental implants and discusses management options and possible causal mechanisms underlying such failures, as well as the factors believed to contribute to implant fracture with literature review.

KEY WORDS: Dental implants, implant fracture, failed dental restoration, overload

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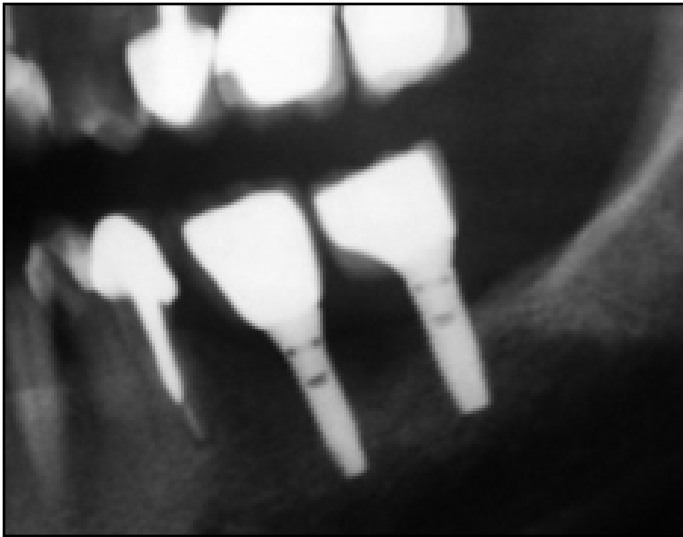


Figure 1: Radiograph of fractured dental implant from Case 1.



Figure 2: Testing implant mobility from Case 1.

INTRODUCTION

The problem associated with osseointegration of dental implant are two types biologic (soft tissues and bone) and mechanical problems. The mechanical problems involved the implant fracture itself are the abutment screw. The Implant fracture is one of the rare mechanical complications in the dental implant it's less than 1% of all complications that may be happen.¹⁻⁵ Causes of implant fracture may be divided into three categories: (1) defects in the design of the material; (2) non-passive fit of the prosthetic structure; (3) biomechanical or physiologic overload. Failure in the production and design of dental implants, bruxism or large occlusal forces, superstructure design, implant localization, implant diameter, metal fatigue, and bone resorption around the implant. Additionally, the galvanic activity of metals used in prosthetic restorations can be cited as a cause.⁵⁻⁷ The overloading of dental implants during functional and parafunctional activity are the major

factors, mal occlusion, and improper fit of the implant. The factors increasing the (over load) on the implant can be mentioned to para function or malocclusion, length of clinically crown. Para function is known as the main etiology.⁶⁻¹¹

CASE REPORTS

Case Report One

A 45 year old female was referred to our clinic with complaints of mobility in her dental implant. She had two dental implants 4mm in diameter with separate crowns in the 36 and 37 (FDI Numbering System) areas (Figure 1). The opposite arch had natural teeth with no history of parafunction. After about 2 years of function with her dental implants, she complained of pain and mobility in the areas (Figure 2). The clinical examination showed that the implant of the first molar was fractured (Figure 3) and it was removed with a trephine (Figures 4, 5). Examination of the broken implant showed that the implant was small in



Figure 3: Clinical removal of upper portion of fractured dental implant from Case 1.



Figure 4: Abutment removal from Case 1.



Figure 5: Removed dental implant and associated parts from Case 1.

diameter and the biting force concentration on the weakest part of implant with uneven distribution of forces caused the fracture.

Case Report Two

A 50 year old male presented to our clinic with a chief complaint of a broken dental implant in

the 26 area. The implant size was 4mm in diameter and a radiograph confirmed its fracture (Figure 6). After careful assessment, it was determined that the patient fractured the dental implant due to bruxism and excessive biting forces. The fractured dental implant was easily removed (Figure 7). The possible cause for broken the implant was inadequate dental implant diameter and size for the forces that were concentrated on the dental implant.

Case Report Three

A 45 year male patient presented to our clinic with a complaint of mobility in his bridge in the upper right arch. The bridge was made for him seven years ago with four implants for support. The patient exhibited severe grinding and hard biting habits. Clinical examination revealed mobility in the 16 area and radiographs confirmed dental implant fracture (Figures 8, 9).



Figure 6: Panoramic radiograph showing fractured dental implant from Case 2.

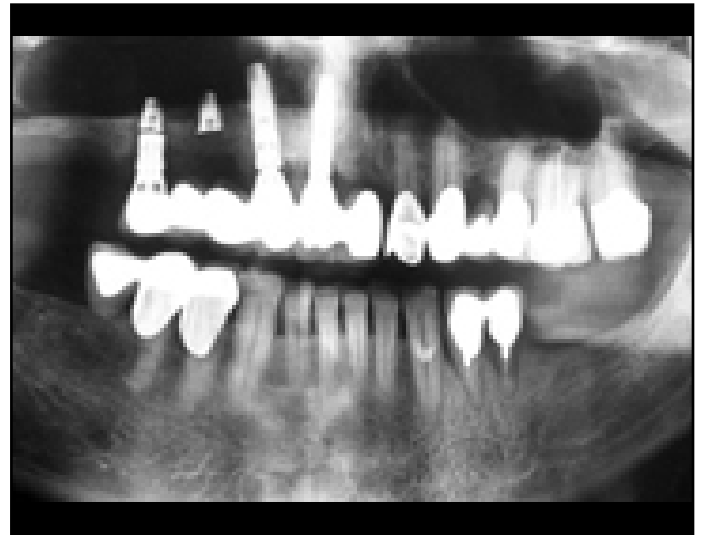


Figure 7: Removed dental implant from Case 2.

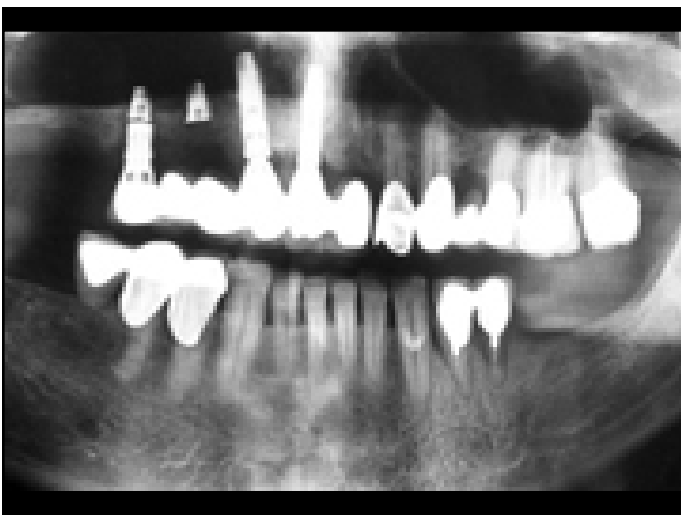


Figure 8: Panoramic radiograph showing fractured dental implant from Case 3.

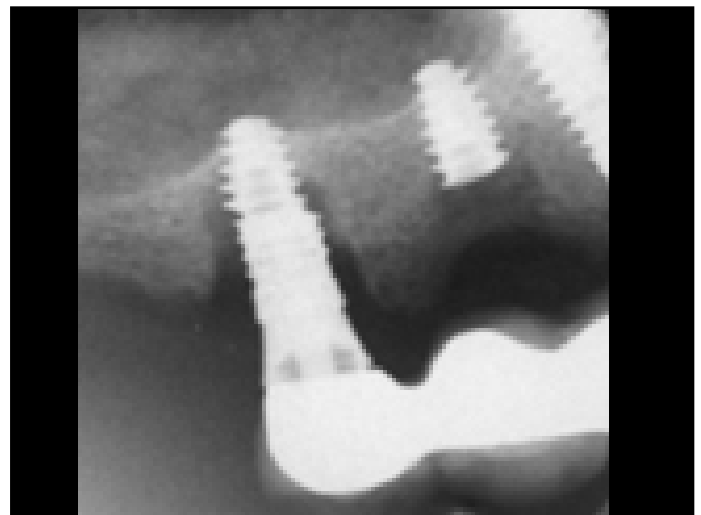


Figure 9: Periapical radiograph showing fractured dental implant from Case 3.

DISCUSSION

Despite the fact that implant therapy has been consolidated with high success rates, as demonstrated in a study by Adell, problems may arise with this type of treatment. Despite its low incidence, consensus in the literature suggests that one of the possible complications that may occur

with dental implants is fracture and treatment,¹⁻⁷ treatment represents a serious challenge to clinicians.^{1,3,5,11} Implant diameter also has a direct influence on the occurrence of fracture, in that dental implants with small diameters have reduced resistance to fatigue. In several of the cases analysed, fracture took place in 4mm diameter in

our cases, thus we recommend to use dental implants with large diameters whenever possible, especially in the mandibular and maxillary posterior regions, where most fractures take place. Adequate prosthetic planning is fundamental to reduce dental implant fracture rates even further.

Biomechanical factors, besides achieving a passive fit of the prosthetic superstructure, must be taken into consideration from the moment implants are placed until prostheses are installed.^{3,9,11} Cantilevers act as levers, generating tension in the fixtures and making them susceptible to fracture, especially in the posterior regions of the mouth. In this situation, whenever possible, the number of implants must be increased, and their placement in a straight-line configuration must be avoided.^{3,5,11} Frequent loosening or fracture of the retaining screws and bone loss around

the implant are characteristic signs that precede the fracture of implants.^{3,7,9,11} It is understood that bone resorption is a consequence of several adverse factors to which the implant/prosthesis system is exposed. Bone loss will increase the cantilever effect with the consequent increase in tension forces, generating stress in the thread portion of the implant, where a hollow cylinder is normally found along with greater fragility, resulting in metal fatigue.^{3,7,9,12} Proper choice of the Implant size and restoration with proper occlusal constriction with minimize the risk of the fracture. ●

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Disclosure

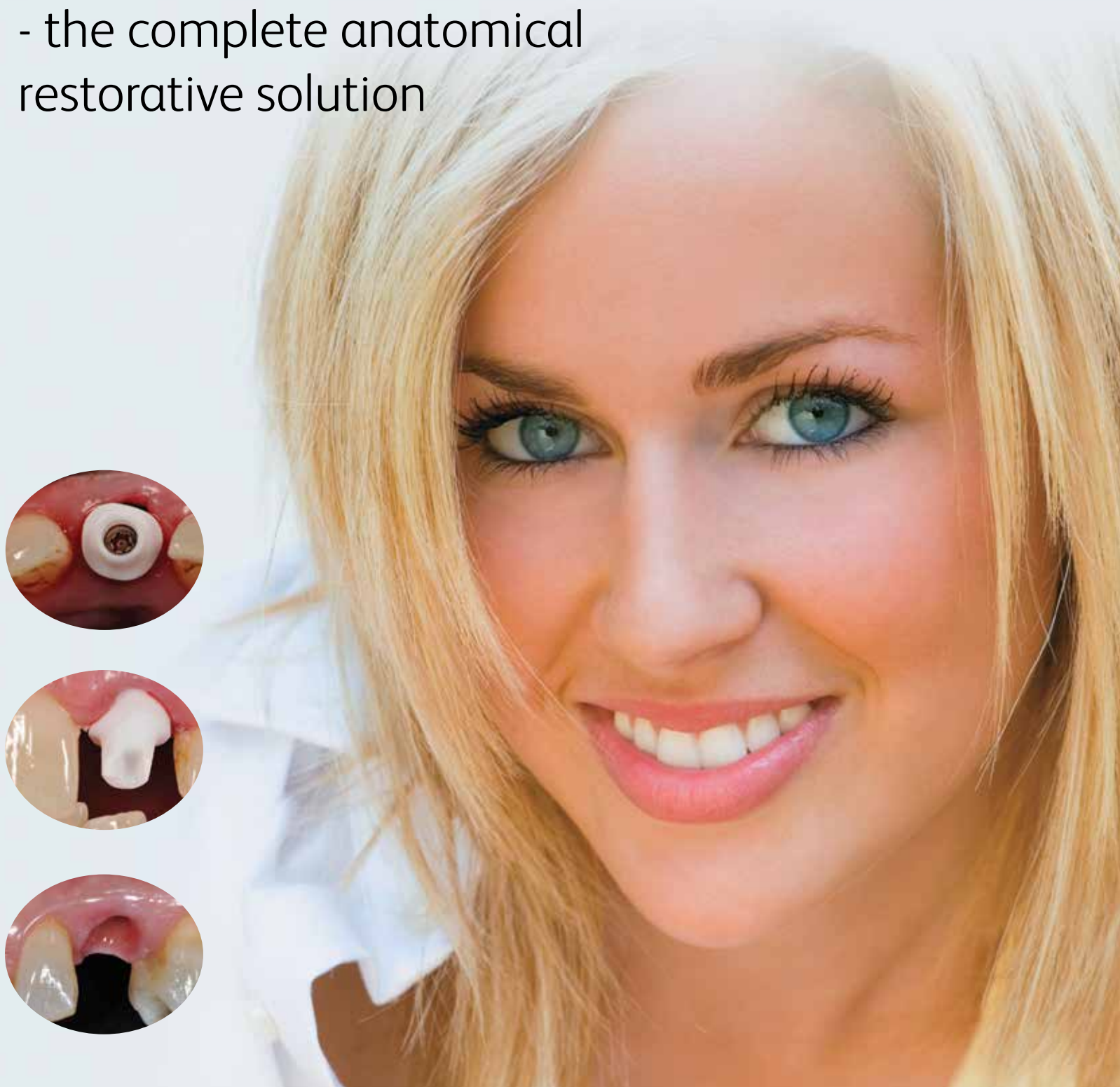
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