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RESEARCH ARTICLE

BIOLOGIC WIDTH AROUND DENTAL IMPLANTS

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Abstract

The biologic width is considered to be essential for maintaining gingival health, especially in the case of teeth in need of restoration. The large use of osseointegrated implants in modern dentistry and the increasing esthetic demands for implant rehabilitations has focused attention on soft tissue reactions to implant placement especially in the area of soft tissue relationship to implant surface. The presence of a quite constant dimension of soft tissue attachment to dental implants, similar for many features to dentogingival junction, has been well documented in histological studies on animal models. Based on similar histological studies, the influence of different variables, like the surgical technique, the surgical protocol, implant loading, implant structure, titanium surfaces and abutment materials on peri-implant biological width has been evaluated. This review demonstrates the present knowledge about this important zone that forms the basis for a successful implant.

Introduction:-

Periodontal tissues form the foundation for proper esthetics, function, and comfort of the dentition. The preservation of a healthy periodontal attachment is the most significant factor in the long-term prognosis of a restored tooth. The periodontium has traditionally been divided into the gingiva and attachment apparatus. Although the periodontal attachment apparatus i.e. alveolar bone, periodontal ligament and cementum is the major tooth supporting system, the supracrestal connective tissue attachment provides further protection and support. This portion of the attachment apparatus, located between the apical level of the junctional epithelium and the alveolar bone crest, consists primarily of oriented bundles of collagen fibers attached to the cervical cementum. This zone and the junctional epithelium delimit an area at the tooth-soft tissue interface which is commonly referred to as the "normal biologic width".

Biologic width is a term coined by Cohen based on the work of Gargiulo et al. who described the dimensions and relationship of the dentogingival junction in humans(Gargiulo et al. 1961).

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Echoing the relationship between the periodontal tissues and a natural tooth, the supporting tissues of an osseointegrated implant must be organized not only to anchor the implant in the bone, but also to form a protective soft tissue seal around the implant as it emerges into the oral cavity. A soft tissue, which surrounds the transmucosal part of a dental implant, separates the periimplant bone from the oral cavity. This soft tissue collar is called "peri-implant mucosa" (Lindhe et al. 2008).

The attachment of the soft tissue to the implant serves as a biological seal protects the implant by resisting the challenges presented by bacterial irritants as well as the mechanical trauma resulting from restorative procedures, masticatory forces and oral hygiene maintenance and thus prevents the development of inflammatory peri-implant diseases.

Around teeth, a sophisticated soft tissue collar seals the tissues of tooth support (i.e. alveolar bone, periodontal ligament and cementum) against the oral cavity(Bosshardt & Lang 2005) while the soft tissue seal around teeth develops during tooth eruption, the peri-implant mucosa forms after the creation of a wound in oral soft and hard tissues. Healing of the mucosa results in the establishment of a soft tissue attachment (transmucosal attachment) to the implant.

In the early years of implant dentistry, research mainly focused on hard tissue integration. Based upon positive long term results with implant-borne fixed partial dentures as well as over dentures using submerged as well as nonsubmerged implants, implant-borne single tooth restorations became more and more popular during the 1990s (Cochran 1996). As a consequence, increasing attention was given to study peri-implant crestal bone as well as soft tissue reactions. Thus, several authors presented histometric data on two-piece, submerged as well as nonsubmerged implants (Berglundh et al. 1991, Berglundh & Lindhe 1996, Abrahamsson et al. 1996, 1997, 1999).

Biologic width around teeth versus implants:-
In general, the similarities between periodontal and peri-implant soft tissues are limited to the form and function of the analogous epithelial structures. The oral, sulcular and junctional epithelia in peri-implant soft tissues are nearly identical in form and function to their periodontal counterparts. In a natural tooth and implant, the junctional epithelial attachment is an important component of the protective permucosal soft tissue seal. Similarly, the sulcular epithelium that forms adjacent to a dental implant provides cellular immunologic protection analogous to that found in the periodontium, and when present, the thick, keratinized oral epithelium also provides protection from the mechanical forces of mastication, restorative procedures and oral hygiene. There are also important differences between periodontal and peri-implant soft tissues. The tissues that anchor the implant in the alveolus lack both cementum and periodontal ligament; instead, the implant is directly connected to bone below the alveolar crest. In addition, there are no gingival fiber bundles analogous to the dentoperiosteal and dentogingival fiber bundles that attached to the natural tooth.

There are differences concerning the structure, the vascular supply, the localization and the circumferential shape of Biologic Width around implants comparing to teeth. These differences have great clinical impact in achieving aesthetic outcomes in implant restorations.

Structure;-
The connective tissue around teeth is cellular, rich in fibroblasts. Around implants, the connective tissue has a paucity of cells and is composed primarily of dense collagen fibers, similar to scar tissue. The direction of fibers is parallel to the implant surface. The connective tissue adheres rather than attaches to the implant surface (Saadoun & Touati 2007).

Vascularity:-
The connective tissue is highly vascularised around teeth, but poorly vascularised around implants (Moon et al. 1999). The vascular supply around teeth is derived from the subperiosteal vessels lateral to the alveolar process and from the periodontal ligament. Peri-implant soft tissue is less vascularised. The blood supply, originates from terminal branches of larger vessels from the bone periosteum at the implant site, but the blood vessels from the periodontal ligament are missing (Berglundh et al. 1994, Buser et al. 1992). In a zone close to the implant surface (i.e. 50–100 lm away), no blood vessels were found.[13,14] Further away from the implant surface and adjacent to the barrier (junctional) and sulcular epithelia, blood vessels were observed (Buser et al. 1992). Thus, the number of blood vessels increased with increasing distance from the implant surface.

Localization:-
Around teeth, the connective tissue fibers are inserted into the dentin coronal to the bone (supracrestal) and provide support for the soft tissues surrounding teeth, usually, the Biologic Width around implants forms apical to the bone crest (subcrestal). The depth is given by the final position of the remodeled bone: 2-3 mm apical to the implant abutment interface in two- piece implants (Berglundh et al. 1994, Buser et al. 1992).

Circumferential morphology:-
comparing to the scalloped morphology of the Biologic Width around natural teeth, the Biologic Width around implants follows the shape of the implant platform. Usually, implant systems offer flat rotational platforms and, in aesthetic area, they are placed 3 mm - 4 mm subgingivally. The Biologic Width is therefore impinged deep subcrestally, and will be far greater at proximal level than on labial or palatal aspect, generating a significantly proximal bone loss (Buser et al. 1992). The differences in these histologic features explain why the inter-proximal papilla, which consistently fills the inter-dental space in natural dentition, is difficult to duplicate surgically in the case of adjacent implants. Periodontal augmentation procedures that are predictably successful in normal dentition may have an increased risk of failure around implants, with the potential for a result worse than the original defect (Kinsel & Lamb 2005).

Factors influencing biologic width around implants:-
Many biomaterial and surgical factors may have an influence on the outcome of soft tissue quantity, i.e. the length of the peri-implant mucosa and also the composition and structural organization of the peri-implant mucosa.

Berglundh et al. (1991) examined anatomical and histological features of the peri-implant mucosa, which formed in a two-stage procedure, and compared these with those of the gingiva around teeth. The abutment consisted of titanium with a machined surface. Histologically, the peri-implant mucosa consisted of a well-keratinized oral epithelium, which was located at the external surface and connected to a thin barrier epithelium (i.e. the equivalent to the junctional epithelium around at teeth, which will be referred to as the peri-implant junctional epithelium) facing the abutment. This peri-implant junctional epithelium terminated 2 mm apical to the coronal soft tissue margin and 1.0–1.5 mm coronal from the peri-implant bone crest. Thus, the mean biological width (including the sulcus depth) was 3.80 mm around implants and 3.17 mm around teeth. This important study in dogs showed that under the conditions chosen, the peri-implant mucosa has a comparable potential as the gingiva around teeth to prevent subgingival plaque formation and subsequent infection.

Influence of implant system:-

Submerged versus non-submerged:-
Studies revealed that a similar mucosal attachment formed on titanium in conjunction with different implant systems and around intentionally non-submerged and initially submerged implants (Buser et al. 1992, Abrahamsson et al. 1996, 1999, Arvidson et al. 1996, Weber et al. 1996). However, the peri-implant junctional epithelium was significantly longer in initially submerged implants than in intentionally non-submerged implants (Weber et al. 1996).

The biological width was revisited in an animal experiment after abutment connection to the implant fixture with or without a reduced vertical dimension of the oral mucosa (Berglundh & Lindhe 1996). While the peri-implant junctional epithelium was about 2 mm long, the supraalveolar soft connective was about 1.3–1.8 mm high.

One-piece versus two-piece implants:-
Evaluating the biological width around one- and two-piece titanium implants that healed unloaded in either a non-submerged or a submerged fashion in dog mandibles, Hermann et al. (2001) suggested that the gingival margin is located more coronally and the biological width more similar to teeth in association with one-piece non-submerged implants compared to either two piece non-submerged or two-piece submerged implants. These data were confirmed in a comparably designed dog study with another implant system (Pontes et al. 2008).

Judgar et al. (2014) in a human study demonstrated more biologic width dimension in two-piece implants (3.26 ± 0.15) compared to one-piece implants (2.55 ± 0.16).

Influence of implant material:-
Abrahamsson et al. (1998) in an animal study demonstrated that the material used for the abutment had a major impact on the location of the soft connective tissue compartment. Sintered ceramic material made of aluminium (Al_2O_3) lead to a periimplant mucosal attachment comparable to that adjacent to titanium abutments. Gold alloy or dental porcelain, however, resulted in inferior histological outcome of the periimplant mucosa.

Kohal et al. (2004) and Welander et al. (2008) have demonstrated the same peri-implant soft tissue dimensions around titanium and zirconia implants installed in the maxilla of monkeys and dogs respectively.

Influence of implant surface characteristics:-
The effects of surface macro design, topography, hydrophilicity and various coatings on the peri-implant mucosa have been evaluated in numerous pre-clinical and clinical studies. The impact of surface topography, often characterized by surface roughness measurements, on the peri-implant mucosa have been investigated in numerous studies.

Cochran et al. (1997) noted no differences in the dimensions of the sulcus depth, peri-implant junctional epithelium and soft connective tissue contact to implants with a titanium plasma-sprayed (TPS) surface or a sandblasted acid-etched surface.

Abrahamsson et al. (2001, 2002) observed similar epithelial and soft connective tissue components on a rough (acid etched) and smooth (turned) titanium surface. The biological width was greater on the rough surface, however, without a statistically significant difference to that around a smooth surface.

In two studies with human biopsy material, less epithelial down-growth and a longer soft connective tissue were found in conjunction with oxidized or acid-etched titanium compared to a machined surface (Glauser et al. 2005, Ferreira Borges & Dragoo 2010). In a study in animals, Watzak et al. (2006) showed that implant surface modifications had no significant effect on the biological width.

Using a new human model, Schwarz et al. (2013) investigated the peri-implant soft tissue dimensions after an 8-week healing period on specially designed healing abutments with different surface roughness and hydrophilicity. The length of the peri-implant junctional epithelium was in the order of 2 mm for all abutment types without statistically significant differences.

Cochran et al. (2014) demonstrated that the epithelial component and BW were significantly greater around the implants with a machined collar than the implants with a SLActive collar.

Immediate versus delayed implant loading:-
The influence of loading on soft tissue healing around implants was one of the topics most frequently investigated. Cochran et al.evaluated the dimension of the implanto-gingival junction around non submerged loaded and unloaded implants testing two different surfaces (SLA and TPS) at 3 and 12 months after implant placement (Cochran et al. 1997). At 3 months, the dimension of the constituents of the biological width in the unloaded group were 0.49mm for the sulcus depth (SD), 1.16 mm for the junctional epithelium (JE), and 1.36 mm for the connective tissue component (CTC). The corresponding measurements in the loaded group were 0.50 mm for SD, 1.44 mm for JE, and 1.01 mm for CTC for the loaded group. Results were similar after 12 months of loading, confirming that the biological width around implants resembles the one present around teeth and that the dimension of its constituents are independent from the loading variable.

Studying immediate versus delayed loading of titanium implants placed in jawbone of monkeys, Siar et al. (2003) and Quaranta et al. (2008) could not detect any significant differences in the dimensions of the peri-implant sulcular and junctional epithelia and connective tissue contact to the implants.

Influence of biotype:-
Kan et al. demonstrated greater peri implant mucosal dimensions in the thick peri-implant biotype compared to thin biotype. (Kan et al. 2003)

Formation of biologic width after Flap Surgery in Healed Ridges:-
The wound healing sequence leading to this establishment of peri implant mucosa has only recently been evaluated. Berglundh et al. (2007) examined the delicate process of wound healing and morphogenesis in the mucosa around non-submerged commercially pure titanium implants in dogs. Healing periods varied from 2 h to 12 weeks. From this study, it can be concluded that the soft tissue attachment to transmucosal (i.e. non-submerged) implants made of commercially pure titanium with a polished surface in the neck portion requires at least 6 weeks in this animal model.

Using a new human model, Tomasi et al. (2013) investigated the morphogenesis of the peri-implant mucosa during the first 12 weeks of healing. They observed that a soft tissue barrier adjacent to titanium implants developed completely within 8 weeks, which is in agreement with observations made in dogs.Concerning stability of soft tissue dimensions over time, it can be concluded that the dimensions of the soft tissue seal (i.e. the biological width) around implants are stable for at least 12 or 15 months (Cochran et al. 1997, Hermann et al. 2000, Assenza et al. 2003).

Formation of biologic width after Immediate Implant Placement into Fresh Extraction Sockets:-
Vignoletti et al. (2009) described histologically and histomorphometrically the early phases of soft tissue healing around implants placed into fresh tooth extraction sockets in dogs. They observed a fast apical down growth of the peri-implant junctional epithelium within the first week of healing and a final biological width of approximately 5 mm with a periimplant junctional epithelium measuring 3.0–3.5 mm at 8 weeks.

Similar dimensional outcomes were reported by de Sanctis et al. (2009) around different implant systems in dogs (i.e. 2.33 – 2.70 mm epithelial length after 6 weeks).When implants are placed into fresh extraction sockets there are conditions that appear to favor a fast apical migration of the peri-implant junctional epithelium and the establishment of a greater final biological width dimension, particularly the epithelial component.

Flap versus Flapless Healing of the Periimplant Mucosa:-
In a dog experiment, teeth were removed either flapless or with flap surgery and implants were immediately placed. After a 3-month healing period, the distance between the peri-implant mucosal margin and the first bone implant contact was significantly greater in the flap group compared to the flapless group (3.69 mm versus 3.02 mm) (Blanco et al. 2008).

Bayounis et al. stated that a significantly longer peri implant junctional epithelium formed at 3 months after implant placement, when the punch diameter was greater than that of the implant (Bayounis et al. 2011). These findings suggest that the diameter of the soft tissue punch should be slightly smaller than that of the implant to obtain better peri-implant mucosa adaptation and subsequent healing.

The flapless approach has, at least in the short-term, some advantages over flap surgery, provided that the diameter of the soft tissue punch is below that of the transmucosal portion of the implant. The disadvantage of the flapless approach is that the bone volume may not accurately be determined. However, the clinical relevance of these histological findings remains to be determined.

Conclusion:-

The biologic width is considered to be essential for maintaining gingival health, especially in the case of teeth in need of restoration. The large use of osseointegrated implants in modern dentistry and the increasing esthetic demands for implant rehabilitations has focused attention on soft tissue reactions to implant placement especially in the area of soft tissue relationship to implant surface. The presence of a quite constant dimension of soft tissue attachment to dental implants, similar for many features to dentogingival junction, has been well documented in histological studies on animal models. Several authors demonstrated that implant system, implant material, surface characteristics of implants, loading can influence the biologic width. The peri-implant junctional epithelium may reach a greater final length under certain conditions such as implants placed into fresh extraction sockets versus conventional implant procedures in healed sites. However most of the studies were done in animals. In future, it can be recommended to perform controlled human clinical studies.

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