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Review Article

Periodontal prosthesis in contemporary dentistry

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Abstract In the last 5 decades, the developments of osseointegrated titanium implants (since 1965) have led to the success of contemporary dentistry. Endosseous implant-supported restorations delivered in accordance with the traditional Branemark protocol have proven to be highly predictable. Today, implants are becoming increasingly common in dental care and provide more therapeutic options, but treatment planning and the sequencing of therapy are critical in implant-assisted and implant-supported cases. Implant prostheses give patients and dentists more options in treatment planning, but also present challenging decisions regarding implant surgery. In essence, the emerging thought is that teeth are expendable, as we now have implants to solve these problems. The fact that peri-implantitis is no simple problem to treat does not seem to affect many who hold that thought. In this article, the authors explain how to properly apply the periodontal prosthesis philosophy, concepts, principles, and techniques in contemporary dentistry. (This article is an update from the article was published in 2005) [1].

Introduction

It is interesting to look back upon the past sixty years spent in the study, practice, and teaching of dentistry after the Periodontal Prosthesis Program was founded by Drs. Morton Amsterdam & Walter Cohen in 1955. As we reflect on where we were and where we are at present, we begin to see in perspective how and why we evolved as we did.

Our own introduction to dentistry was definitely prosthetically oriented. We were given a sound and intense program of study in the basic sciences, but there was little if any correlation to that which we did in preclinical and clinical dentistry. Not only was that correlation lacking but there was little if any correlation between the various aspects of clinical dentistry. We wonder just how

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far we have come today in solving this problem (Dr. Morton Amsterdam) [2].

The principles of periodontal prosthesis developed in the 1950s—1970s by Drs. Amsterdam, Abrams, and Weisgold explained in Periodontal Therapy, edited by Drs. Goldman and Cohen, provide relevant diagnostic and therapeutic criteria and guidelines that apply to teeth as well as implants.

The technique of periodontal prosthesis allows multiple pontic replacement in fixed bridge often on severely mobile, compromised and reduced number of abutment teeth. The science is overwhelmingly in favor of this type of bridge in certain situations where conventional dentures and implants are not possible for whatever reasons. The technique relies on good oral hygiene and periodic maintenance, a reduced but healthy periodontal condition, multiple cantilevers often with couple pontics cantilevered off the last remaining abutment, subgingival (75—80%) and/or supragingival (20%) margins, acrylic, composite or porcelain veneering material on a metal framework and with a narrower occlusal table and shorter/shallower cusps to reduce horizontal force and occlusal trauma. Full arch splinting design can stabilize the mobile abutment teeth. This type of bridge has increased but not increasing mobility and excellent long term success rates. The principles in the past are still valuable and do apply to contemporary dentistry including implant restoration.

For these situations, occlusal, restorative, surgical, esthetic, biomaterial, pharmacologic, and psychologic skills must be carefully combined for optimal results [3].

The first osseointegrated titanium implant was inserted into a human jaw by Branemark in 1965 [4,5]. Endosseous implant-supported restorations delivered in accordance with the traditional Branemark protocol has proven to be highly predictable. This type of restoration is becoming more and more popular today. Implant-supported prostheses have been used for fully edentulous, partially edentulous, and single-tooth implants, and surgical and restorative approaches for implant prostheses have greatly improved in the past 50 years [6—9]. In essence, the emerging thought is that teeth are expendable, as we now have implants to solve these problems. The fact that periimplantitis is no simple problem to treat does not seem to affect many who hold that thought.

The dilemma for the ethically oriented professional is whether to save the natural dentition or to replace it with an implant. In 2011, "Three diagnostic criteria" for singlerooted teeth have been suggested from a periodontal point of view to solve this problem by Dr. Ricci's group and direct the clinician toward the proper biologically and ethically oriented treatment [10].

Three diagnostic criteria are as follows

1. Tooth stability

From a periodontal point of view, stability, vitality, and integrity (*The SVI rule: stable, vital, intact*). Of a tooth are definitive indications to maintain it and to proceed with regenerative therapy, even in a very compromised situation.

2. Type of osseous defect

If the tooth is contained within the envelope of the residual bony walls, the same good prognosis will apply to an immediate implant placed within the envelope of bone in an extraction socket.

3. Decontamination of the natural root

A decontaminated root surface must be obtained to achieve new attachment. As it compares with the use of a sterile implant in implant therapy.

As a consequence, there is no reason to proceed with placement of an artificial tooth, such as an implant, as a substitute for a natural tooth if the potential for repair and the surgical treatment of the site are the same for both procedures (Table 1).

"Periodontal Prosthesis" is defined as those restorative and prosthetic endeavors that are essential in the treatment of advanced periodontal disease. It refers to the treatment of the dentition mutilated by periodontal disease, including the concepts, principles, and techniques that may be used in any restorative or tooth replacement procedure involving the natural dentition [2].

These practices are just as applicable to implant restorations, from diagnosis, treatment plan, esthetics, periodontal/peri-implant perspectives, periodontal biotype, surgical perspectives, restorative perspectives, orthodontic perspectives, occlusal concepts and splinting perspectives, failures and complications management, maintenance, sequence of therapy, to the emergence profile of the abutment restoration [7].

In this article, the authors explain how to properly apply the periodontal prosthesis philosophy, concepts, principles, and techniques to contemporary dental therapy.

Indication for implant placement

One of the great uses for implants is when individuals have lost all their teeth. Another is when replacing bridges; the pontic area can now be restored with an implant. But with all of the wonderful restorative materials today, teeth that have broken down many times can be treated and maintained indefinitely.

Since the advent of bonded composite resins in the late 1980s, the success rate of restoring tooth surfaces in comprehensive perio-restorative cases has seen a major improvement; and due to the continuing evolution of wonderful restorative materials [11,12], every day we get

Table 1 Requirements for regenerative periodontal therapy on natural teeth vs requirements for immediate implant placement [10].

Tooth	Implant
Stable	Primary stability
Contained within envelope of bone	Contained within envelope of bone
Decontaminated	Sterile implant

better and better results that continue to stand the test of time. Yet here we are today, extracting teeth and replacing them with implants at an incredible rate never seen before.

Saving natural teeth

In essence, healthy, functional and cosmetic restoration of severely compromised natural teeth can be achieved without implant treatment in some clinical situations by following this workflow [13]:

1. Patient presents with decayed tooth.
2. Diagnosis to ensure trying to keep a tooth or teeth does not negatively affect existing healthy teeth.
3. Removal of decay through proper methods and then replacing lost tooth structure with bonded composite resins.
4. Placement of a provisional to allow for ideal contours and tissue health. The provisional is critical, as it allows the surgeon vertical access to the underlying periodontal tissues.
5. Surgical procedures are undertaken to remove pocketing. Surgery should encompass the creation of a parabolic architecture of the bone, biologic shaping of each tooth for long-term maintenance, and the addition of an abundance of connective tissue for protection of the periodontium. The end result of the surgery must permit the restorative dentist to place a clear margin in his or her final restorations.
6. At four weeks, a reline or remake of the provisionals is undertaken, creating a 1-mm gap coronal to the existing tissue. No margination is to be undertaken at this time.
7. Fourteen weeks from the day of surgery the final margins are placed. A feather edge [13] is recommended when the crown finish line is located at root surface.

Table 2 Periodontal prosthesis vs Implant prosthesis.

	Periodontal Prosthesis	Implant Prosthesis
Anchorage [14]	Periodontal ligament: proprioceptor—Flexible	Osseointegration—Rigid (as in ankylosis)
Attached gingiva	Required	Required (especially for rough surface implant)
Biological width [15]	Supracrestal, 2.04 mm:(from crest of alveolar bone to coronal part of tooth)	Subcrestal, 2.5 mm: (from junction of implant head and abutment to apical of implant) Supracrestal (possible in platform switch implant)
Surgical procedure	Less trauma	More trauma
Crown to root/implant ratio	Poor Longer clinical crown	Once osseointegration is achieved, crown-to-implant ratio may not be important
Occlusion	Narrow occlusal table; reduce lateral forces	Narrow occlusal table; reduce lateral forces
Impression technique	More complicated	Simple, with impression coping
Complications [16]	Periodontitis, occlusal trauma, root caries, root fracture	Periimplantitis, fistula, fixture/screw failure, prosthesis failure. More complicated.
Cosmetic concern Papilla preservation	Difficult	Difficult, especially with 2 implants adjacent to each other Improved by pink esthetic (pink porcelain)
Function of final restoration	Good	Good
Preparation of ridge	Orthodontic therapy to improve bony defect, GTR Soft tissue augmentation	Orthodontic therapy to build up implant site; increase bone and soft tissue volume, GBR PRGF, PRP, PRF
Occlusal wear	Erupt to compensate for wear because of cementum/bone	No eruption to compensate for wear; problem especially in single tooth implant
Root caries	Yes	No
Periodontal maintenance	Every 3—4 months; requires excellent oral hygiene	Every 6 months; requires excellent oral hygiene
Long-term follow up	Up to 50 + years	Single tooth implant: 40 + years Long span C&B: Up to 24 years
Influence of the 3-D [14]	Not critic	Critic
Bone-to-Implant/tooth Relationship on Esthetics:	As long as there is no attachment loss	2 mm buccal plate (prefer 2—4 mm)
Proximity [17—19]	Tooth and tooth 1.0 mm	Tooth and implant 1.50 mm without platform switching 1.25 mm with platform switching (possible) Implant and implant 3.0 mm without platform switching 2.5 mm with platform switching (possible)

8. Final placement of restorations, with care taken to make sure they are properly contoured with full 360-degree margin closure. Special care of proper contours where furcations have been removed is critical.

Lessons and guideline from periodontal prosthesis [13] (Table 2)

Orthodontic perspectives

Orthodontics has always played a major role in periodontal prosthesis. For example, orthodontics was used in the past to retract maxillary and mandibular anterior teeth that had splayed, which was done with removable appliances (Fig. 1). Fixed orthodontic appliances were used to upright mesially tilted posterior teeth when bodily movement required a more stable appliance. As research began to show that tooth position has a significant affect on soft and hard tissues, orthodontics began to be used to reformat the periodontium and align teeth.

Today, implants are used when natural teeth are seriously compromised. Forced eruption before crown lengthening procedures, molar uprighting, and realignment of anterior teeth are all examples of situations in which implants can be used. When implants are used to anchor orthodontic teeth movement the therapeutic period is decreased [7].

Orthodontic therapy can now be used to create or develop the future implant site by using forced eruption of hopeless teeth to alter or increase the soft and hard tissues before implant placement. It also can be used to recreate lost interproximal papillae.

Site development

In 1998, Salama, Garber, Rosenberg. et al. [9] explored the roots of the concept of implant site development within the philosophy and principles of periodontal prosthesis. In addition, the myriad of techniques that are presently collectively referred to as site development are systematically classified into a sequential four-tiered approach:

1. Space management
2. Osseous related management and enhancement
3. Soft tissue enhancement
4. Developing the restorative—gingival interface that optimizes their efficient application as well as overall success.

The principles of occlusion

Because of the periodontium is compromised in most periodontal prosthesis cases, the narrower occlusal table was suggested and the lateral occlusal forces reduced. In most

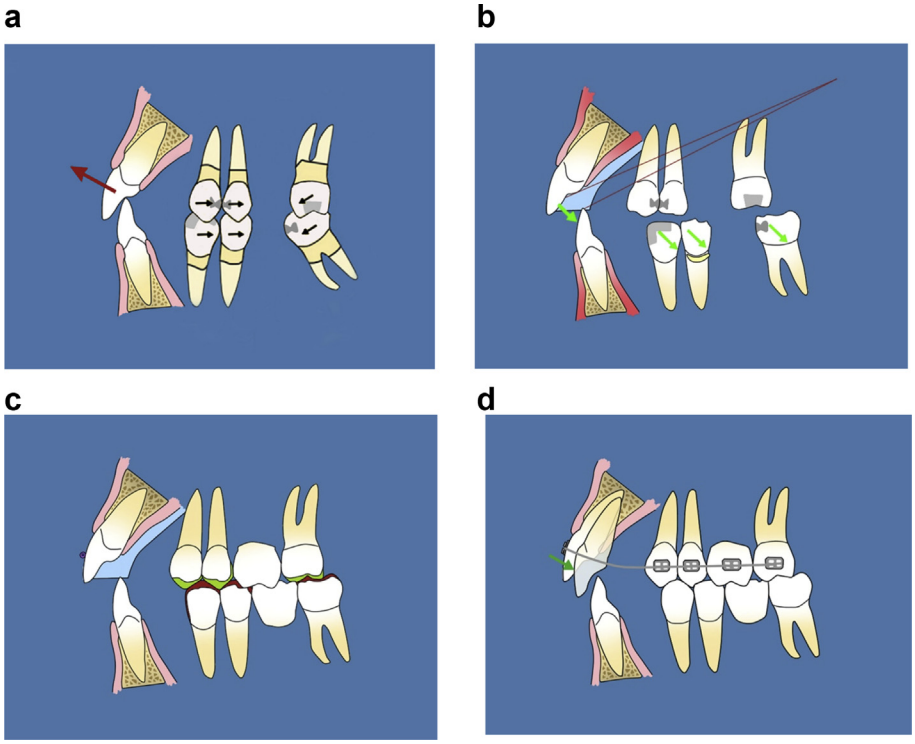

Figure 1. **a**. Posterior bite collapse after missing upper and lower 1st molars. Maxillary anterior teeth had splayed. **b**. Modified Hawley bite plane was applied to disarticulate posterior teeth. **c**. After posterior teeth passive erupt, temporary build-up and/or temporary bridges are inserted. **d**. When posterior support is set up and the occlusal vertical dimension is decided, retract maxillary anterior teeth that had splayed by using fixed or removable appliances. Final restoration (either C & B or implant restoration) can be done.

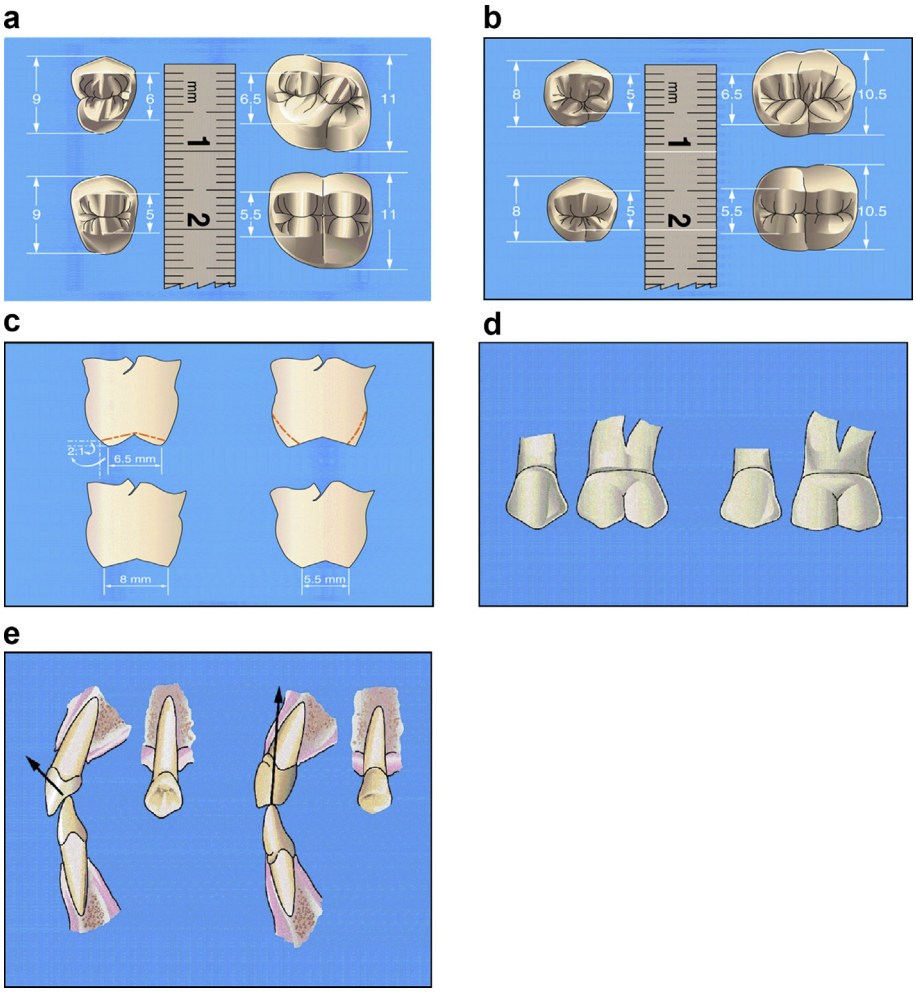

Figure 2. **a**. Mechanical modifications in occlusal form as a modified cusp in periodontal prosthesis. Note comparison between buccolingual width of occlusal table of unworn tooth and that of restored tooth. **b**. Comparison in a lower posterior tooth between unworn natural tooth and restored tooth with therapeutic cuspal modification. **c**. Decreasing posterior cusp height will cause occlusal table to be widened (upper left, lower left). After cuspal height reduction, a compensatory narrowing of occlusal tables is necessary (upper right, lower right). **d**. Comparison of cusp height of natural unworn tooth and that of restored dentition. **e**. Left: Occlusal relations of unrestored canine, direction of transmission of occlusal load in this case is predominantly horizontal (arrow). Right: Centric hold created in restored canine permits occlusal load (arrow) to be transmitted axially.

cases, it is necessary to decrease posterior cusp height to accommodate a decrease in incisal guidance. Modified canine plane forms were created to permit occlusal loads to be transmitted axially (Fig. 2) [20,21]. The same concept will fit the implant prosthesis. Weinberg and Kruger [22] suggested using flat cuspal inclinations and minimizing cantilever lengths, and suggested that maxillary molars placed in cross-occlusion and occlusal anatomy be modified to decrease torque.

Immediate loading implant dentistry

The combination of the guidelines of periodontal prosthesis with state-of-the-art implant dentistry can lead to predictable, beneficial, and efficient treatment, even for the most difficult patients and circumstances at immediate loading implant cases (Ganeles et al.) [3]. The principles of occlusion derived from periodontal prosthesis are summarized as follows [23]:

1. The teeth should be in maximum occlusion when the jaws are in centric relation at an acceptable vertical dimension, allowing for an adequate interocclusal distance.
2. The mandible should have freedom to move to and from centric relation without restraint.
3. The healthy, functional and esthetic pattern should satisfy the needs of the patient.
4. The cuspal relations of the teeth in both anterior and posterior directions should allow the mandible to move to and from centric relation without restraint.
5. Inclined plane control of the mandibular excursive movements should be supplied by the anterior teeth (especially the canines) and the buccal cusps unilaterally on the working side. No posterior tooth contact is required or desired during protrusive movements.
6. Mechanical modification of the total occlusal restorative design is mandatory in the execution of periodontal prosthesis. These modifications have as a basic intent of

the reduction and control of occlusal leverage and the axial radicular transmission of occlusal load.

7. Reduction of horizontal overloading of the posterior teeth may be greatly enhanced by shortening cusp height. The occlusal design should provide a decrease in the height of bucco-lingual cuspal angulations and at the same time present the proper form necessary to do the following:
   a) permit the posterior teeth to stabilize the mandible in centric relation;
   b) permit mandibular freedom of movement to and from centric relation;
   c) prevent non-working interference (prevent non-functional or balancing occlusal contact in lateral jaw movement);
   d) prevent protrusive interference (prevent posterior occlusal contact in protrusive jaw movement); and,
   e) prevent parting of the anterior teeth during all mandibular glide patterns.

Periodontal biotype perspectives

According to Weisgold's study, there are two major periodontal biotypes: thin-scalloped and thick-flat [24,25]. Their characteristics are as follows:

Thin-scalloped

- distinct disparity between height of gingival margin on direct facial and height of gingival margin on the interproximal surface
- delicate and friable soft-tissue curtain
- underlying osseous form scalloped, dehiscences and fenestrations often present
- small amount of attached masticatory mucosa (quantitative and qualitative)
- reacts to insult by recession
- subtle, diminutive convexities in cervical thirds of facial surfaces

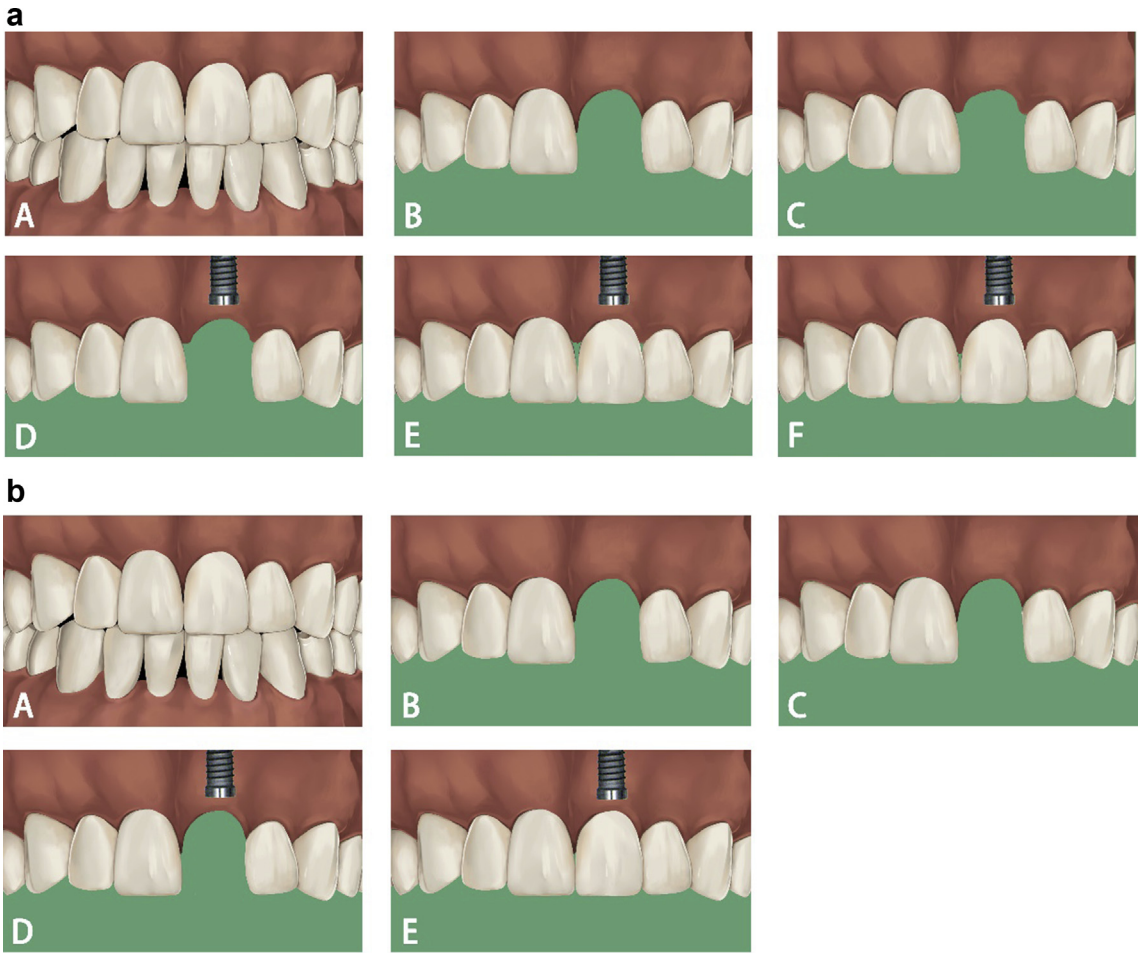

Figure 3. **a**. Computer images of thin-scalloped type periodontium (A). B. Immediately after extraction of maxillary left central incisor; C. 2 months post extraction (note loss of interproximal papillae); D. placement of fixture; E. crown on fixture (note "black triangle"); F. attempt to hide black triangles by making a more square tooth form. (Reproduced with permission from Dr. Arnold Weisgold [6]). **b**. Computer images of thick-flat type periodontium (A). B. Immediately after extraction of maxillary left central incisor; C. 2 months post extraction (note interproximal papillae are intact); D. placement of fixture; E. crown on fixture. (Reproduced with permission from Dr. Arnold Weisgold [7]).

Table 3 Salama et al. classification of predicted height of interdental papillae [9].

Class	Restorative environment	Proximity limitations (mm)	Vertical soft tissue limitations (mm)
1	Tooth—tooth	1.0	5.0
2	Tooth—pontic	N/A	6.5
3	Pontic—pontic	N/A	6.0
4	Tooth—implant	1.5	4.5
5	Implant—pontic	N/A	5.5
6	Implant—implant	3.0	3.5

- contact areas of adjacent teeth located toward the incisal or occlusal thirds
- teeth triangular in shape
- small contact areas of adjacent teeth faciolingually and incisogingivally

Thick-flat

- not as great a disparity between height of gingival margin on direct facial surface and height of gingival margin on interproximal surface
- denser, more fibrotic soft-tissue curtain
- underlying osseous form is flatter and thicker
- large amount of attached masticatory mucosa (quantitative and qualitative)
- reacts to insult by pocket depth
- more prominent, bulbous convexities in cervical thirds of facial surfaces
- contact areas of adjacent teeth located more toward the apical
- teeth more square in shape
- large contact areas of adjacent teeth faciolingually and incisogingivally

The periodontal biotype not only affects the natural dentition, it will affect the esthetic result in an implant-supported prosthesis as well.

In most cases when the patient has a thick-flat periodontium, the papillae can be preserved. When the patient has the thin-scalloped periodontium, there is often papillary recession (Fig. 3) (Table 3).

Conclusion

Four decades after Dr. Amsterdam's monograph (since 1974), the basic tenets associated with periodontal prosthesis, interdisciplinary therapy continues to guide restorative and reconstructive efforts even as we move into the new millennium. Combining the guidelines of periodontal prosthesis with implant dentistry can lead to predictable, beneficial, and efficient treatment, even for the most difficult patients and circumstances.

The developments of osseointegrated titanium implants have led to the success of contemporary dentistry. Implant prosthesis give patients and dentists more options in treatment planning; at the same time, it creates a more complicated decision regarding when to execute the implant surgery. Applying the periodontal prosthesis philosophy, concepts, principles, and techniques to the implant-supported prosthesis provides clinicians with guidelines for performing this type of procedure, and offers an alternative to using conventional periodontal prostheses.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.kjms.2018.01.008.