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Biologic Width – Exploring the Mystery of a Silent Zone

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Abstract:
Biologic width is a specific concept which reveals the dimensional relationship between epithelial attachment, sulcus depth, connective tissue attachment and alveolar crest.An adequate understanding of relationshipbetween periodontal tissues and restorative dentistry is paramount to ensure adequate form, function and esthetics, and comfort of the dentition. Violation of biologic width leads to complications like gingival inflammation and alveolar bone loss. Maintenance of gingival health is one of the keys for the longevity of teeth, as well as for the longevity of restorations.Thisarticle gives the wide aspect of thecomplex question of biologic width and represents an attempt to answer some of the demands in relation to it and discusses various methods for biologic width assessment and guidelines for margin placement.

Keywords:*Biologic width, gingival inflammation,,margin placement, periodontal health,*

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I. Introduction

Maintenance of gingival health is one of the keys for the longevity of teeth, as well as for the longevity of restorations. In this context, the biologic width functions as a barrier against the entrance of microorganisms into the internal medium of the periodontal ligament and into the gingival and osseous connective tissue. An adequate understanding of the relationship between periodontal tissues and restorative dentistry is paramount to ensure adequate form, function, esthetics, and comfort of the dentition.[1]

II. Definitions

Khuller N and Sharma N (2009) defined biological width as "the dimension of the soft tissue, which is attached to the portion of the tooth coronal to the crest of the alveolar bone".[2]

Nevin and Skurow (1984) defined biologic width as "the sum of the combined supracrestalfibers, the junctional epithelium and the sulcus."This was over 3mm when measured from the crest of bone.[3,4]

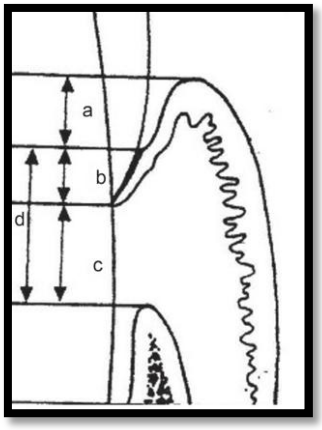
World Workshop on the classification of Periodontal and Peri implant diseases and conditions (2018) states that Biologic width is a commonly used clinical term to describe the apico- coronal variable dimensions of the supracrestal attached tissues. The supracrestal attached tissues are histologically composed of the junctional epithelium and supracrestal connective tissue attachment. The term biologic width should be replaced by ***supracrestal tissue attachment.***[5]

III. Historical Background

It was first described by ***Sicher in 1959*** as "dentogingival junction" in which he conceived of a "physiologic division of labor of supporting tissues".[6]

Data from the original paper by ***Gargiulo et al (1961)***[7] was used as the basis for the introduction of the notion of biologic width. The reported findings were gleaned from 30 human cadaver jaws, with an age range of 19 to 50 years. 287 teeth were considered, of which 325 surfaces were examined histologically and

quantified.The average was a constant 2.04 mm (the epithelial attachment being 0.97 mm, and connective tissue being 1.07 mm) with a sulcus depth of 0.69 mm.



(a) Histological sulcus (0.69 mm) (b) Epithelialattachment (0.97 mm) (c) Connective tissue attachment (1.07mm) (d) Biologic width (b+c)[8]

The total of the attachment is therefore 2.04 mm (1.77 to 2.43 mm) and is called the biologic width.[9]This is essential for preservation of periodontal health and removal of irritation that might damage the periodontium.

In ***1977, Ingberet al*** described ―Biologic Width and credited ***D.Walter Cohen*** for first coining the term and suggested that a minimum of 3 mm was required from the restorative margin to the alveolar crest to permit adequate healing and restoration of the tooth.[10]
Maynard & Wilson (1979) divided the periodontium into three dimensions; superficial physiologic, crevicular physiologic and subcrevicular physiologic.[11]
Similar biologic width dimensions were also reported by ***Vacek et al 1994***.[12] Evaluating 171 cadaver tooth surfaces, they observed mean measurements of 1.34 mm for sulcus depth, 1.14 for epithelial attachment, and 0.77 mm for connective tissue attachment. This group also found that the connective tissue attachment was the most consistent measurement.Vacek and colleagues found that the biological width increased anteroposteriorly (1.07 to 2.08mm) and that 15% of restoration that impinge in the biologic width had a biologic width of less than2.04 mm.[4]

IV. Concept Of Biologic Width

There is general agreement that placing restorative margins within the biologic width frequently leads to gingival inflammation, clinical attachment loss, and bone loss. This is thought to be due to the destructive inflammatory response to microbial plaque located in deep periodontal pockets or gingival recession. These changes have been substantiated by studies that have assessed the histological and clinical responses of periodontal tissues to restorative margins placed within the biologic width.[2]

Newcomb (1974)analyzed 66 anterior crowns with subgingival margins of varying depths and compared them to uncrowned contra lateral controls[13].The results showed that the nearer a subgingival crown margin was to the epithelial attachment (ie. nearer the biologic width), the more likely that severe gingival inflammation occurred.

Parma-Benfenati et al (1986) observed approximately 5 mm of osseous resorption when restorative margins were placed at the alveolar crest in beagle dogs.[14] Minimal resorption was observed where restorations were placed 4 mm coronal to the alveolar crest.

Gunay et al (2000) demonstrated that restorative margin placement within the biologic width was detrimental to periodontal health.[15]In a 2-year study, they evaluated 116 prepared teeth compared to 82 unrestored teeth in 41 patients and found that the papillary bleeding score and probing depths increased at sites where the restorative margin was <1 mm from the alveolar crest.

V. Interproximal Biologic Width

Interproximally, the biological width is similar to that of the facial surface[11] but the total dentogingival complex is not.
Koisand Spear pointed out that the dentogingival complex is 3.0mm facially and 4.5mm to 5.5mm interproximally. They noted that the height of interdental papilla can only be explained by increased scalloping of the bone.[11]

Spear suggested that additional 1.5 to 2.5mm of interproximal gingival tissue height require the presence of adjacent teeth for maintaining of the interproximal gingival volume. Without the adjacent tooth the interproximal gingival tissue would flatten out, assuming a normal 3.0mm biologic width.[11]
Becker and colleagues (1970) defined variation of gingival scalloping as flat scalloped and pronounced scalloped.[11]
Van der Velon (1982), using interproximal denudation, showed that the interproximal tissuerebounded or regenerated 4.33 mm 3 years later.This is consistent with ***Nyman's (1977)*** and***Rusling's (1976)*** findings of 3.5 and 5.1 mm,respectively, of tissue rebound after 2 years. [10.]

Tarnow and colleagues (1992) found that for the gingival tissue to assume complete filling of the interdental space, the distance from the contact point to alveolar crest should not exceeded 5 mm to 5.5mm. Greater distance results in significant loss of alveolar height.16

Cho et al (2006) also found that as the interproximal distance between the teeth increased the number of papilla that filled the interproximal space also decreased.[10]

Clinicalexperience has led some clinicians to recommendwaiting at least 6 months (Maynard andDaniel, 1977; Rosenberg and colleagues, 1999;Lanning and colleagues, 2003; Deas and colleagues,2004) to 3 years (Kois, 1994) to permitfull maturation and tissue rebound to occur. [10]

VI. Significance of Biological Width

Biological width is of great significance with respect to restorative dentistry. In the human body, ectodermal tissue serves to protect against invasion from bacteria and other foreign materials. However, both teeth and dental implants must penetrate this defensive barrier. The natural seal that develops around both, protecting the alveolar bone from infection and disease, is known as the biological width. [8]

VII. Evaluation of Biologic Width Violation

Clinical method: The signs of biologic width violation are chronic progressive gingival inflammation around the restoration, bleeding on probing, localized gingival hyperplasia with minimal bone loss, gingival recession, pocket formation, clinical attachment loss and alveolar bone loss.[17]
Bone sounding: The Biologic width dimension can be identified for each individual patient by probing under anesthesia to the bone level (referred to as sounding of bone) and subtracting the sulcus depth from the resulting measurement.[18]
If this distance is less than 2 mm at one or more locations, a diagnosis of biologic width violation can be confirmed.[19] However; this method is not used routinely for biologic width assessment when other methods are available. Its use should be limited to surgical procedures under local anaesthesia as a presumptive guide for bone level assessment.[20]
The biologic violation can occur in some patient in whom margins are placed more than 2mm. This statement is in reference to the fact given by ***Vaceketal in 1994*** who proposed that the biologic width dimensions extend in the range of 0.75mm to 4.3 mm.[6] Thus according to this information, biologic width assessment should be performed for each patient to determine whether they need additional biological width in excess of 2 mm for restoration to be in harmony with their periodontal health.[12]
Radiographic evaluation: Radiographic interpretation can identify interproximal violations of biologic width. A new innovative parallel profile radiographic (PPR) technique has been devised which could be used to measure both length and thickness of the dentogingivalunit(DGU) with accuracy.[21] This technique could measure both the length and the thickness of the DGU with accuracy, as it is simple, concise, non-invasive, and a reproducible method.[22]

VIII. Margin Placement And Biologic Width

A clinician is presented with three options for margin placement: supragingival, equigingival, and subgingival.[23]
Supragingival margin: It has the least impact on the periodontium. It has been applied in nonesthetic areas due to the marked contrast in color and opacity of traditional restorative materials against the tooth. Its advantages are ease of tooth preparation, finishing and duplication of the margins.
Equigingival margin: They were thought to favour more plaque accumulation than supragingival or subgingival margins, and therefore results in greater gingival inflammation. These concerns are not valid today, because the restoration margins can be esthetically blended and can be finished easily. From a periodontal viewpoint, both supragingival and equigingival margins are well tolerated.

Subgingival margin:

1. Restorative considerations (caries and tooth deficiencies) will frequently dictate the placement of restoration margins beneath the gingival tissue crest.[24]
2. Subgingival also termed as infragingival, means restorative margin is located below the marginal gingiva.
3. It gives an esthetically pleasant result.
4. But it also poses the greatest risk to damage to the periodontium if tissue attachment area is encroached.
5. To add on to the above disadvantage, this type of margin is not accessible for finishing and polishing
6. This,therefore, acts as a niche for bacterial growth and causes gingival inflammation.[25]
7. Investigators have correlated that sub gingival restorations demonstrated more quantitative and qualitative changes in the micro flora, increased plaque index, gingival index, recession, pocket depth and gingival fluid.[24]

Restorative considerations in placing subgingival margin are:

- To create an adequate resistance and retentionform.
- To alter the tooth contour because of caries or other structural deficiency.
- Mask the restoration interface by locating it subgingivally.[12]

IX. Margin Placement Guidelines

Based on the sulcus depth the following 3 rules can be used to place intracrevicular margins:[26]

1. If the sulcus probes 1.5 mm or less, the restorative margin could be placed 0.5 mm below the gingival tissue crest.

2. If the sulcus probes more than 1.5 mm, the restorative margin can be placed in half the depth of the sulcus.

3. If the sulcus is greater than 2 mm, gingivectomy could be performed to lengthen the tooth and create a 1.5 mm sulcus. Then the patient can be treated as per rule 1.

Valderhaug&Birkeland (1976) evaluated 114 patients with 329 total crown restorations.[23] Most of the crowns (59%) were located subgingivally at the beginning of the study period. After 5 years, only 32% of the crown margins remained below the gingival margin.

Waerhaug (1978) stated that subgingival restorations are plaque-retentive areas that are inaccessible to scaling instruments.[24] These retentive areas continue to accumulate plaque even in the presence of adequate supragingival plaque control.

Waerhaug (1980) demonstrated gingivitis and attachment loss associated with sub marginal restorations in monkeys and dogs.[27]

Clinical and histological observations of human teeth by ***Dragoo& Williams (1981)*** demonstrated compromised healing associated with gingival bevel crown margins compared to shoulder preparations.[28.]

Orkin et al. (1987) demonstrated that subgingival restorations had a greater chance of bleeding and exhibiting gingival recession than supragingival restorations.[25]

Stetler&Bissada (1987) evaluated the effects of width of keratinized gingival and subgingival restorations on periodontal health.[29] Teeth with subgingival restorations and narrow zones of keratinized gingiva showed significantly higher gingival index scores than teeth with sub marginal restorations with wide zones of keratinized gingival. Thus, clinicians should consider gingival augmentation for teeth with minimal keratinized gingiva before placing subgingival restorations.

Flores-de-je-Coby et al (1989) studied the effects of crowns margin location on periodontal health and bacterial morphotypes in humans 6-8 weeks and 1year post insertion.Subgingival margins demonstrated increased plaque, gingival index scores, and probing depths. Furthermore, more spirochetes,fusiforms, rods, and filamentous bacteria were found to be associated with subgingival margins.[30]

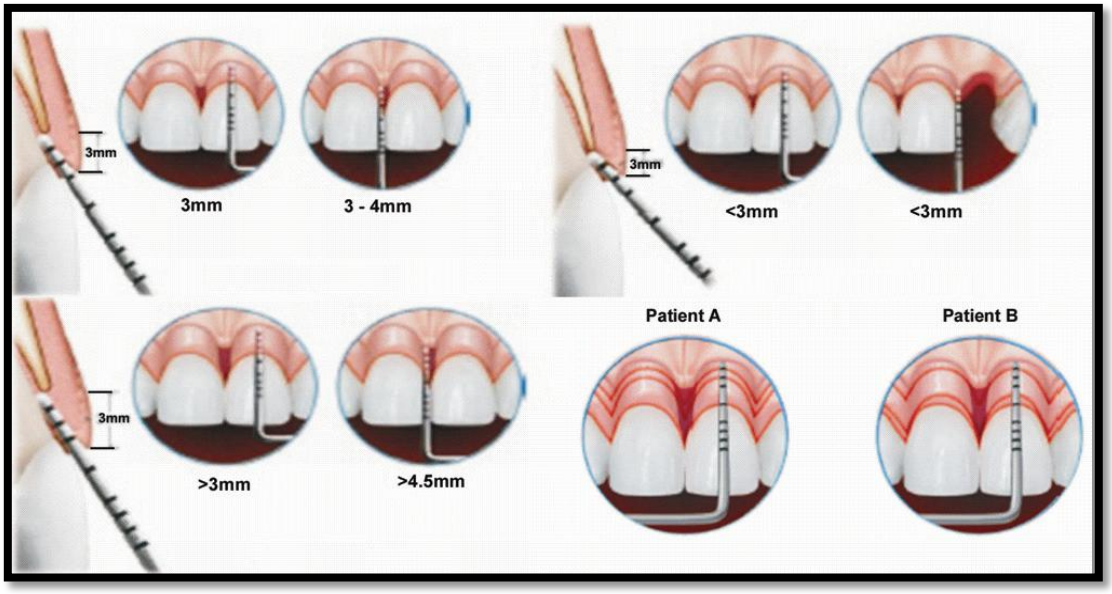
X. Categories of Biologic Width

Kois (1994) proposed three categories of biologic width based on the total dimension of attachment and the sulcus depth following bone sounding measurements: Normal Crest, High Crest and Low Crest.[31]

Normal crest patient (85%): In this, the mid-facial measurement is 3.0 mm and the proximal measurement is a range from 3.0 mm to 4.5 mm. In these cases, the gingival tissue tends to be stable for a long term. The margin of a crown should generally be placed no closer than 2.5 mm from alveolar bone.

High crest patient (2%): In this, the mid-facial measurement is less than 3.0 mm and the proximal measurement is also less than 3.0 mm. In this, it is commonly not possible to place an intracrevicular margin because the margin will be too close to the alveolar bone.

Low crest patient (13%): In this, the mid-facial measurement is greater than 3.0 mm and the proximal measurement is greater than 4.5 mm. Traditionally, these patients have been described as more susceptible to recession secondary to the placement of an intracrevicular crown margin.



(a) Normal crest showing biologic width on labial and interproximal site, (b) High crest showing biologic width on labial and interproximal site. (c) Low crest showing biologic width on labial and interproximal site, (d) Patient A- Low crest (unstable); and Patient B- Low crest (stable)[8]

XI. Violation Of The Biologic Width

It is the inadequacies of the tooth transition zone rather than depth of margin placement that cause tissue inflammation, and it is indeed possible to place restoration margins subgingivally (> 1 mm) without usurping the traditional notion of a biologic width. In other words, the biologic width can be physiologically disregarded or ―disturbed.[32]

XII. Effects Of Biological Width Violation

The restorative procedures are technique sensitive and involve a great deal of understanding of the anatomy, function and condition of the teeth/implants and their surrounding structures. Placing restorative margins within the biologic width frequently leads to: [18]

- Gingival Inflammation.
- Clinical Attachment Loss.
- Bone Loss.

Clinically these signs of biological width violation appear as a pain around the restoration margin, bleeding from the inflamed gingival margin area of involved tooth and gingival recession.[12]

Gingival tissue recession: Attachment loss and bone loss around the defective tooth leads to clinically receded gingival margin or in other term gingival recession. This seems to be the body's response to recreate the space between the alveolar bone and the margin to allow space for the tissue attachment. Overall recession is more in highly scalloped and thin gingiva.[34]So factors which influence the gingival recession are:

- Gingival physiology whether gingiva is thick & fibrotic or thin and fragile.
- Whether the periodontium is scalloped or flat in its gingival form.

***Newcomb (1979)*[13]**analyzed 66 anterior crowns with sub gingival margin and compared them with uncrowned control. The study result shows that a crown margin placed close to biologic width zone result in severe gingival recession.

Gunay et al (2000) demonstrated that restorative margin placement within the biologic width is detrimental to periodontal health. They studied 116 prepared teeth compared to 82 unrestored teeth and found that papillary bleeding score and probing depths increased at sites with restorative margin was <1mm from the alveolar crest.[15]

XIII. Reconstruction Of Biologic Width

Violated biologic width can be reconstructed by means of a number of techniques.

Surgical crown lengthening: The concept of crown lengthening was first introduced ***by Cohen (1961)***. It includes a combination or individual surgical procedure like soft tissue recontouring by gingivectomy/ gingivoplasty and osseous recontouring. The indication of each of the above procedure depends on patient related factors.[12]

The clinical crown is that portion of the tooth that extends occlusally or incisally from the investing soft tissue, usually the gingiva ***(American Academy of Periodontology 1992)***.[26]
While many situations require it, crown-lengthening surgery is often underutilized. Because of this, too much reliability is placed on post and core restorations and deep subgingival margin placement to gain adequate retention for restorative purposes. This often leads to root fractures, in the case of post and core restorations, and violation of the biologic with in the case of deep subgingival margins. These factors contribute to greater expense and frustration for the patient, hence further complicating restorative and periodontal therapy.[3]
Crown lengthening surgery is designed to increase the clinical crown length[20]

Surgical Diagnosis and Treatment
Kois (1994) stated that only 3 mm is necessary tosatisfy the requirements for a stable biologicwidth (2.04 biologic width; 1 mm sulcus depth).Because the sulcus follows the osseous crest, herecommended determining the total dentogingivalcomplex by probing through the sulcus to thegingival crest and described three osseous crestlocations.[10]
Bragger and colleagues (1992) showed thatcreating a distance of 3 mm from the alveolarcrest to the future reconstruction margin wasstable periodontally for up to 6 months. [10]
Ingber and colleagues (1977) stated "thataverage measurements do not necessarily reflect
any one clinical situation, however, they doestablish a basis upon which decisions can bemade. Therefore, the 3 mm biologic width is avariable average, which may not prevent marginalimpingement or adequate tooth exposure" [10]
Herrero and colleagues(1995) noted that most cliniciansattempting to expose 3 mm of tooth structurefailed to do so, suggesting that greater than 3 mmwas required.
Rosenberg and colleagues (1980and 1999) and Weinberg and Eskow (2000) recommendeda distance of 3.5 to 4 mm, whereas***Wagenberg and colleagues (1989)*** recommendedat least 5 to 5.25 mm.
Pontoriero and Carnevale (2001) recentlystudied 84 crown-lengthening procedures in 30patients for up to 12 months postoperatively.They found that the initial 3.7 ± 0.8 mm interproximalcrown exposure was reduced to only0.5 ± 0.6 mm of clinical exposure owing to3.2 ± 0.8 mm of interproximal tissue regrowth orrebound. The degree of tissue rebound variedwith tissue biotype (a thick biotype had significantlygreater rebound).
They concluded thatwhen crown lengthening,
1. A greater removal of osseous support shouldbe considered.
2. In esthetic areas, sulcular marginal placementshould await final gingival stability.
This need for adequate bone removal is supportedby ***Lanning and colleagues (2003),*** whoshowed that with ≥ 3 mm of osseous reduction, astable biologic width and adequate tooth exposurewere both achievable and maintainable at3 months.[10]

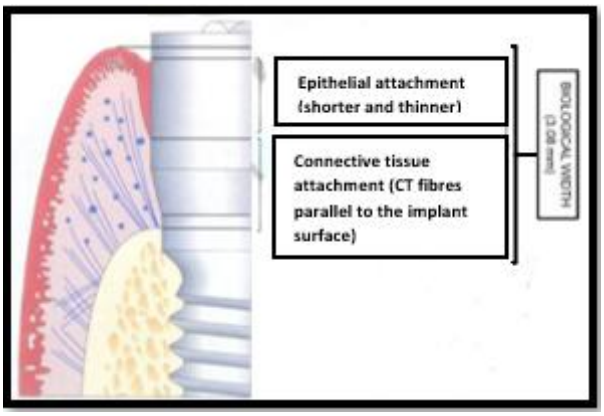
To select the proper treatment approach for crown lengthening, an analysis of the individual case with regard to crown-rootalveolar bone relationships should also be included.
If a patient complains about their "small front teeth" and the periodontium is of a thin biotype, full exposure of the anatomical crown can be accomplished by a gingivoplasty/gingivectomy (external bevel or internal bevel) procedure.[3]

XIV. Escaping Biological Width Violation

Maynard and Wilson[10] claimed that all three of these dimensions (Superficial physiologic, crevicular physiologic, and subcrevicular physiologic) affect restorative treatment decisions and the clinician should "conceptualize" all three areas and the interplay between them and restorative margins. It is said by many researchers that margin placement into the subcrevicular physiologic space should be avoided to prevent the placement of "permanent calculus" beyond the crevice.
In ***1984, Nevins and Skurow***[2] stated that when subgingival margins are indicated, the restorative dentist must not disrupt the junctional epithelium or connective tissue apparatus during preparation and impression taking. The researchers recommended limiting subgingival margin extension to 0.5-1.0 mm because it is impossible for the clinician to detect where the sulcular epithelium ends and the junctional epithelium begins. They also emphasized allowing a minimum 3.0 mm distance from the alveolar crest to the crown margin.[8]

XV. Biologic Width And Dental Implants

	Natural Tooth	Implant
Implant/tooth-epithelium junction[34]	Longer and thicker	Shorter and thinner
Cementum [34]	Present	Absent
Supracrestal fibres orientation[34]	Perpendicular	Parallel
Biologic width [34]	2.07	3.08
Supracrestal avascular zone[3]		Present (50 to 100 micrometers)



Biologic width around implant[8]

Berglundh and Lindhe (1996) suggested that the soft tissue attachments (biologic width), once established, were nature's mechanism for protecting the zone of osseointegration from the bacterial and mechanical challenges of the oral cavity. This study validates the clinical rationale for augmenting soft tissue prior to abutment connection or nonsubmerged implant placement when thin mucosal tissues are present.[35]

The soft tissue barrier is composed by a sulcus with a non-keratinized sulcular epithelium and a supra crestal connective tissue with an area of dense circular fibers near to the implant surface.[36]The presence of junctional epithelium facing the titanium has also been evidenced by a large number of studies. Periimplant biologic width is composed of the sulcus and by the supracrestal epithelium and connective tissue component. The influence of five different factors on implant biologic width has been evaluated these are: surgical technique, loading time, abutment material, implant structure and position, immediate post extraction insertion.

For example, onepiece implant designs have been implicated in more closely mimicking the biological width around natural teeth. Similarly, platform switching (as in controlling the dimension of the abutment) during the period of osseointegration affects biological width by altering the position of the microgap and controlling circumferential bone loss around dental implants. In addition, a scalloped implant platform is available that follows the osseous structure of the maxillary anterior teeth and may prevent interproximal crestal bone resorption during healing. These results may have important implications when dealing with esthetic implant-borne restorations, considering that longtermesthetic survival depends on soft-tissue dimensions that remain healthy and vertically constant over time.[37]

On implant: junctional epithelium+connective tissue = biologic width 1.88mm+1.05mm= 3.08 mm.[12]

With appropriate oral hygiene, the intracrevicular position of the restoration did not appear to adversely affect peri-implant mucosal health or stability. The lack of observed peri-implant mucosal pathology in these situations was attributed to the smooth implant component surfaces and the ―rotation symmetrical design. This was contrasted with the scalloped cementoenamel junction of teeth.[32]

XVI. Conclusion

We can say that the relationship between the periodontal health and the restoration of teeth is intimate and inseparable. The biological width is essential for preservation of periodontal health, which itself is dependent on the properly designed restoration. Restorations with supragingival or equigingival margins should be preferred. If restorative margins need to be placed near the alveolar crest, crown-lengthening surgery or orthodontic extrusion should be considered to provide adequate tooth structure while simultaneously assuring the integrity of the biologic width.[1]

Repeated maintenance visits, patient cooperation and motivation are important factor for improved success of restoration procedure with positive periodontal health.[12]

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