

# The Papilla – Key Element in Anterior Tooth Replacement

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The predictability of osseous integration has made implants an integral part of today's treatment planning for literally any number of missing teeth. While originally conceived to provide support retention and stabilization to a hybrid form of a full arch removable prosthesis, implants have rapidly evolved into use for the treatment of predominantly partial edentulism.

If implants are now to successfully meet the demands of the patient with partial edentulism, they must meet or satisfy the self same criteria of conventional restorative modalities creating the *illusion* of natural teeth. New ceramic systems today mimic the complex optical properties of natural enamel, so that *the key to indistinguishable implant supported restorations is retaining the integrity and form of the surrounding periodontal tissues of the implant recipient site.* This surrounding framework of hard and soft tissues must be either **preserved** at the time of extraction or subsequently **redeveloped** so that the implant-supported restoration emerges out of gingival tissue that has the identical configuration to that of an adjacent natural tooth (or a tooth prepared for any other form of ceramic restoration).

Just as the lips frame the smile in its entirety, each individual natural tooth, crown, or implant-supported restoration is framed in its cervical half by the gingival architecture. This coronal soft tissue frame thus extends from one interdental papilla through the rise and fall of the free gingival margin to incorporate the opposite interdental papilla and is termed the Restorative Recipient Site (RRS).

### *Soft Tissue Gingival Form*

The **individual restorative recipient site** thus exhibits two distinct zones.

- 1.) ***The free gingival margin*** – Specific to any individual with varying degrees of curvature depending on the periodontal biotype – *thick/flat*, showing a lesser curvature than *thin/scalloped*.
- 2.) ***The interdental papilla*** – These twin pyramidal-form tissues extend apically on either side of the contact points of the teeth buccally and lingually. They are separated by a soft tissue indentation termed the col. (Each individual papilla is therefore bilobed and divided into two by this col.)

The papilla is three-dimensional in form, so that for it to be esthetically effective it needs to be present not only in the vertical sense (that is at the same height as the adjacent teeth), but also positioned horizontally or bucco-lingually in the same sagittal plane as the labial surfaces of the adjacent teeth – not tucked within an embrasure.

### *Hard Tissues Osseous Scaffold*

The above soft tissue profiles are supported by an osseous scaffold similar in form and dimensions but located about 3mm apically. This distance first defined histologically by Gargiulo and is referred to as the Biologic Width and comprises (i) the connective tissue attachment (ii) the junctional epithelium (a hemidesmosomal attachment) (0.97 mm) (iii) the gingival sulcus added about another 1mm to this reported inviolate parameter.

It is interesting to note that the Biologic Width measured interproximally between two teeth seem to exceed that on the direct facial or lingual. Tarnow, Kois and Kan noted that this “biologic” width interproximally appeared to be 4.5mm – i.e. the dimension from the tip of the papilla to the interproximal height of bone. However, if these teeth immediately adjacent to the papilla are removed, the distance to the IMB decreases to match that on the labial. This is probably related

to the contact presence of the teeth and the subgingival support and bolstering of these tissues and an interwoven collagen fibre network supporting the papilla. Certainly removal of adjacent teeth flattens the interdental peaks and results in similar dimensions of the biological width interproximally and labially.

### Resolving Esthetic Dilemmas Within the Individual Restorative Receptor Site

These should be categorized as occurring in either :

- a. The free gingival margin zone
- b. The papillae
- c. Both free gingival margin -- 2 papilla

A deficiency in the form of the *free gingival margin* can predictably be treated surgically by a process of soft tissue grafting or at times resolved with orthodontic eruption of the compromised tooth in the site, thereby moving the entire attachment apparatus of hard and soft tissue coronally to resolve the deficiency.

However, the interdental papilla poses a dilemma, because surgical procedures are “*predictably unsuccessful*” -- This may be due to the fact that the papilla can be viewed as an anatomical terminal end organ, and so requires its vascular supply within a defined limited proximity.

The papilla thus comprises a wide osseous base curved bucco-lingually, but it is separated into a labial and a lingual soft tissue peak by a depression (the col) between the peaks (Fig. \_\_\_\_ ). Again it is worth noting that following removal of a tooth and the adjacent contact points, the col rounds out and the papilla collapses vertically without its lateral bolstering support. The interproximal measurement decreases from 4.5 to the 3mm typically found on the labial. Delayed subsequent replacement with a pontic or implant results in a papilla that may only present with a single peak positioned midway bucco-lingually in the embrasure. This creates the shadowing of an inverted dark triangle between teeth almost as if the tissue was not present.

For full normal expression the papilla requires

1. the presence of an underlying osseous scaffold, the interproximal height of bone (IHB) in sufficiently close proximity
2. a tooth replacement exerting subgingival lateral pressure on the soft tissues
3. and a restorative contact point optimally positioned to create buccal and lingual papillary peaks.

The distance or vertical dimension of the dento-gingival unit interproximally (between the teeth) has been well documented by Tarnow, Kois, Van der Velden and Kan to be 4 – 5 mm. To clarify this parameter, it indicates that the distance from the tip of the papilla (or tooth/restorative contact point) to the underlying interproximal peak of the osseous, (IHB) measured midway between two natural teeth is reported at 4 – 5 mm.

This data infers that for the papilla to be present between two teeth, the underlying support of the IHB will usually not exceed a distance of 4.5 mm from the papilla soft tissue tip. *While this original data was recorded for a papilla and measured midway between teeth, further research indicates that these limiting vertical dimensions will vary, depending on the specific nature of the restorative-supporting element on either side of any given papilla.* This article will delineate not only the relevant vertical requirements necessary for the presence of any particular papilla, but also the horizontal proximity limitations.

A classification based on the different possible supportive element combinations adjacent to a papilla resulted in 6 specific categories.

Class I - a tooth on either side of the papilla

- Class II - a tooth on one side and a pontic on the adjacent side
- Class III - a tooth and an implant on either side of the papilla
- Class IV - an implant and pontic bordering the papilla
- Class V - a papilla between two adjacent implants
- Class VI - a papilla between two adjacent pontics

Insert 2 charts 1mean 1 range (Fig. \_\_\_\_ )

As described above, the dimensional requirements for the predictable presence of a papilla appears to vary depending on the nature of the adjacent supporting elements. The chart defines both the *vertical and horizontal* limiting dimensions necessary for the predictable presence of the papilla.

The horizontal limiting factor refers to the width of the bone measured mesio-distally at the osseous base of the papilla.

The relevance of this data is that it allows for a prognostic clinical evaluation of any site to ascertain if following a procedure the papilla will be present or to prevent unexpected untoward esthetic sequelae following any form of tooth replacement. It therefore empowers the clinician with treatment planning acumen to optimally replace a tooth, predictably managing the esthetics of the surrounding soft tissues, in particular the papilla.

### Class I: Tooth-To-Tooth Papilla Requirements

In this Class I category, the **horizontal** limiting factors were described by Tal, which indicated that for the presence of the papilla, the adjacent teeth could not be closer than 1 mm.

The **vertical** requirements for the presence of a papilla, first described by Tarnow, and researched by Van Der Velden indicated the predictable presence of the papilla in approximately 90% of the cases if the distance from the tip of the papilla to the underlying osseous scaffold did not exceed 4.5mm.

From a restorative perspective, in those cases where the distance from the interdental contact point of the restoration to the osseous exceeds this 4.5 mm parameter, the soft tissue may not fill the entire embrasure space and the papilla will appear foreshortened. If this abbreviated papilla requires esthetic remediation, two alternatives exist: - 1. To bring the osseous peak interproximally into closer proximity to the contact point to support the soft tissue of the papilla via orthodontic eruption 2. Or to restoratively extend or lengthen the contact vertically moving it closer to the tip and the papilla.

The loss of osseous interdentally with a resultant soft tissue deformity may at times be associated with increased pocket depth, and some quite extensive degree of loss of attachment to the tooth. However, the tooth root beyond the periodontal defect, still contained in bone in the area apical to this osseous loss can be orthodontically manipulated coronally using light eruptive forces. These orthodontic forces exert tension on the remaining periodontal ligament fibers still attached to the root, thereby moving the root and adjacent lying osseous coronally. Orthodontic manipulation of one or both teeth on either side of the missing or deformed papilla can reposition the osseous peak within the 4.5 mm limit and remains the most effective and predictable method of restoring the presence of a lost papilla between two teeth by restoring the I.H.B. proximity. Orthodontic eruption to regenerate hard and soft tissue is a well recognized, researched, and effective modality not only limited to a single tooth but also to multiple units.

### Class II: Tooth-To-Pontic Papilla Requirements

The study data indicates that this Class II “tooth-to-pontic” scenario is quite different to that which occurs in a Class I “Tooth-to-tooth” papilla relationship. In a Class II, one of the restorative-supporting elements is entirely missing and is replaced by a pontic. Tooth loss without immediate replacement invariably results in a flattening of the adjacent papilla peaks and a decrease in height of the dento-

gingival complex or osseous bone sounding from 4.5 mm to 3 mm. This tooth loss makes the virtual base between the restorative supportive elements that much wider, extending, in effect, one or more teeth over. This increased width comprising the new edentulous ridge and pontic space appears to provide for a greater collateral vascular supply to the tip of a papilla and measurements indicate that the distance between the tip of the papilla or restorative contact point to the underlying osseous can exceed the 4.5 mm of a Class I tooth-to-tooth relationship up to 9mm with a mean of 5.5.

Esthetic Treatment planning for tooth replacement in those cases where the vertical bone height (I.H.B.) is not present may preclude an implant because of resultant esthetic compromise. However if a soft tissue ridge augmentation of the edentulous area is possible, this increased vascularity can reportedly support the soft tissue of a papilla at a vertical distance exceeding 4.5 mm to provide for esthetic harmony adjacent to a bridge pontic. Edentulous ridge augmentation as first described by Abrams 1972 in combination with subgingival lateral bolstering pressure exerted onto the papilla by the pontic (W. Geller and F. Kopp, 1993) can create an optimally located contact point. It can predictably allow the Class II tooth-to-pontic soft tissue papilla to fill the boundaries to the restorative contact point, despite an increased contact point-to-osseous distance of up to 8.0 mm (mean 6.5 mm). This information allows the clinician to make prudent decisions.

Alternatively the tooth adjacent to the edentulous site could be orthodontically erupted as described for Class I deformities to relocate the I.H.B. coronally before or after implant placement – if an implant is the replacement of choice.

### Class III : Tooth-To-Implant Papilla Requirements

The Class III tooth-to-implant relationship really defines the sophisticated inter-relationships of papillary requirements. The horizontal proximity limitations were described by Esposito and should exceed 1.5 mm between the tooth and the implant bordering a papilla.

In measuring the vertical distance from the contact point to the underlying osseous, the study presented a dilemma as the interproximal bone configuration often varied from that evaluated in an optimal tooth-to-tooth relationship. The inter-proximal osseous presented in many different forms ranging from the typical coronal peak being traditionally visualized midway between the teeth. More often it was evident on radiographs and on bone sounding as an angular defect with the osseous usually being considerably more coronal immediately adjacent to the tooth and ramped apically through the interproximal space to reach the base of a defect immediately adjacent to the head of an implant – not unlike the typical angular bone defect between two periodontally compromised teeth.

The measurements in this study were therefore made on either side of each papilla to record bone levels immediately adjacent to the implant and then adjacent to the tooth in the same interproximal space – i.e., at least two bone sounding measurements were recorded for each interproximal space, using thin endodontic files to ensure correct vertical recording of exactly where bone contact began.

Bone soundings in this manner indicated that within any single interproximal space one measurement of the contact point to osseous could often exceed 4.5 mm (in this Class III tooth-to-implant group), provided the other one remained within the limits of 4.5 mm. The result of these clinical data indicates that a papilla was often present even if arbitrary interproximal probing exceeded 4.5 mm.

Two or more bone sounding measurements repetitively showed the region adjacent to the tooth probing predominately between 4 and 4.5 mm, while the measurements immediately adjacent to the implant were considerably higher with a mean of 6.5, but ranging up to 8.4 mm or more yet still retaining the presence of the papilla. The hemiseptum of bone of the angular defect supported and provided sufficient **vascularzation** for the soft tissue and the papilla while the fibres of the

connective tissue attachment that insert horizontally into the adjacent tooth also appear to add support.

It is evident then that for the papilla to fill the interproximal space, only one point within proximal space needs to be within the required traditional vertical “tooth-to-tooth” measurement of 4.5 mm. It is also important to note that this is a 3-dimensional osseous configuration, and while measurements may be evaluated in a frontal plane, it is also possible that the bone could be ramped from the buccal to the lingual with the highest point on the lingual. If it were that the 1 HB bone was within the 4.5 limit solely on the lingual, this might also move the papilla deeper within the interproximal space, which may be esthetically unacceptable because of resultant shadowing but show up as adequate on a 2 dimensional x ray.

It was not within the scope of this particular study to measure this.

The overall 1 HB range within the study was from 3.5 mm – 9 mm (rounded off to the nearest .5 mm). The mean was a 6.5 mm. Average measurements give the clinician only a rough guide as to any clinical situation but for a more definitive clinical guide it is probably wise to utilize the lower end of the range as this is probably more predictable.

This information becomes clinically relevant because should the papillary tissue be missing and not fill the proximal space in a restoration, and the IHB immediately adjacent to the tooth exceeds the 4.5 mm limit – it is prognostically indicative of a

implant aesthetic problem and the clinician should **resort to** alternative tooth replacement solutions. Once again according to the data on the chart, if the IHB exceeds 4.5mm on the adjacent tooth a bridge with a pontic is esthetically more predictable.

Alternatively a tooth destined for extraction that upon probing exhibits an IHB depth of greater than 4.5 mm but retains a significant portion of the root unaffected in bone could be preemptively orthodontically erupted to redevelop the interproximal bone to within the 4mm limit prior to extraction. Subsequent implant placement would not then result in an esthetic papilla deformity because of a previously deficient IHB.

#### Class IV: Implant-to-Pontic Papilla Requirements

The vertical requirements for the IHB in the implant-to-pontic space are considerably different with the IHB immediately adjacent to the implant, ranging from 3.0 to 7 mm. The ability for collateral circulation from a wider virtual base of the pontic space to support the soft tissue, and the lack of a horizontal limitation facilitates a potentially greater IHB dimension. From a treatment planning perspective an implant-to-pontic relationship is considerably easier to esthetically manage than an implant-to-implant relationship. The mean IHB dimension in a

Class IV implant-to-pontic space can be greater thereby developing more optimal papilla height – and not limited to the 3.4 mm height and IHB dimension of a Class V implant-to-implant relationship.

Histologically there are no connective tissue fibres inserting at right angles into the implant, rather a more annular circumferential arrangement of scar like fibrous tissue, parallel to the implant surface with decreased vascularity and cellular activity.)

#### Class V: Implant-To-Implant Papilla Requirements

The implant-to-implant papilla relationship is exceedingly complex. Tarnow described the horizontal limitations tending to be at least double that of a tooth-to-implant relationship, with a very minimum dimension of 3 mm necessary. This appears to be related to the three dimensional formation of a biologic width beyond the implant head and abutment connection. The lateral spread of the resultant horizontal bone loss measuring about 1.3 mm tends to overlap when two implants are adjacent creating the vertical reduction in the IHB. In a multi-center study with Tarnow, Salama and Garber, the mean IHB between adjacent implants was found to be only 3.4 mm, with the majority of the recordings falling between a 3 and 4 mm range.

*This would result in a tiny peak of bone interproximally and so the author advocate at least 4mm of inter implant distance to allow for a more substantial mesiodistal width of interproximal bone.*

From an esthetic perspective, it would be as well to note that within this particular group approximately 50% fell within the 3 mm group. This is indicative of the fact that from the esthetic perspective when planning implant-to-implant it would be prudent to realize that a 3 mm rule should be used as a guideline. As such, the IHB is approximately 1.5 mm to 2 mm less than a tooth-to-tooth or tooth-to-implant relationship. The IHB actually further increases in an implant-to-pontic relationship.

This data infers that from an esthetic perspective the implant-to-implant relationship is the most complex to deal *with the most stringent requirements. It is a multifactorial issue related to the implant dimensions (wide or narrow) the implant surface and implant head design. The Biologic Width formation as a result of the 3D restorative patterns vertically 2mm and horizontally 1.3mm at the actual position of the micro abutments connection.* In esthetically-relevant zones, this relationship should be avoided, opting for one of the alternatives, such as implant-to-pontic, as the resultant height of the generated will not be as flat, but more closely approximate natural teeth.

## Class VI: Pontic-to-Pontic Papilla Requirements

In a pontic-to-pontic relationship the virtual base has been greatly expanded and the IHB ranges vertically from 3.5 – 9 mm with the mean being 6 mm. Once again, this is dependent on the clinical ability to obtain the necessary soft tissue for grafting.

The information derived is useful from a prognostic treating planning perspective and emphasizes the essential need to bone sound the full width of each interproximal space prior to embarking or deciding on an implant supported restorative modality. If this distance exceeds those described in the chart, then preemptive orthodontic eruptive measures may be required prior to tooth extraction of the adjacent tooth and tooth to be replaced. Alternatively when this is not possible following implant placement it is possible to orthodontically relocate the adjacent tooth and bone more coronally creating an angular defect with bone 4.5mm from the contact point to support a papilla. A distinction should be made early that if a tooth is destined for extraction, but has a compromised IHB, it may be effective to reupt it first, regenerate the bone in the interproximal space prior to extraction and implant placement. This is usually preferable to eruption of the adjacent tooth that often compromises the pulp and requires restorative endeavors to correct if the esthetic papillary dilemma is discovered after the fact.

In those sites where the edentulous area is a mature site, previously augmented with a connective tissue ridge augmentation, albeit that a soft tissue papilla is present between the tooth and the preexisting pontic, if the IHB measurement exceeds 4.5 mm, it would be esthetically most unpredictable, in fact dangerous to contemplate replacing the pontic of the bridge with an implant, as loss of the papilla height and tissue may ensue. If an implant is deemed for any reason to be essential, then eruption of the adjacent tooth to reposition the IHB within the 4.5 mm parameter could be an effective pre-placement modality. This again may require endodontic therapy and certainly recrowning of the tooth, as well as an implant crown. Overall, the data in the classification does empower the clinician to make relevant and prudent choices when deciding on tooth replacement in the anterior esthetically relevant zone.