Aesthetic Considerations in Implant Therapy - A Review

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ABSTRACT

The success of dental implant depends on its integration with the surrounding tissue and this is influenced by various factors, like implant material, amount of bone and its quality and the implant loading condition. The peri-implant tissue is comprised of the soft (mucosa) and hard (bone) tissues. Absolute contact between the peri-implant bone and the implant surface is another factor essential for the success of any implant system. The direct structural and functional connection between ordered living bone and the surface of a load-carrying implant is defined as "Osseointegration". The bone undergoes remodelling so as to maintain bone strength and mineral homeostasis. The preservation of biological seal, the anatomy and quality of bone where implant needs to be positioned, implant macrostructure are some of the factors that dictate the integration of the implant to the hard tissue. In addition, the gingival morphology also plays an important role in determining the final aesthetic outcome. Gingival morphology is described in terms of gingival phenotype or gingival biotype. "Gingival phenotype" is a term that addresses to the variations in the thickness and width of the keratinized tissue whereas "Gingival biotype" depicts the thickness of the gingiva in the facio-palatal / faciolingual dimension. Inadequate gingival thickness is a major reason for periodontal attachment loss and marginal tissue recession in a patient, directly contributing to the periodontal disease progression. The peri-implant soft tissue consists of a junctional epithelium (JE) and the connective tissue but owing to the biologic differences between the peri-implant and periodontal tissues, the peri-implant tissues are more vulnerable to mucosal inflammation and bone loss. The health of the peri-implant tissues play an important role in the long-term outcome of dental implants. The preservation and reconstruction of soft tissue around dental implants is an important aspect of dental implantology. Restoring the function, aesthetics and harmony of dentition is the primary intention of implantology. This is achieved with a sound crestal bone stability and healthy peri-implant soft tissue. Other factors like abutment material and its connection to the implant, the neck design also affects the peri-implant soft tissue integrity. This review discusses the various factors that directly and indirectly influence the aesthetic outcomes following a dental implant placement.

KEY WORDS

Aesthetics, Peri-Implant Tissue, Osseointegration, Platform Switching

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BACKGROUND

Dental implants have revolutionized the way by which they have successfully been able to replace missing teeth since they integrate well with the peri-implant tissues - the soft (mucosa) and hard (bone) tissues.¹ Various factors such as implant material, bone quality and quantity and the implant loading condition dictate this integration. The peri-implant soft tissue consists of a junctional epithelium (JE) and the connective tissue resembling the soft tissue surrounding the teeth. The attachment of the junctional epithelium to the implant or abutment surface is hemi-desmosomal in nature with connective tissue present apical to it. The circularly arranged connective tissue fibres have their orientation parallel to the implant / abutment surface while reaching out towards the oral epithelium (Figure 1). The fibres arising from the crest of alveolar bone and the periosteum are positioned close to the implant surface, without any adherence to the surface.

Figure 1. Represents the Difference in Soft Tissue Attachment to Natural Teeth and Dental Implants

For dental implants to succeed, the integration of the hard tissues and implant surface is essential. The direct structural and functional connection between ordered living bone and the surface of a load-carrying implant is defined as "Osseointegration". The bone undergoes remodelling so as to maintain bone strength and mineral homeostasis.

"Gingival phenotype" addresses the variations in the thickness and width of the keratinized tissue.^{2,3} Whereas "Gingival biotype" depicts the thickness of the gingiva in the facio-palatal / faciolingual dimension.⁴⁻⁶ Inadequate gingival thickness is a major reason for periodontal attachment loss and marginal tissue recession in a patient, directly contributing to the periodontal disease "progression."⁷ Seibert and Lindhe described the gingival biotype as 'thick-flat' and 'thin-scalloped' variants. In inflammatory conditions, thick gingival biotypes portray an increased incidence of pocket formation whereas gingival recession is common in thin gingival "tissues."⁸ A broad zone of keratinized tissue with flat gingival contour and a thick underlying bony architecture providing increased resilience to any inflammation or trauma are the features of typical too thick gingival biotypes. Whereas, thin gingival biotypes feature thin keratinized tissue, scalloped gingival contour with thin bony architecture, increasing their sensitivity to any inflammation or trauma. The gingival morphology plays a critical role in determining the final aesthetic outcome. Evidence suggests that individuals with thick biotypes portray a greater success rate in immediate implants in the "anterior."⁹

RATIONALE OF SOFT TISSUE INTEGRITY AROUND IMPLANTS

Eventually, the success of implants depends on the maintenance of the health of peri-implant tissues. Dental implants associate with the oral tissues through two surfaces;

1. Peri-mucosal interface (forming the biological seal),
2. Endosseous interface (provides stability and rigidity to the implant). A transmucosal seal formed by the peri-implant soft tissue, resists recession and provides an environment for the prosthesis which is self-cleansable and makes it able to withstand the mechanical forces.

The interface between the implant and mucosa comprises of two components - epithelial tissue and connective tissue. Following implant / abutment placement, epithelial migration begins in the apico-coronal direction and forms the junctional epithelium on reaching the implant surface, about 1 – 2 mm long compared to the natural teeth.^{11,12}

Once the epithelial cells reach the implant surface, their attachment occurs directly via a basal lamina (< 200 nm) and hemidesmosomes. Failure to achieve and maintain the peri-implant mucosal seal, the epithelium migrates apically into the bone / implant interface, causing partial or complete encapsulation of the endosseous implant. There is the absence of cementum and fiber insertion into the implant surface and therefore a peri-implant pocket extending into the osseous structures may form if biological seal is not achieved.

	Attachment	Orientation of Collagen Fibres	Source of Blood Supply	Biological Width / Seal
Teeth	Basal lamina and hemidesmosomes	Perpendicular	Periosteum, PDL	J.E - 0.97mm C.T - 1.07mm
Implants	Basal lamina and hemidesmosomes	Parallel	Periosteum	J.E - 1.88mm C.T - 1.05mm

Table 1. The Characteristic Features of Soft Tissues Adjacent to Teeth and Implants

The collagen fibres of the connective tissue form a cuff-type arrangement around the implant abutment.¹³ The length of the connective tissue attachment (1.3 to 1.8 mm) depends on the design of the implant as well if it is one- or two-part implant system. Studies say that the use of plasma spray surface strengthens the attachment of the connective tissue with fibres inserted functionally at 90 degrees into the plasma sprayed surface of the implant. Type I collagen forms the major constituent of the supracrestal connective tissue of the peri-implant mucosa. Withal, gingiva and peri-implant mucosa exhibit similar proportion of collagen type I, III, IV, VII, and fibronectin, with proportion of collagen type V in peri-implant tissues. Studies depict that an adequate biological seal is attainable only if a supracrestal smooth titanium surface of at least 3 mm long is present in the apico-coronal direction with

junctional epithelium occupying approximately 2 mm, while the rest being occupied by the connective tissue.

Berglundh and Lindhe defined the entire contact length as the "biologic width", with 2.0 mm of J.E and 1.3 - 1.8 mm of connective tissue. The biologic differences between the peri-implant and periodontal tissues render the peri-implant tissues to increased mucosal inflammation and bone loss. The enduring stability of the implant is strongly influenced by the peri-implant soft tissue integrity.

Factors Affecting Soft Tissue Integrity

1. Influence of Mucosal Thickness

Essentially, a minimum of 3 mm of peri-implant mucosa is needed for a stable epithelial-connective tissue attachment, else it would lead to bone loss in order to maintain the biologic width.¹⁹ In a study by Linkivicious, interproximal bone loss was additionally seen in implants with thin tissue type as compared to the group with thick tissue pattern. The study revealed that if initial tissue thickness was less than 2.5 mm, a bone recession of 1.45 mm within the first year of function might occur and it can be avoided in tissues with thickness more than 2.5 mm.²⁰ Only a negligible amount (0.2 mm) of bone loss would occur if implant-abutment junction is located 2 mm or more above the bone level.²⁰ Augmentation of thin mucosa before implant placement would help provide favourable results. An increase in papillary height is observed within 2 years if proper soft tissue sealing around the implants is achieved, without any requirement soft tissue augmentation.

Loss of implant papilla is one of the most undesirable condition in implant dentistry and is tricky to handle since the "black triangle" causes major problems like undesirable phonetics, food impaction and unacceptable aesthetics. Factors such as crestal bone height, interproximal distance, tooth form/shape, gingival thickness, and keratinized gingiva width directly affect the peri-implant papilla morphology.

Figure 2. Implant Design

2. Effect of Abutment - Material, Design

Surface and connections on soft tissue integration

a. Abutment Material

With increased awareness and demand for aesthetics, development of new abutment materials other than titanium is being worked upon.

b. Implant neck design/crest module. (Figure 2)

Finite element analysis studies reveal that the cortical bone in the implant neck region bears the highest bone stress, with the implant crest module bearing the major stress after loading. "Misch and Bidez²¹" concluded that shear stress in the crestal region is more with a smooth, parallel sided crest module whereas an angled (more than 20°) crest module decreases the risk of bone loss. Soft tissue integration is also affected by the implant neck design, whether it is a microtextured or macro textured surface. An animal study revealed a higher and better bone-implant contact and the overall soft tissue response in micro grooved implants versus the microtextured implants.

3. Impact of Abutment Disconnection on Soft Tissues

The transmucosal component in a two-piece implant system can cause undesirable effect on soft tissue integration due to unintentional abutment loosening, eventually leading to increased bone remodelling. It is a common finding that apical repositioning of the soft tissues and marginal bone resorption occur due to repeated connections/disconnections.

IMPLANT-HARD TISSUE INTERFACE/ OSSEOINTEGRATION

Osseointegration was first described by Branemark et al. in 1969 as "A direct structural and functional connection between ordered living bone and the surface of the load-covering implant." The concept lies on the fact that the formation of titaniumO₂ over the surface of titanium implant due to oxidation, causes osseointegration. There is direct apposition of bone on implant surface, when viewed under light microscopy. After the placement of an implant into the marrow cavity, ensuring an adequate healing period, a layer of compact cortical bone circumscribes the implant without any apparent intermediating soft tissue. The implant surface when examined under electron microscopy, is found to be separated from the surrounding bone by an amorphous, granular, electron-dense layer (100 nm to 400 nm thick) of uncalcified collagen fibrils.²³ This layer however does not negatively impact the success of the osseointegration. But when this layer is replaced by the presence of connective tissue, osseointegration fails to occur.

Factors Affecting Osseointegration

1. Biological Seal

An effective biologic seal between the implant material and the tissues is a necessity for the successful and an extended survival of the implant in the belligerent environment of the oral cavity. If the seal is violated, adjacent soft tissues get inflamed, followed by osteoclastic activity of the underlying hard tissue and chronic resorption of the supporting bone. With continued loss of the supporting bone, granulation tissue fills up the discrepancies and the implant becomes increasingly mobile, resulting in entry of the bacterial toxins further into the area around the implant. Eventually, the

destruction caused will give rise to an acute suppurative inflammation or acute inflammation, with pain on mastication and extensive mobility that renders unserviceable support of the dental prosthesis.

2. Peri-Implant Marginal Bone

The health of peri-implant marginal bone is controlled by the following parameters: biologic width, platform switching, implant design in the cervical region, thread geometry, depth of insertion and the microlesions produced by the intervention during second-stage prosthetic processing. A stable bone anchoring the implant neck, provides the required reinforcement and hence favourable gingival contour stability.

1. Biological width - The entire contact length between the implant and the 2 mm long epithelial portion and the 1 - 1.5 mm long connective tissue attachment is defined as the biological width. The long-term preservation of the healthy peri-implant tissues is essential for ensuring appropriate function and aesthetics.
2. Tarnow stated that there also exists a horizontal component (contributing to the biologic width) approximating 1 - 1.5 mm that maintains the health of the interproximal bone and, in turn, the papilla.
3. Bone anatomy at the implant site - The geographic distribution of bone in the implant vicinity should favour the placement such that it provides a commendatory environment to the implant prosthesis.

The height and thickness of the facial bone and the bone height of the alveolar crest in the interproximal area together constitute the bone anatomy.

Kois et al. surveyed 100 patients and based on the vertical distance of the osseous crest to the free gingival margin categorized them as having high, normal or low crests. An increased vertical distance increases the risk of tissue loss after an invasive procedure. Kois examined 1 mm loss of the bone tissue in the apical direction after extraction and immediate implant placement, if the vertical distance of the dentogingival complex on the mid facial aspect is measured to be 3 mm or more.²⁵

The crest of interproximal bone plays a crucial role in the anatomical appearance of peri-implant papillae. In a study, Tarnow revealed that when the contact point to the bone distance was 3 - 5 mm, papilla was well established. Whereas when this distance was 6 mm, papillae did not fill up the space in 45 % cases and at a distance of 7 mm, papilla did not form in 75 % cases. Thus, a difference of 1 - 2 mm is significant to achieve soft tissue aesthetics.

3. Quality of Bone

A high failure rate of implants is observed in a poor-quality bone as compared with a bone of high quality. Low survival rates for dental implants in the maxillary arch (especially the posterior maxilla) as compared to those in the mandibular arch have been reported by many clinical studies, reason being the differences in bone quality of the two arches. It was Lekholm and Zarb, who described the bone quality on the basis of radiographic assessment as well as resistance during the implant drilling procedure. Correspondingly, the bone has been categorized into four bone types.²⁷

- Type - 1 - Almost the entire bone is composed of homogenous compact bone.

- Type 2 - A thick layer of compact bone surrounding a dense trabecular bone.
- Type 3 - A thin layer of cortical bone surrounding a dense trabecular bone.
- Type 4 - A thin layer of cortical bone surrounding a low-density trabecular bone.

This classification does not specify ridge dimensions categorically and provides less details regarding vertical or horizontal ridge augmentation for bone deficiencies.

4. Implant Macrostructure

It has been observed that microstructural modifications of the implant surface also potentiate their clinical success, with roughened implant surfaces showing higher adhesive strength than smooth surfaces. A study comparing bone to implant contact (BIC) in six different implant surfaces, revealed that hydroxyapatite (HA) coated and sandblasted / acid etched surfaces show highest BIC.

5. Optimal Implant Positioning

The implant actually simulates the presence of tooth root in the alveolar bone. Thus, the 3-dimensional placement of the implant should be in a mesiodistal, faciolingual and apico-coronal comfort zone.²⁹ Mesiodistally, the placement of the implant shoulder at least 1 mm from an adjacent tooth is considered to be favourable. Facio-lingually, the implant shoulder margin placed 1 mm palatal to the point of emergence of adjacent teeth, is considered as the ideal point of emergence. The factors deciding the apico-coronal location of the implant shoulder are -

1. The pattern of cervical bone resorption
2. Implant diameter
3. Root size discrepancy
4. Thickness of the marginal gingiva and proximal tissues.

Placement of the implant collar 2 mm apical to the cemento-enamel junction (CEJ) of the adjacent tooth is suggested, in the absence of any gingival recession and its location should be 3 mm from the free gingival margin in cases where gingival recession is present. Apico-coronally, the implant position should be approximately 2 mm apical to the midfacial margin of the planned prosthetic restoration.¹⁰

6. The Platform Switch Concept

In conventional implant system, abutments usually closely fit with the implant shoulder in the contact zone. And there exists a micro gap between the contact point at the implant abutment junction (IAJ) which serves as a niche for bacterial, thus contaminating the peri-implant tissues leading to crestal bone loss in the vertical and horizontal dimensions.

Early in 1990s, it was accidentally discovered that due to the non-availability of the matching abutments, major implant companies were using the narrow diameter abutments on the wider diameter implants. Radiographic examination on a long term follow up revealed vertical changes in the crestal bone height around these implants as compared to the implants restored with their formulaic prosthetic components of matching diameter. This observation was suggestive of the fact that the loss of crestal bone height can be reduced if the outer edge of the implant abutment interface is horizontally repositioned inwardly, away from the outer edge of the

implant platform. From this evolved the concept of "Platform Switching" (Figure 3). Platform switching keeps the micro gap away from the implant shoulder and closer towards the axis, thus protecting the crestal bone from any inflammatory involvement.³⁰

Figure 3. Platform Switching Concept

7. Implant Neck Geometry and Size of the Micro Gap (Figure 4)

The neck design of an implant system directly affects the integrity of the soft tissue. Microtextured and macro textured surfaces have a positive influence on the stabilization of interface for peri-implant tissues, thereby preventing the reduction of marginal bone during the first year of implant placement. Size of the micro gap between the implant and the abutment exerts nominal effect on marginal bone remodelling and is independent of the size of the micro gaps, the micro movements induce significant bone loss.

Figure 4. Different Implant Neck Designs. (A) Turned Neck Implants, (B) Micro-Threaded Implant (C) Micro-Grooved Implant

8. Abutment Disconnection and Microlesion

Violation of the biologic width due to the occurrence of micro movements occurring while the replacement of secondary components at the time of insertion of the prosthetic counterparts, results in epithelial tissue migrating apically leading to the resorption of the marginal bone. A good integration of the connective tissue to the titanium surface at the IAJ prevents the epithelium from migrating apically and this is hampered by plaque accumulation/exchange of secondary components (healing caps/impression posts), imposes risk on the crestal bone.

CONCLUSIONS

Aesthetics is important to the dental practitioners since it is significantly more difficult in the implant-prosthetic therapy as compared to the teeth-supported restorative therapy. The time interval between extraction of a tooth and placement of an implant, in conjugation with all the factors discussed above, is another important factor in determining the aesthetic and functional success of the final implant restoration. This time interval directly relates to the amount of bone resorption taking place thus compromising the soft tissue profile.

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