The Dimension of the Biologic Width Related to Aesthetic Implant Restorations

Master Thesis

Master of Oral Medicine in Implantology

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Summary

Objectives: The master thesis is a review on the role of the Biologic Width formation in the aesthetic outcome of implant restorations. Topics were the effect of Biologic Width formation on bone resorption, and the consequence for the implantological approach if this biological mechanism is taken into account to minimize bone loss: concepts, implant protocols, surgical techniques, implant design, implant positioning and prosthetic approaches.

Methods: A computer-based search of electronic databases (MEDLINE) was performed. Of 80 articles 48 were included, comprising animal, human and multicenter studies, clinical case reports, and literature reviews. Selection criteria were histometric studies of Biologic Width, aesthetic implant clinical cases, implant design related to aesthetics, diagnosis elements in aesthetic implant restorations and surgical approaches related to aesthetics.

Results: Biologic Width is a zone of connective tissue separating epithelium from underlying bone. The re-establishment after implantation is associated with bone loss that depends partially on the patient’s individual anatomical condition but can be minimized by: adequate preparation of the implant bed, preservation (or recreation) of alveolar bone, atraumatic soft and hard tissue management, surgical and prosthetic technique as well as implant placement and shape.

Conclusions: Obtaining excellent aesthetic results requires not only superior diagnosis, planning, and execution, but taking into account the biological response of hard and soft tissues and the consequences for bone loss around implants. Keeping the requirements for Biologic Width in mind regarding surgery, implant shape and placement will minimize bone loss and result in simpler and shorter treatments with a better aesthetic outcome.

Key words: Biologic Width, dental aesthetics, implant design
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1 Introduction

Nowadays practitioners must satisfy an extremely aesthetically aware population. Unreasonable demands from patients and unrealistic promises by practitioners can lead to unsatisfactory experiences for all parties. An understanding of aesthetic possibilities and limitations of dental implants and the practitioners own expertise will reduce the risk of unforeseen problems (1). Dental aesthetics is defined as achieving a pleasing appearance of the dental restoration, in harmony with the surrounding teeth and tissues. In general, that implies mimicking healthy dental structures and surrounding them with healthy soft tissues in a natural and harmonious fashion (2). Higher demands determined that implant concepts have undergone (and continue to undergo) a significant evolution, not only in terms of materials, surfaces and designs, but also in clinical and technical management (3). New implant and abutment designs have been introduced. Still, in a recent five year study, Jemy reported only 60% of the cases with full gingival support and the other 40% had incomplete papilla, long crowns and recession of the soft tissue (4). In the quest to achieve the perfect aesthetic soft tissue result, it is easy to focus only on the surgical and clinical techniques to recreate ideal soft tissue forms without due regard to the biology of soft tissue in health and in disease (2). In implantology, marginal bone loss is the key to aesthetic soft tissue contour (5). Good aesthetic finish of implant-restorations requires healthy peri-implant soft tissue at the appropriate location (2). A clearer understanding bone and soft tissue responses to implants enables the clinician to better plan the aesthetic outcomes of implant treatment (3). Gingival aesthetics around teeth is based upon a constant vertical dimension of healthy periodontal soft tissues, the Biologic Width, which often dictates where the final gingival margin will be (6). It is, therefore not surprising that the position and stability of the alveolar bone ridge surrounding dental implants ultimately determines where the gingival margin rests (2).

As during the 1990’s implant-borne single tooth restorations in aesthetic area became more and more popular, increased attention was given to study peri-implant crestal bone as well as soft tissue reactions. Thus, Berglundh and coworkers (1991, 1996) and Abrahamsson and collaborators (1991, 1996, 1997) presented histometric data on two-piece implants. Cochran et al (1997) and Hermann et al (2001) first published peri-implant histometric results, confirming the Biologic Width dimensions
Implant dentistry steadily evolves as more is learned about the unique biologic interrelationships of the dental implant restoration and the surrounding hard and soft tissues (7).

**Thesis objectives**

The master thesis is a literature review of studies and theories about the Biologic Width and of the way in which this structure influences the aesthetic outcomes of implant restorations. In fact, it is a pretext and an opportunity for reevaluating the topic of bone loss around implants and of the consequent quantitative and qualitative alteration of soft tissue around implants, which usually determine alteration in “red and white aesthetics”

**Research questions**

1. Which are the biological mechanisms and the patterns of bone and soft tissue remodeling around implants? How predictable is bone loss, and which other factors influence it?

2. How much bone loss is the consequence of Biologic Width formation, and what is the impact of Biologic Width formation on successful aesthetic implant restoration?

3. How do all these biological mechanisms influence the implantological approach: the concepts, implant protocols, surgical techniques, implant design, implant positioning and prosthetic approaches?

4. How predictable are aesthetic and stable results? What are the possibilities and the limits, and what means and methods can practitioners use in order to obtain the best stable aesthetic result?

2 **Material and methods**

A computer search of electronic database in MEDLINE was performed. The search was limited to English language. Keywords such “biologic width around titanium implants”, “dental implant biologic width”, ”bone loss around implants”, ”platform switch
implants”, “flapless surgery”, “socket classification” and “soft tissues around implants” were used.

Another method of search was the use of known author’s names: Kois JC, Elian N, Saadoun AP, Lindhe J, Buser D.

Included were: animal studies, human studies, multicenter studies, clinical case reports, literature reviews.

A total of more than 80 articles were selected and studied of which 48 were considered to be relevant and included in the Bibliography. Selection criteria were the inclusion of: histometric studies of Biologic Width; aesthetic implant clinical cases; a relation of implant design to aesthetics; surgical approaches related to aesthetics (flap versus flapless surgery, immediate implants, socket preservation); diagnosis elements in aesthetic implant restorations.

Four books and a Master Thesis were quoted.
3 Results

3.1 Oral aesthetics

3.1.1 Fundamental aesthetic criteria

Aesthetic principles refer not only to tooth aesthetics but include gingival aesthetics and final aesthetic integration into the frame of smile, face and, more generally, the individual (9). Both dental and gingival aesthetics act together to provide a smile with harmony and balance. A defect in the surrounding tissues cannot be compensated by the quality of the dental restoration and vice versa (10).

3.1.2 Gingival aesthetics

The fundamental criteria related to gingival aesthetics are well established and they include both gingival health as well as gingival morphology (11). It is necessary to pay attention to the position of the gingival margin, the shape (height, volume) the colour, texture and the contour of the labial gingival tissue and the adequacy of the inter-dental papillae (2). The elements which provide a good aesthetic at gingival level are:

- **Gingival health** – the attached gingiva has a coral pink color and firm texture, with an orange – peel appearance. (10)

- The **gingival outlines** in the anterior sextant - should be symmetrical to the opposite side, and should align the gingival architecture of the canines and central incisors in the same horizontal plane (9).

- **Balance of gingival levels**: the gingival contour of lateral incisors should lie somewhat more coronal compared to that of central incisors and canines. (10)

- The **gingival zenith** (the most apical point of the gingival outline) usually lies distal to the center of the tooth. (10)

- The presence, the level, and the shape of **papillae**: a pyramidal shape of papillae and a normal proportion of 25% - 35% of papillary coverage at the inter-proximal surface is appealing. Anything above or below this ratio is not (9).

3.1.3 Dental aesthetics

In teeth, the physiological performance is the result of an intimate and balanced relationship between biologic, mechanical, functional and aesthetic parameters (10).
There are a number of criteria for dental aesthetics. One of them is the tooth profile, which includes the submergence and emergence profile of the teeth. The first is defined as the portion of the root and the gingival attachment that emerges from the bony structure and extends to the base of the periodontal sulcus. The dental root form and position have a direct influence on the aesthetics, shape and support of the soft tissues both facially and inter-proximally. The emergence profile is the dento-gingival complex that extends from the base of the sulcus to the free gingival margin. The dimensions vary greatly from 0.5 mm to 4 mm in a healthy periodontium. A variety of guidelines have been developed to control the emergence profile. The primary guideline should serve to provide contours that can be maintained by the patient’s oral hygiene habits (9).

Other criteria include the form, dimension, and proportion of individual teeth and the inter-proximal contact areas, their characterization (opalescence, translucency and transparency), as well as their surface texture and color, including fluorescence and brightness (10).

3.1.4 Aesthetics and biologic conditions

All the elements of oral structures present at the same time both esthetics and biological interconnectivity particulars. In clinical practice, the respectful restoration of healthy biological relational conditions should always take precedence over aesthetic relationships. As a matter of fact, a loss of control of biological relationships whose fragility may lead to structural breakdown will invariably generate disease (8).

3.1.5 Bone loss and aesthetic challenges

The main problem and challenge in implant restoration is the bone loss. Resorption at the buccal plate (in width and in height) causes recessions, while the proximal bone loss conduct to alteration of papilla height and shape (5). This situation can lead to the aspect of “black triangles” or to a squared shape of the teeth, by modifying the quality of inter-proximal contact areas (9).

**Bone loss after tooth extraction** - In health, the soft tissue follows the osseous contours. Physiologic osseous morphology reveals a scalloped architecture around the tooth prior to tooth loss. Tooth extraction is associated with three dimensional bone loss, and subsequent remodeling of the residual ridge: from scalloped turns into flattened ridge. (12) The amount and the pattern of bone loss are well described in the literature.
Significant ridge resorptions, vertical and horizontal, may significantly compromise the potential for aesthetic rehabilitation (13). Approaches like immediate implantation, or “socket preservation” are expected to minimize post-extraction bone loss.

*Bone loss and implant placement* - Crestal bone loss has been shown to occur around dental implants, and its precise mechanisms are not yet completely understood. There are many factors that determine and influence the bone loss around implants: the recipient’s particularities: gingival biotype and bone density, the implant design, the 3-dimensional positioning of the implant platform, the surgical trauma, the case management, the occlusal overload. (14)

It has been demonstrated during the past decade that the bone loss that occurs around implants during the first postoperative year is related primarily to the formation of Biologic Width. (15)

### 3.2 Biologic Width around teeth and implants. Basic biologic principles

#### 3.2.1 Biologic Width around teeth

The physiological dento-gingival junction of natural teeth including the length of the epithelial attachment, the length of the connective tissue attachment and the depth of the sulcus is known as “Biologic Width”. The mean value of the Biologic Width around a natural tooth is 2.73 mm). This unit is a physiologically formed and stable dimension and forms at a level dependent on the location of the crest of alveolar bone. (16) Due to a large range of possible variations in sulcus depth dimension, authors usually refer to Biologic Width as including only the connective tissue and the junctional epithelium.

The average dimension of the Biologic Width around a tooth is approximately 2.04 mm. It consists of 1.07 mm connective tissue and 0.97 mm epithelial attachment. In healthy periodontium at midfacial level, the sulcus depth is approximately 1 mm. Proximally, when the interdental papilla fills the gingival embrasure, about 5 mm of soft tissue is present between the bone crest and the tip of interdental papilla. The 5 mm consist of 1 mm connective tissue, 1 mm epithelial attachment, and 3 mm of sulcular depth.

The Biologic Width follows the architecture of the bone crest, which follows the scalloped shape of cement-enamel junction. The difference between the facial and proximal bone crest can range from 2.1 mm to 4.1 mm. The type of periodontium, thin
scalloped or thick flat, determines the degree of scalloping of the bone. (17) The complex is supracrestally located.

3.2.2 Biologic Width around implants

Biologic Width formation around implants has been established as well and soft tissue dimensions have been measured. (15, 6) Biologic Width around implants is a physiologically formed and stable dimension, and this unit forms at a level dependent on the location of the crest of the alveolar bone. (15)

A certain width of the peri-implant mucosa is required to enable a proper epithelial and connective tissue attachment. If this soft tissue dimension is not satisfied, bone resorption will occur to ensure the establishment of attachment with an appropriate Biologic Width. (18, 14) Thus, any bone loss influences the level where the Biologic Width will form, and, in turn, the need of formation of Biologic Width may result in bone loss. This is why the Biologic Width cannot be discussed independent, but connected to the problematic of bone loss around implants, which, in turn, determines the final aesthetic result. This constant dimension, as an interface between the bone level and the free gingival margin, often dictates where the gingival margin will be. Thus, the position and stability of the alveolar bone ridge surrounding dental implants ultimately determines where the gingival margin rests. (2)

Experimental studies in dogs demonstrated a mean Biologic Width of 3–4 mm. The measurements found 2 mm of junctional epithelium and 1.3–1.8 mm connective tissue. (18) Dimensions have been found to be similar between different implant systems and they remain stable over time. (1) (5)

Some human studies also reported that the average facial dimension of peri-implant mucosa of implants placed in two stages is slightly greater than that of the dento-gingival complex (3mm). (12)

3.2.3 Comparison between Biologic Width around teeth and implants. Clinical relevance

There are big 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.
1. **Structure** – The connective tissue around teeth is cellular, rich in fibroblast. 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. (5)

2. **Vascularity** – The connective tissue is highly vascularised around teeth, but poorly vascularised around implants. (19) The vascular supply around teeth is derived from the subperiosteal vessels lateral to the alveolar process and from the periodontal ligament. (20, 21) 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. (20, 21, 7) A zone of avascular connective tissue is directly adjacent to the implant surface. (20, 21)

3. **Localization**: a striking difference - if 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 remodelled bone: 2-3 mm apical to the implant abutment interface in two-piece implants. (20, 21)

4. **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, (22) generating a significantly proximal bone loss.

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. (7)

Therefore, the preservation or augmentation of soft tissue prior to implant placement is of paramount importance to obtaining optimal gingival contours surrounding the restoration. (23, 7)
3.3 Dimensions, configuration and location of Biologic Width around implants. Factors of influence

Biologic Width is consistent. Its formation is not depending upon the quality of soft tissue, implant design, upon the surface roughness neither upon surgical protocol (submerged or non-submerged). (2) But all these factors influence not only the dimension but also the apico-coronal position of Biologic Width, by influencing the amount and the pattern of bone loss. Consequently, the characteristics of soft tissue are significantly influenced. (24)

3.3.1 Vertical component of Biologic Width

Peri-implant mucosa dimension is dependent upon the gingival biotype. (12) In thick biotypes, Biologic Width might measure 4 mm or more, while in thin gingival byotipes, it is 3 mm or less. The thick biotype is more resistant to recession (0.7mm), and results often include pocket formation after any apical migration of the junctional epithelium. In thin biotype there is an increased risk of facial recession (1mm) and interproximal loss of gingival tissue after any surgical procedure. (1) Minimally invasive or flapless surgery is recommended, in order to minimize compromises to the blood supply. (25)

Non-submerged, one piece implants allow for stable peri-implant soft tissue, and a Biologic Width much coronal and with dimensions close to natural teeth. (15) It has been proved that the non-submerged technique is a predictable one, showing certain advantages: lack of the microgap at or below the crest; lack of second stage surgery; more mature soft healing (15). Cochran and colleagues reported that a space of 3 mm in height is required for periimplant sulcus formation around one stage dental implants (0.16 mm the sulcus, 1.88 mm the junctional epithelium and 1.05 mm the connective tissue). (24, 12) Thus, several implant design have been modified to allow a polished collar to create Biologic Width at the alveolar crest. (24) Surgeons recommended embedding the polished collar into alveolar bone in the aesthetic regions, in order to avoid the aesthetic problem of the metal showing through the gingiva. But polished titanium surfaces are not favorable for osseointegration. The alveolar crest will further resorb and also, an additional 0.75-0.9 mm of tissue recession can occur after abutment connection. (24)

The implant surface - “Rough is good for bone, not for soft tissue.”

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A factor that influences the level of the final Biologic Width is the position of rough–smooth border related to the bone crest level. Bone will stabilize at the rough-smooth border. The deeper position of this border increases the bone loss (26). This phenomenon is independent of loaded or unloaded implants. (27, 26)

**Microgap** - “Bone stays away of bacteria and micromotion.”

The presence and position of an implant abutment interface has the most profound influence upon the bone loss and Biologic Width formation around two stage implants. (28) After an implant–abutment interface is established (in two stage implants inserted at or below the crest level), the bone resorbs 1.5 – 2 mm apically due to Biologic Width formation. When the implant abutment connection was placed at gingival level, supracrestally (as in conventional single stage implant placement), less bone loss occurred and the Biologic Width measurement was similar to that of natural dentition. In excessive apical placement of the interface microgap, more bone loss is observed and the Biologic Width increases accordingly. (22) This is independent of early or immediate loading, or immediate postextractional insertion. (28) The influence of the microgap is bigger than the influence of the rough-smooth limit positioning.

This phenomenon could potentially cause apical recession of the facial marginal gingiva, and a reduction in papillary height. (7)

The influence of the micro-gap was associated with micro-motion and bacterial colonization. (28) In natural dentition has been demonstrated that interseptal bone will resorb approximately 2 mm apically and 1.5 mm laterally from the plaque on the tooth surface. Similarly acts the *bacterial colonization* associated with adjacent implant platforms.

In presence of 150 microns micromotion, bone loss occurs in 3 weeks. (29) A recent study showed interesting results comparing the quantitative *micromotion* in different implant systems. All implant–abutment connections with a clearance fit exhibited micro-motion. Precision conical connections (Ankylos, Astra Tech) showed no micromotion. (30)

In two stage systems, placed at or below the crest, the repeated assembly and re-assembly of components such as healing abutments, impression copings, final abutments, and framework try-ins can significantly disturb the epithelial and connective

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4 Tarnow Dennis (2008). (29)
tissue layer and allow for apical migration of all tissue compartments resulting in increased bone loss. (12, 4)

The rule of Biologic Width is that a zone of connective tissue separates epithelium from the underlying osseous structures. Once epithelium is established at the abutment-implant level, the connective tissue zone must be re-established to separate the bone from the epithelium. This can be achieved only by remodelling of osseous structures, thereby making space for the connective tissue zone. Bone cannot be maintained immediately below epithelium without a connective tissue interface (within 1.5 – 2 mm), regardless of the implant surface topography. (12)

Thus, the necessity of bone to establish Biologic Width in vertical dimension requires that the implant-crown interface be located at least 2 mm coronal to the osseous crest in order to reduce the bone remodelling (2.84 mm in one piece implant, 3 mm in two pieces implant). (27)

The apical placement of a micro-gap (interface), as recommended clinically in order to achieve a harmonious emergence profile in areas of aesthetic concern, has the most significant influence on the hard and soft tissues, with the largest Biologic Width dimension, the most apical location of the crestal bone, small connective tissue contact area, very long epithelial attachment, and the most apical location of the gingival margin. (27)

3.3.2 Horizontal component of Biologic Width

The horizontal component of the bone loss determined by the formation of Biologic Width has been investigated by Tarnow and colleagues. In a clinical and radiologic human study, they reported that this horizontal bone loss component is in the range of 1.3 – 1.4 mm. (31) This amount of bone loss is of paramount importance regarding the positioning of the implants: adjacent to teeth, or adjacent to other implants. They showed that a clear trend of increased bone loss existed as the interimplant distances decreased. (32) This fact has an important clinical significance because the increase in crestal bone loss produces an increase in distance between the base of contact point of the adjacent crowns and the bone crest. Consequently, the formation of aesthetic papillae might become questionable.
3.3.3 Biologic Width and aesthetics in implant restorations

Successful aesthetic implant therapy relies on optimal gingival profile and underlying osseous support. (7) A long term aesthetic outcome survival depends on soft tissue dimensions that remain healthy and vertically constant over time. (24)

Preservation of buccal and interproximal hard and soft tissues is profoundly influenced by the vertical and horizontal components of Biologic Width (7, 18, 27, 28). The bone loss associated with the formation of Biologic Width may alter the surrounding hard and soft tissues, having important consequences upon the aesthetic of the implant restorations. Facial bone loss may cause recessions. Thus increases the crown-implant ratio. The reconstruction’s dimensions and proportions are altered or the metal collars become exposed. In this manner, alterations of gingival outline, emergence and submergence profile occurs. Proximal bone loss may jeopardize the formation of interdental papillae. The mean time, pockets formation increases subgingival bacterial colonization, which could result in further alveolar bone loss. (14)

Papillae

The most important criterion in preserving or creating the papilla between a tooth and an implant or between two implants is the proximal underlying bony support. (33, 32)

In natural dentition, the presence of papillae is supported by the interdental peak of bone, by the supracrestal Biologic Width and by a rich vascularisation. In implant restorations, due to the particularities of Biologic Width around implants, maintaining or reforming papillae between implants and teeth and between adjacent implants is one of the main challenges of a successful treatment.

Papilla between a tooth and an implant – “5 mm rule”

Papilla between an implant and a tooth respects the “5 mm rule”, the same way like in natural teeth. It will fill the embrasure space almost 100% if the distance from the base of contact point to the crest of the bone is 5 mm or less. If the distance is 6 mm – just 1 mm longer – the papilla will be present only 55% of the time. (32) The smallest amount of change in this dimension can have dramatic effects on presence or absence of the papilla. (17) The second rule is that the papilla will be present only when a contact point is present. If an extraction is performed, the papilla will recede by approximately 1.5 mm to 2mm due to the shrinkage of the pseudopocket that forms the col. It will return only after a full, intact contact is reinstalled. (17)
Maintaining the platform implant at a distance of 1.5 - 2 mm to the adjacent tooth prevents that the horizontal component of the Biologic Width around the implant will remodel the bone peak adjacent to tooth. This bone peak and the supracrestally Biologic Width of the tooth usually maintain the level of papillae between implants and teeth, even in deeper position of the platform. Thus, when evaluating the potential of papilla re-growth next to a single implant, it is essential that no bone loss or attachment on the adjacent tooth exists. Papilla will return after the contact point is re-established by provisional or final crown. (17) The vertical height of the top of the implant is not critical for the contact point to be established. Therefore, even if the implant is placed deeper, the papilla will usually fill in. Negative consequences would occur in the situation that the adjacent tooth would need to be extracted. (17)

**Clinical implications**

In certain situations, respecting the 1.5 mm distance is difficult. Implants of smaller diameter may be required in certain cases, or orthodontics, in order to create more space before the implant is placed.

It is also very important that clinician should do everything possible to avoid further bone loss on the adjacent teeth during implant placement and uncovering.

- Flapless procedures and papilla saving incisions are measures that may prevent the exposure of the interproximal bone. The opening of the interproximal area causes an average bone loss of 0.7 mm, when compared to only 0.2 mm if the incision spares papilla. And this is a significant factor for papilla regrowth. (17).

- One-piece implants and platform switch implants are an alternative for minimizing the lateral bone loss.

- Forced eruption of a tooth to be extracted is the golden standard for producing an aesthetic result without jeopardizing periodontal support for adjacent teeth. It ensures the reformation of Biologic Width at a more coronal level, thus maintaining its periodontal health. (34)

**Papilla between implants**

Reforming a papilla between two implants has been a continuing challenge for clinicians on the global level. (17) The horizontal components of Biologic Width between two adjacent implants may overlap, resulting in increased crestal bone loss. This is why the recommended distance between two adjacent implants should be at least
3 mm, in order to preserve the interimplant bone, which, in turn would support the interimplant soft tissue. The mean papillary height between two adjacent implants was reported as only 3.4 mm. (32)

The main issue in maintaining or re-forming a papilla between two implants is that the Biologic Width around an implant is usually located subcrestally, apical to the implant abutment connection, due to the deep positioning of flat implant platforms, below the inter-implant bone crest. (24, 32) The avoidance of undesired consequences may request measures like: increasing the inter-implant distances more than 3 mm; augmentation of the inter-implant buccal bone; maintaining a 3 mm thickness of buccal lamella, in order to support the soft tissue. (5)

Taking into consideration the anatomical particularities of the Biologic Width, the unanimous recommendation is to preserve or create by orthodontic or augmentation procedures a sufficient amount of bone and soft tissue prior to implantation. It is important to remember that soft tissue augmentation is not possible without hard tissue support. (24)

3.3.4 Biologic Width and implant design

Implant designs are evolving to maintain bone at predictable positions on the implant body. (35) The alterations that impact the most tissue recession are located primarily in the cervical and collar area. (5) The shape and diameter of the platform are of great importance, as well as stable and simplified prosthetic choices in abutment design. (35)

One piece implants - Studies showed that the least marginal bone loss occurred when the rough limit was placed at crestal level, and the polished collar was placed above the alveolar crest. One piece implant designs show a more closely mimicking the Biologic Width around natural teeth. (27, 24) The Straumann Standard implants present a 2.8 mm polished collar, similar to the dimension of the Biologic Width. For more 1 mm apical positioning of implants in situations where mucosal conditions require shorter transmucosal dimensions, Standard plus implants offer a 1.8 mm polished collar. (26)

Wide diameter implants - Increased horizontal bone remodeling were found around wide diameter implants. (4) Soft tissue recession around a wide diameter implant averaged 1.58 mm compared to 0.57 mm around a standard-diameter implant. While the wider diameter implant should provide an anatomically correct emergence profile, it may be more prudent to use standard-diameter implants in the aesthetic zone to avoid thinning the buccal cortical bone and excessive soft tissue recession. (5)
**Platform switch implants** - The use of prosthetic abutments with reduced width in relation to the implant diameter (platform switching), during the period of osseointegration, affects Biologic Width by altering the position of the microgap. (24) This seems to have a great potential to limit the crestal resorption. The reduction of the abutment of 0.45 mm on each side (5 mm implant/4.1 mm abutment) was found to be sufficient to avoid peri-implant bone loss. The reported bone loss was 0.6 – 1.2 mm, comparing to 1.5 – 2 mm. (24, 36, 37, 38)

**Scalloped implants** - A scalloped implant platform, that follows the osseous structure of the maxillary anterior teeth may conserve the tissue architecture by minimizing the proximal bone remodeling induced by the subosseous position of the implant head, thus improving the support of the papilla. They were developed specifically for the situations exhibiting three-dimensional ridge topography. (24, 12, 5, 4)

**Implants with microthreads** reaching the col seem to prevent bone resorption from occuring. These results, however, must still be proven by research. (5)

Implant systems with restorative abutments positioned deep inside the implant allows the abutment–implant joint to remain stable, and allows the Biologic Width to form and remain on the side of the abutment, rather than the side of the implant.

### 3.3.5 Biologic Width and surgical techniques

The most general surgical approaches for implant placement are submerged and non submerged surgical techniques, using one–piece and two-pieces implants. In both situations full thickness flap are usually raised.

**Submerged / non submerged implants**

No difference in soft tissue dimensions was found around bone level two–pieces implants that had been placed utilizing a submerged technique as opposed to placing them using a non submerged approach, but the dimension of Biologic Width was greater, and the position more apical than in one piece, non submerged implants with a rough – smooth border at the alveolar crest. In this second situation the smallest value of Biologic Width was measured: 2.84 mm, similar with that in natural teeth: 2.73 mm.

**Flap design**

“Raising a flap in order to see the bone is a bye-bye bone party”³

³ Robert E Lamb (2003) (39)
Flapless surgery, or limited flap designs (papilla preservation incisions) minimizes bone loss because it does not interrupt the blood supply and consequently provides a better aesthetic outcome, with less papilla recession. (5)

Widely mobilized flap design generates more bone loss (1.2 mm) compared to flapless technique. (5) Tarnow reported 2.11 mm vertical bone loss with flap surgery versus 0.6 mm flapless. (29) After full thickness flap procedures bone stabilizes more apically and Biologic Width forms further apically. This bone loss adds to that requested by Biologic Width formation.

Flapless immediate implant surgery produces a significant reduction in the vestibular Biologic Width and a minor reduction in buccal plate resorption. (40)

3.3.6 Biologic Width and case management

Measures to prevent bone loss and more than that, to preserve and enhance hard and soft tissues prior to implant placement are of paramount importance. In this manner, a favourable recipient site for obtaining the final aesthetic outcomes can be created. Prosthetic driven principles for creating an Aesthetic site foundation have been well described. (13) The result should be the recreation of a favourable Frame of reference. (9)

Implant placement and extraction timing.

The moment of implant treatment - immediate, early, late implantation – seems to be very important, as a factor of preventing gingival recession.

Immediate implantation proves to be favourable for the conservation of bone and gingival level. Conserving teeth until implant placement stabilizes cortical bone and enables the convex form of soft tissues to be maintained at the vestibular level, thus creating the illusions of natural roots. (5)

Minimal invasive extraction and socket preservation

Augmentative procedures at the extraction moment have been developed, preventing the collapse of the tissues: Colla – plug technique after Sclar, Ice cone technique after Elian and Tarnow. (41)

More and more authors emphasize the benefits of minimal invasive approaches. Shanelec’s study confirms a high clinical success rate of immediate implants placed
micro-surgically in anterior sockets of the anterior maxilla with immediate provisionals. (42)

**Prosthetic solutions**

Immediate loading did not produce changes in the dimensions of peri-implant soft tissue (43) but may have influence upon bringing more coronally the level of Biologic Width formation.

Immediate implant placement with immediate fixed provizionalization is advocated to facilitate maintenance of the gingival esthetics. (44, 45)

The use of a single implant with two prosthetic crowns is one of the ways of preservation of the inter-dental papilla and gingival contours, compensating for the alveolar bone crest resorption at the platform of a second implant due to Biologic Width formation. (46, 17)

Provisional bridge or acrylic removable dentures for guiding soft tissue healing prior to implant placement is a well known successful approach. (5, 7, 47)

**3.4 Biologic Width as a rationale for implant placement. Three-dimensional positioning of implant platforms and surgical protocols**

The most common problem in aesthetic area is the treatment of three-dimensional osseous morphology with conventional flat platform implants. (12) Most of the authors agree that for optimal aesthetics, the implant should be placed as deep as biologically acceptable, while at the same time the abutment-implant should be kept away from the bone to minimize tissue trauma and remodeling. (4) The final vertical position of an implant neck into a scalloped ridge or a extraction socket can be a significant challenge as a deep or shallow position can compromise either interproximal bone or expose the buccal surface of an implant. Another consequence of deep implant placement is that additional subgingival prosthetic manipulation may result in tissue inflammation and eventual bone resorption, therefore compromising long term osseous support for the soft tissue. (4)

There are differing opinions among clinicians regarding the appropriate positioning of the implant restorative platform in the vertical and sagittal planes relative to the alveolar crest.
An apical and palatal orientation of the coronal platform relative to the alveolar crest is generally advocated for favorable facial and proximal emergence profiles of the definitive crown. (7)

Some authors recommend that the implant platform should be placed 3 to 5 mm from the cement-enamel junction of the adjacent tooth. (27, 48, 5) Both buccal and lingual bone walls should be at least 1 to 2 mm in thickness. (24) Saadoun requires 3 mm of buccal bone in order to obtain aesthetic stable results. (5)

3.4.1 The ITI protocol

The International Team for Implantology (ITI) protocol for single implant restoration defines the correct three dimensional implant placement describing the so-called comfort zone. In this protocol, Straumann implants are used, having a 2.8 mm polished collar. The correct implant platform position is described as: 1 – 1.5 mm mesio-distally distanced to the adjacent tooth, 1.5 – 2 mm palatal from the ideal point of emergence, and 1 mm apical to the cement-enamel junction. This ideally results in an implant shoulder located approximately 2 mm apical to the midfacial gingival margin of the implant restoration. The lateral and vertical components of Biologic Width lead to predictable bone resorption. In single implant the recession of the interproximal soft tissue is lessened by the bone support from the adjacent teeth. In adjacent implants the inevitable loss of interdental bone reduces the papillary scaffold with apical recession of the soft tissue. Immediate implantation, socket preservation and flapless procedures are not recommended being considered non predictable and non reliable approaches. Necessary bone augmentative procedures are accomplished before or at implant placement time. The necessary soft tissue conditioning measures are the use of gingiva formers and periodontal surgery at second stage surgery. (49)

3.4.2 Tissue directed implant placement (Kinsel, Lamb)

A favorable recipient site (with optimal facial and inter-proximal gingival contours) is developed prior to the implantation moment. Ovate pontics of either a fixed or
removable prosthesis are used. (7, 47, 50) In this approach, subsequent corrective gingival surgical procedures, in the context of reduced vascularity of the soft tissue structures surrounding dental implants are avoided. (7)

A modified tissue punch technique (flapless) is used. This conserves crestal tissue and minimizes disruption of blood supply, to maintain the gingival frame, as opposed to the reflection of a full thickness flap. Single stage implants with 2.8 mm height polished collar are used and solid abutments. The 3-dimensional positioning of the implant body

![Fig. 3 Three dimensional positioning of single implant – Kinsel/Lamb (7)](image)

and the restorative platform lessens the Biologic Width influences on alveolar bone loss, thereby preserving support for the overlaying soft tissues. The *correct* positioning of implants is defined as: the proximal surface of the restorative platform is positioned at least 2 mm coronal to the alveolar bone, parallel with the mid-facial cement-enamel junction of the contra-lateral natural tooth. The facial extension should be in line with the natural tooth.

The facial and palatal margins of the platform may be supra-gingival. In adjacent

![Fig. 4 Adjacent implant positioning – Kinsel/Lamb (7)](image)

implants, the separation between the restorative platforms should be 3 – 4 mm. The authors perform intraoral preparation of the abutments and, if necessary, of the implant platform. Special titanium burs are used. Cooling spray from the dental hand-piece adequately controls the heat generated through the metal and does not cause adverse effects to the adjacent peri-implant tissues. (7) In situ preparation of the solid abutment and implant platform allows the development of a parabolic shape that follows the circumferential outline of the osseous crest, and is unique to the patient. (7)
approach provides adequate space for a properly contoured crown restoration, helps the maintenance of physiologic Biologic Width, and controls the precise location of the intra-sulcular crown margins. The definitive crown has the facial and palatal contours that simulate a natural tooth; as a consequence, a good control of plaque retention can be achieved. (7)

3.4.3 Biologic Width protocol (Taffet G)

This protocol, similar to that of Dr. Lamb, reported successful aesthetic results. The used standard practice since 2004 is: every time possible flapless approach. Every time possible immediate implantation is performed. If immediate implantation is not possible, alveolar bone preservation measures are performed. Straumann Standard implants with a 2.8 mm polished collar are used, and placed 2-3 mm supracrestally, transgingivally. Prosthetic protocol consists of intraoral preparing of the abutment and, if necessary, of the implant platform followed by usual impression techniques, similar to natural teeth. (51)
4 Discussion

The knowledge of the amount and the pattern of bone loss determined by the Biologic Width formation correlated with the other known factors that modulate the bone response in implant treatment is a valuable tool in initial complex diagnosis, treatment planning and execution.

The fact that the Biologic Width is still a topic of interest (still researched in the latest years studies), underlines the importance of this structure in implant treatment. It is closely related to possibilities or limits in achieving aesthetic results with implant restorations.

Clinical controlled human studies of the Biologic Width seem to be insufficient. (52)

The bone loss attributed to the formation of Biologic Width has been demonstrated mostly in animal experiments, with flat platform implants, in which, usually full thickness flaps were elevated at the moment of implantation and, sometimes, a second time, in situations of second stage surgery. It is known now that full thickness flap elevation generates a certain amount of bone loss. So, the question still remains: how much bone is lost due to Biologic Width formation and how much and to which extent other factors increase the bone loss around implants? (15, 6, 18)

There are still controversies about the real amount of bone loss determined by this entity. It has been accepted that the bone loss in the first post-operative year is primarily determined by the formation of Biologic Width. The measurements revealed dimensions of Biologic Width like 3mm - 4mm in height (2 mm the junctional epithelium and 1.3 mm – 1.4 mm in width). On the other hand, normal bone loss values during the first post-operative year are also presenting variations: 1.5 - 2 mm vertically and 1.4 mm laterally in two piece implant after abutment connection, 1 mm (5), 0.7 - 1.2 mm (4).

Consequently, soft tissue was reported to follow the bone resorption (6), or, on contrary, some authors sustain that in certain circumstances, soft tissue is poorly influenced by the bone loss. (45)

The classic apical and palatal positioning of implant platforms, being advocated to provide the most “safe” aesthetic result, generates, in fact, the most bone loss, increased Biologic Width and an unfavorable emergence profile from health maintenance point of view. Even though it is known that osseointegration does not occur on polished
surfaces, the ITI Protocol promotes a deep placement of a 2.8 polished collar. The clinical appearance of this process in the single implant restoration is often not affected because of the maintenance of the proximal bone by adjacent teeth. A negative aesthetic consequence would occur with adjacent implant restorations. (7)

Protocol and rules for implants placement should be determined not only by the dimension of the Biologic Width, but also by the final apico-coronal position of it. The attempts to bring the Biologic Width as close as possible to the level of the crest takes into consideration new implant designs and may lead to changes in the concept of correct three-dimensional implant placement and correct surgical approaches. (7)

Protocols as those of Dr. Lamb and Dr. Taffet are more consistent with biologic principles, and already proved successful predictable results in a simplified, cheaper and less time consuming manner. Still, they are not widely used; on the contrary, they are considered to be very risky. This contradiction may frustratingly generate confusion. What seems to be true is that for applying for this minimal invasive protocol, the clinician needs to have very high skills in diagnosis, case management and execution. Dr. Lamb’s opinion is that “the deeper and palatal positioning of implants is a more predictable way of keeping dentists out of trouble”⁴. Dennis Tarnow’s statement was: "Bob Lamb’s technique for placing implants is the best, but you have to be a great surgeon to use this technique"⁵.

The use of new implant design (scalloped, platform switch, micro-threaded) is promising. They still lead to certain compromises and inconveniences, therefore more research is needed. (7, 17)

Complex, traumatizing, expensive and time consuming protocols, which one can say that they neglect the biologic principles, are sometimes preferred instead of minimal invasive, cheaper, less time consuming protocols. Even though some authors consider that flapless surgery and immediate implant placements are not predictable and reliable approaches, there are many studies proving faster and simpler ways of obtaining successful aesthetic results. Recent trends, researches and case reports have shown that with minimal invasive approaches (flapless procedures), modified implant design, immediate implantation and provisionalization, reduced bone and soft tissue remodeling may be expected. The evident advantages are: a reduced operative time, an accelerated

⁴,⁷ Private correspondence between Dr. Verdes I and Dr. Lamb RE.
healing and increased patient comfort (as pain and swelling are reduced). (53, 54) It is true that these approaches require advanced clinical experience, surgical judgement, a proper case selection and prosthetics protocols. (53, 54)

Most of the successful aesthetic results are reported in single tooth implant situations. The multiple adjacent implants cases are poorly documented. In this context, aesthetic restorations are still not esthetically predictable. (49) Some impressive successful adjacent implants cases have been reported by Lamb and Kinsel. (47)

The biologic response of hard and soft tissues is one of the most important factors to be taken into consideration in developing a treatment plan. Treatment planning should be made according to initial complex aesthetic and functional diagnostic, assessing the patient’s aesthetic expectations and pointing out very clear the final aesthetic and functional outcomes, the possibilities and the limits.

As possibilities of hard and soft tissue augmentation after implantation are limited, due to structural and vascular particularities of the soft tissue around implants, case management and decisions making become very important. The first decision is if a tooth is to be extracted or not, taking into consideration all future consequences. Then comes the decision concerning the moment of extraction, and what way should it be performed. Methods have been developed to preserve and enhance the alveolar bone before implantation, or even before tooth extraction, in order to compensate for bone resorption. (13) The frequently used are: orthodontic tooth eruption, socket preservation, and guided bone regeneration. (13) The modern trends insist on minimal invasive approaches.

Concepts like aesthetic site foundation and aesthetic guided bone regeneration (13) have been introduced. Preservation and augmentation procedures are recommended to be prosthetically driven. It is accepted that, at least 2 mm of bone thickness around implants is required at crestal level, in order to ensure the long term stability of the soft tissue. (13) It is necessary that the implant bed have the ideal hard and soft tissue topography, in order to compensate the bone loss determined by the future implant positioning. Building one step at a time, based on previously successful outcomes before placing an implant into a deficient ridge is the most predictable way for successful aesthetic results. (13)
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7 List of abbreviations

ITI  International Team for Implantology
Declaration of academic integrity

I declare that I independently completed this thesis and this thesis was not previously submitted to another academic institution. I also confirm that no other sources have been used than those indicated in this thesis and the thoughts taken directly or indirectly from external sources are properly marked as such.

Muenster, 02.03.2010

Joe Bloggs