

Oral Rehabilitation Using Dental Implants and Guided Bone Regeneration

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Abstract

The advent of osseointegrated dental implants focused initially on functional rehabilitation. Interest today centres on aesthetics and the philosophical ideal of replicating nature. Implants can be placed beyond resorbed anatomic limitations where the final prosthesis should be, rather than within the pre-existing resorbed bone. In order to achieve this, the following must be considered: implant positioning, adequate bone support and the overlying soft tissue envelope. Common techniques to modify the surgical environment include different methods of bone grafting and regeneration, ridge expansion and sinus augmentation. With the advent of growth factors like bone-morphogenetic proteins, restoration of bony contours will become more predictable. Soft tissue management techniques include tissue expansion and contouring, gingiva grafts and advancement or rotational flaps. Though some of these procedures can be done concurrently with implant placement, a secondary surgical procedure is often required. Ideal implant positioning involve establishing correct orientation in all dimensions. Due consideration should also be given to occlusion and harmony of the final restoration with the adjacent dentition.

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Introduction

Form follows function and adaptation to physiologic demands dictates skeletal form.' In the oro-facial region, tooth loss leads to atrophy of the alveolar arches in all planes. The resultant tissue deficit is continuous and progressive.² Without intervention, the prolonged period of edentulousness results in loss of facial height." Function and aesthetics are compromised, even with conventional prosthesis. In addition, there is a psychosocial impact on the patient as the quality of life diminishes.⁴

Osseointegrated dental implants focused initially on functional rehabilitation.⁵ Decades of experience have shifted the parameters and interest today is centred on the philosophic ideal of replicating nature. The concomitant success of guided tissue regeneration has enabled implants to be placed beyond resorbed anatomic limitations.⁶ This forms the current approach to aesthetic oral rehabilitation, where the final prosthesis rather than the pre-existing resorbed bone dictates the placement of implants.⁷

Key to Aesthetic Oral Rehabilitation

In order to obtain optimal aesthetics in implant dentistry, three major parameters must be considered. These are the bony base, the implant structure and the soft tissue envelope⁸ (Fig. 1).

Bone

The underlying bone forms the base on which implants are retained and through which occlusal forces are dissipated. The residual ridge is, however, often deficient as a result of disease and functional atrophy following tooth loss (Fig. 2a). This is often accentuated by the destructive mechanical forces of a prosthesis or of a compromised hormonal state, as in osteoporosis. In addition, the pattern of ridge resorption results in a discrepancy between the opposing arches.⁹ The resultant loss in quantity and density poses an impediment to optimal implant placement unless adequately managed. The ability to rebuild the bony support in order to place implants is critical to obtaining an aesthetic result (Fig. 2b).

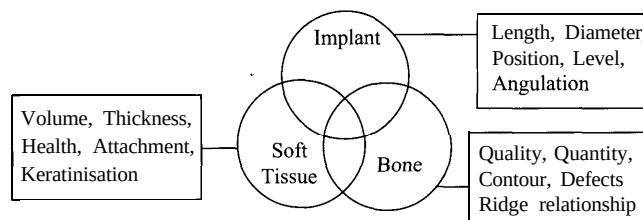


Fig. 1. Factors influencing an aesthetic result.

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The Implant

Implants of sufficient length and diameter must be used. These should be placed in optimal positions and at an appropriate angle to serve as anchorage for the final prosthesis (Fig. 2c). Length and diameter influence the total surface area available for integration with the surrounding bone, which in turn affect the distribution of occlusal forces. The use of longer and wider implants also allows engagement of cortical boundaries for improved stability. Wide diameter tapering implants allow the creation of natural tooth contours as they correspond closely to tooth form and dimensions. Attention to surgical detail, initial stability of the implant, application of physiologic loads and institution of an adequate oral hygiene regime will enable long-term retention of the functional implant.¹⁰

Soft Tissue Envelope

A unique characteristic of dental implants lies in its transmucosal emergence through the overlying tissue. The peri-implant mucosa forms a firm cuff around the implant, and serves as a barrier to oral microbes. Implant emergence, tissue thickness and keratinisation thus play a role in aesthetics as well as long-term tissue health. The overlying soft tissue envelope also serves as the limit to ridge augmentation procedures unless expanded or surgically modified.¹¹ Ridge resorption leads to a compensatory increase in fibrous tissue thickness resulting in flabby residual ridges. However, there is usually a net tissue deficit and flattening of contours, especially interproximally. This must either be surgically modified or compensated for prosthetically.

Relationship between Hard and Soft Tissue Levels

In the natural dentition, there is a relationship between the level of the marginal tissues and the underlying bone. This comprises a gingiva sulcus and an attachment mechanism of epithelium and connective tissue, each approximately 1 mm in depth. This concept of ‘biologic width’ is widely accepted in conventional prosthodontics and “sounding to bone” to obtain a guide to positioning the margins of restorations is a direct application of this principle.¹² As peri-implant and periodontal tissues share many histochemical and morphologic features,¹³⁻¹⁵ it is suggested that implants should be placed at the level of the bony crest to avoid excessive mucosa thickness (Fig. 2d).

The other factor influencing final soft tissue levels is the presence of teeth.¹⁶ Whether it is due to functional stimulation, or the mere presence of a surface for attachment, the existence of acceptable gingiva levels even in the presence of bone loss is a common finding. Replacement of missing teeth with implants simulates this effect and allows long-term maintenance of aesthetic tissue levels.

Relationship between Implant Placement and Bone Levels

Long-term osseointegration of implants is undisputed. What is less emphasised is the role of the implant in retaining bone around itself. The rate of bone loss, measured at between 0.2 and 0.25 mm per annum in edentulous ridges, stabilises to annual crestal changes of 0.1 mm.¹⁷⁻¹⁹ Likewise, ridge maintenance has been reported through the insertion of cones or blocks of bioactive glass or hydroxyapatite, the concept of preventive implantation.²⁰ Implants enable transmission of physiologic stimulus or a functional load and thus play an important role in retaining long-term bone levels. Both underloading and overloading lead to resorption and control of load distribution is thus essential.^{1,21}

Rebuilding the Skeletal Form (Table I)

Bone graft and guided tissue regeneration techniques have enabled the placement of implants in areas of bony defects. Autogenous grafts are the gold standard due to the possibility of survival osteogenesis.²² Allografts, xenografts and alloplasts are used as alternatives in smaller defects, or when donor sites are unavailable.²³ In all cases, osteoconduction is an important reason for grafting the defect though the possibility of osteoinductive factors have been raised with demineralised freeze dried bone allografts.²⁴

In a review of bone graft techniques and materials, thirty-eight different combinations were described. Onlay grafts using either iliac crest or the symphysis region as donor sites have been performed both concurrently or as staged procedures. Inlay or interpositional grafts, sinus and nasal floor augmentation procedures have all shown variable results.^{25,26} In addition, splitting of the alveolar crest, bone compaction techniques, LeFort procedures and lateralisation of the inferior alveolar nerve²⁷⁻²⁹ have been suggested to facilitate the placement of longer and wider diameter implants. None have provided the panacea and a combination of these are

TABLE I: HARD TISSUE MANAGEMENT TECHNIQUES

Bone grafts
Onlay grafts
Interpositional grafts
Bone regeneration (using membranes or titanium mesh)
Dehiscences and fenestrations
Horizontal and vertical augmentation
Ridge modification
Sinus augmentation
Nasal floor graft
Split alveolar crest
Bone compaction
Nerve lateralisation
LeFort procedures
Bone morphogenetic proteins

currently in use. Though success to various degrees have been ascribed, the lack of consensus reflects the general lack of predictability in this field.²⁵ Resorption of the graft before and during function negates some of the benefits gained during the initial surgery.³⁰

Guided tissue regeneration techniques using barrier membranes of e-PTFE have also been widely reported.^{31,32} This is based on the exclusion of extra-skeletal elements during the initial healing period, allowing selective repopulation with osteogenic elements (Fig. 2e). The initial success with repairing local defects like dehiscences and fenestrations have extended to include larger defects and those extending beyond the skeletal envelope.^{33,34} Tinti³⁵ reported a vertical regeneration of up to 7 mm. Success has, however, not been universal and complications like membrane exposure and soft tissue recession remain.³⁶

The desire for membrane resorbability has led to a host of new products.³⁷ The concept of bone regeneration is, however, not new and its possibility has long been established.^{38,39} The need for a membrane with specific permeability has been shown to be unnecessary as impermeable titanium caps as well as macro-porous titanium mesh have both resulted in bone regeneration.^{40,41} With the advent of growth factors like bone morphogenetic protein,⁴² restoration of bony contours will become more predictable.

The concurrent placement of implants in association with bone grafts and regenerative techniques may also be advantageous as implants also serve as a stabilising factor. In a study on extra-skeletal bone augmentation in rabbit tibia, Rasmusson⁴³ showed that there was a decrease in bone volume following barrier removal, and that this was less over an implant body indicating that the presence of the implant had a stabilising effect on retention of the augmented bone.

Techniques Of Soft Tissue Management (Table II)

Besides generating an adequate bony bed for implant placement, due consideration should be given to the soft

tissue envelope. Of particular concern would be the ability to re-establish the interdental papilla as the absence of papilla is synonymous with disease and visually not aesthetic. The ability to recreate the papilla is dependent on the presence of sufficient tissue volume. This soft tissue volume should be generated before beginning the prosthetic reconstruction as subsequent soft tissue repair is difficult. When sufficient tissue volume is present, tissue contouring can then be achieved using an interim restoration to shape the underlying tissues by gently compressing the underlying tissues.

Soft tissue deficits can be augmented using a variety of surgical techniques. The use of tissue expanders have been tried but not established as routine use. The development of soft tissue bulk is done generally secondary to a bone grafting procedure, or using connective tissue grafts largely from the palate. Deficits in vertical and horizontal planes can thus be corrected. The use of palatal grafts, however, entails the creation of a secondary donor site, thus fuelling the search for a suitable allograft.

Flap designs to minimise soft tissue recession have been advocated.⁴⁴ Minimally invasive techniques with incisions which spare the interdental papilla have been suggested. In addition, when an adequate band of keratinised mucosa is available, the use of a small-diameter tissue punch to remove the overlying tissue allow "key-hole" implant site preparation which avoids tissue recession associated with raising of a flap.

When raising of a mucoperiosteal flap is required, attention to vascular supply is important as poorly designed flaps may lead to tissue necrosis and loss of soft tissue volume. When repositioning flaps, kinks or excessive tension must be avoided. The colour and keratinisation of the mobilised tissue should also be considered and a secondary surgical procedure may be required subsequently to match the adjacent tissues. Partial thickness flaps are used to recreate keratinised mucosa by allowing secondary keratinisation of the periosteum.

Suggested Protocol for Soft Tissue Development

In the two-stage surgical approach, primary closure over the implant is the stated objective. The disadvantage of this would be the need for distorting vestibular anatomy to obtain closure and a second surgery for uncovering the implant, which is by itself a traumatic procedure. The alternative single stage approach overcomes these disadvantages but does not by itself increase vertical height of the tissue. If tissues are adequate, either procedure, in combination with split-thickness flaps, enables creation of a suitable emergence profile. When a two-stage technique is used, tissue repositioning can be done during the second stage surgery through an incisional technique rather than using excisional techniques like tissue punches or electrocautery.⁴⁵

TABLE II: SOFT TISSUE MANAGEMENT TECHNIQUES

Tissue contouring
Tissue expansion
Tissue grafts
Connective tissue
Free gingiva
Allografts
Full thickness repositioned flaps
Apical
Coronal
Lateral
Partial thickness flaps

In the absence of adequate soft tissue, tissue grafting or regeneration is required. The posterior palate is the donor site of choice and the subepithelial connective tissue graft as advocated by Langer⁴⁶ is commonly used. Alternatively, tissue regeneration, using some form of tissue expansion and stretching of tissues in a staged procedure, has been suggested. A high healing abutment is then placed to serve as a strut to ensure that the tissue remains taut. Filling the dead space with alloplastic material helps to maintain the space. The important consideration is the increased availability of tissue for tension-free closure over a larger underlying structure provided by the procedure. Primary closure is attempted over this newly created bed. The tissues being slightly mobile due to muscular pull will result in fibrous repair rather than bone regeneration. The additional bulk of soft tissue gained improves aesthetics and allows for a more pleasing emergence form (Figs. 2f, 2g & 2h).

Implant Placement and Positioning (Table III)

Another key determinant of aesthetics is optimal implant positioning. Implant positioning is best decided upon pre-surgically using diagnostic models mounted on a semi-adjustable articulator. The curves of Wilson and Spee, as well as the functional occlusal relationship of the implant, can be visualised and the most favourable implant sites chosen. With the help of a surgical template, idealised positioning of the fixture can then be attempted in all planes. It should be noted that the angle of placement chosen is very often a compromise between the many factors that influence our final decision.

This is because the most favourable position in terms of receiving or distributing the occlusal load may not be surgically possible as the bony housing ultimately limits our choice. Likewise, the presence of vital structures and the roots of adjacent teeth are major determinants.

Bucco-labial flaring is sometimes inevitable in the Asian population due to the inherent skeletal pattern, accentuated by ridge resorption patterns. These can be

corrected using angled abutments.⁴⁷ With more severe angulations, customised abutments are required.⁴⁸ Mesio-distal positioning is critical and the placement of fixtures interdentally must be avoided as this can neither be corrected prosthodontically nor effectively masked. Correct apical-coronal level is also important as the implant restoration must harmonise with the existing dentition. Too coronal a position leads to exposed margins. Conversely, excessively apical positioning leads to creation of a high soft tissue cuff which might not be sustainable in terms of long-term tissue health. When 2 or more teeth are lost, slight countersinking of the fixtures is necessary to recreate the interdental papilla.

Importance Of Using Wide Diameter Implants

The diameter of an implant is important as it affects the surface area for integration as well as load distribution. Its relevance to the final aesthetic result lies in size discrepancy and long-term tissue health at the cervical emergence point. The normal dentition has teeth of various diameters and forms and is generally wider than the average implant diameter of 4 mm.⁴⁹ In order to achieve an aesthetic emergence, the smaller diameter implant is placed more apically which compromises the overall tissue health due to the thicker transmucosal tissue. On the contrary, wider diameter implants allow more superficial placement as there is less discrepancy of size between the emerging implant and the final crown. The development of tapered implants enables wider diameter implants to be easily placed without damage to underlying vital structures.

Advances in Implant Prosthetics

A discussion on implant aesthetics would be incomplete without a discussion on prosthetic developments today. The standard abutment, which connects implant to final prosthesis, has developed into anatomic and aesthetic forms.⁵⁰ Increase in choice includes designs which have a tapered or elliptical cross section, different cuff heights and emergence angles, as well as a curvature which follows that of the cementum-enamel junction. The advent of porcelain abutments adds to the plethora of available products. These are favoured when the overlying mucosa is thin, or when the implant is placed too superficially as porcelain abutments avoid the graying associated with the use of titanium abutments.

While it is an objective to surgically regenerate lost tissues, limitations exist and there are instances where prosthetic compensation is the preferred option. An acrylic flange is the simplest means of compensating for lost tissue and achieving lip support as it can be easily added to the final prosthesis. Adequate support for the lips reduces facial skin folds associated with ageing. The introduction of a wider range of more natural looking

TABLE III: GUIDELINES ON IMPLANT POSITIONING*

1. Avoid vital structures
2. Place within bone or limits of bone augmentation
3. Attempt parallelism in all planes, and to each other when possible
4. Incorporate an offset to favour load distribution
5. Place parallel to roots of adjacent teeth, without extreme convergence or divergence
6. Use the curves of Spee and Wilson as guides
7. Direct implant against the functional cusp of the opposing tooth
8. Place implant to receive axial loading
9. For ease of prosthetic manipulation, a mesial tilt is favoured
10. At or around the level of the bony crest
11. Appropriate distance apart from each other
12. In harmony with adjacent teeth positions

*Modified with permission from: Chong W L. Asian Dentist 1998; 7:14-5.

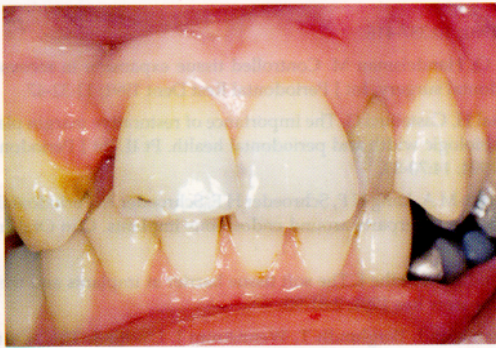


Fig. 2a. Pre-surgical view showing crowded and malaligned front teeth, missing right lateral incisor and soft tissue deficit.

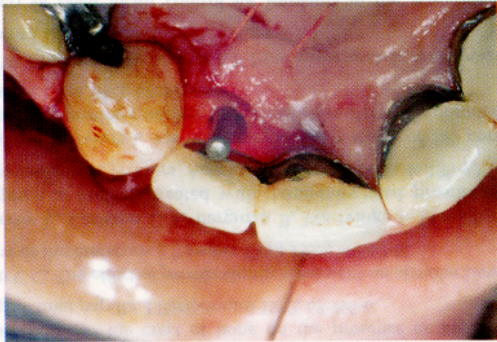


Fig. 2c. The provisional bridge was tied in during the surgery to establish S-dimensional orientation. A guide pin was inserted into the prepared site and can be seen emerging palatal to the cingulum of the lateral incisor crown.

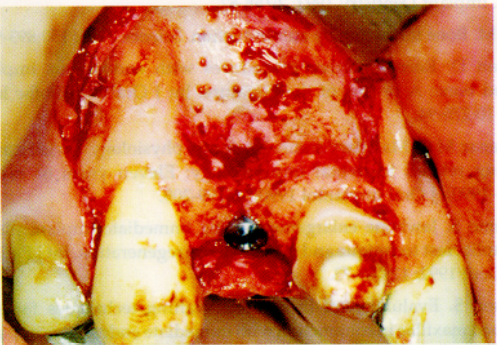


Fig. 2e. Labial bone decorticated in preparation for receiving bone graft. This releases osteogenic cells abundant in the marrow spaces. An allograft was used in this patient to provide a scaffold and support for the overlying membrane to promote osteogenesis.

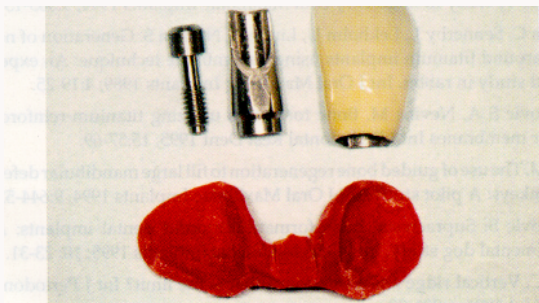


Fig. 2g. The components of the implant prosthesis used to restore the patient is shown. These are the porcelain crown, the titanium alloy abutment and the abutment screw. At the bottom of the picture is the verification index made of acrylic which is used to orientate the restoration intra-orally.

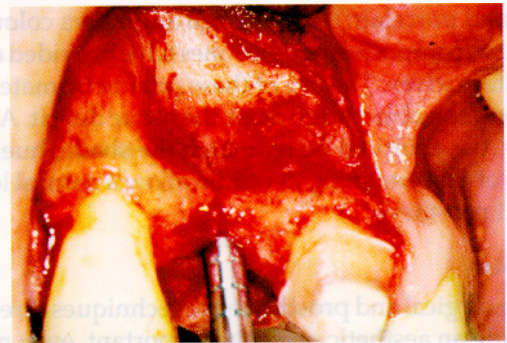


Fig. 2b. Anterior view of surgical site showing severe bony concavity and narrow alveolar crest. The alveolar crest was split and bone expansion was done using an osteotome.

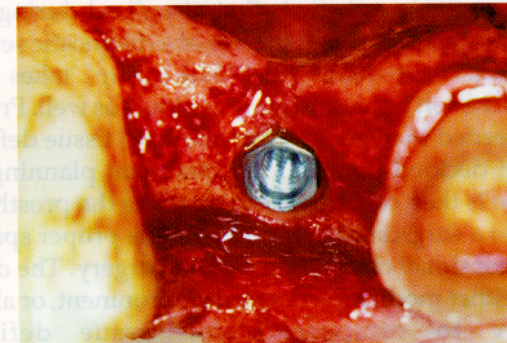


Fig. 2d. Close up of titanium implant showing the anti-rotational component. A 1 mm hex. Note the superficial position of the top of the implant with respect to the crest of the ridge. This is believed to reduce the long-term marginal bone loss.

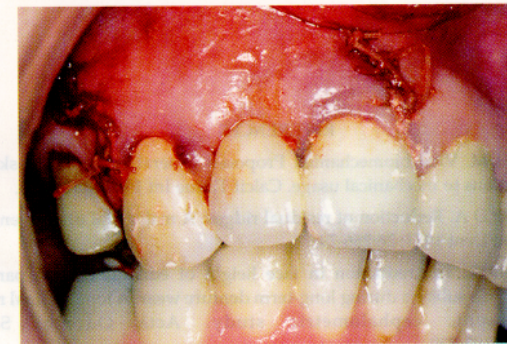


Fig. 2f. Soft tissue closure was established and the site allowed to heal for 6 months. A provisional restoration was used to establish final gingiva contours.



Fig. 2h. The final result is shown. The implant crown emerges the mucosa. The tissue deficit has healed successfully. The other anterior teeth were restored using porcelain crowns in conjunction with elective endodontics to achieve a pleasing smile.

acrylic and porcelain teeth, as well as gingiva coloured porcelains, composites and silicones have provided even more alternatives. The use of these prosthetic materials has a common objective to mask the tissue deficit. Additionally, the ability to better match the shade, hue and chroma of the remaining dentition allow a natural looking final prosthesis.

Conclusion

While surgical and prosthodontic techniques directed at creating an aesthetic result are important, even more fundamental lies the need to combine the two disciplines and place the implant with the final restoration in mind. The final aesthetic is first visualised during the diagnostic phase through the use of a diagnostic set-up of the final restoration. This "trial set-up" takes into account the soft tissue and bony contours as well. Procedures needed to overcome soft and hard tissue deficits are then decided upon during treatment planning. A template is then constructed to translate the prosthetic plan into a surgical template to provide proper spatial and dimensional orientation during surgery. The decision to either modify the surgical environment, or alternatively to compensate for tissue deficits prosthodontically can then be undertaken. A combination of the techniques described above will enable a final result which is aesthetically satisfying.

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