The Impact of Osseointegrated Implants as an Adjunct and Alternative to Conventional Periodontal Prosthesis

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Abstract: ***In the last 4 decades, the developments of osseointegrated titanium implants 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 this article, the author explains how to apply the periodontal prosthesis philosophy, concepts, principles, and techniques to the implant-supported prosthesis.***

The first osseointegrated titanium implant was inserted into a human jaw by Branemark in 1965.[1,2] Endosseous implant-supported restorations delivered in accordance with the traditional Branemark protocol have 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 40 years.[3-7]

From a surgical standpoint, traditional implant placement is performed 6 to 12 months after extraction, delayed implant placement is executed 6 to 8 weeks after extraction when soft-tissue healing is complete, and immediate implant placement is done right after extraction. From a restorative standpoint, immediate occlusal loading protocol involves an implant-supported temporary or definitive restoration in occlusal contact within 2 weeks of implant insertion. Early occlusal loading refers to an implant-supported restoration in occlusion between 2 weeks and 3 months after implant placement. Delayed or staged occlusal loading refers to an implant prosthesis in occlusion more than 3 months after placement. The delayed occlusal loading approach may use either a 2-stage surgical procedure that covers the implants with soft tissue or a 1-stage approach that exposes a portion of the implant at the initial surgery. [8-29]

"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.[3] These practices are just as applicable to implant restorations, from occlusal concepts to the emergence profile of the abutment restoration.[5]

In this article, the author explains how to apply the periodontal prosthesis philosophy, concepts, principles, and techniques to the implant-supported prosthesis.[3-7]

Learning Objectives:

After reading this article, the reader should be able to:

- describe how to apply the periodontal prosthesis philosophy, concepts, principles, and techniques to the implant-supported prosthesis.
- discuss the sequence of therapy in periodontal/implant prosthesis.
- explain why the major difference in treatment planning between the past and today is timing.

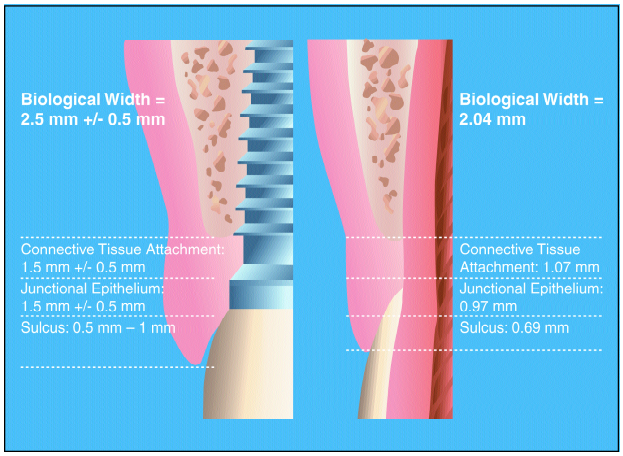

Figure 1—The biologic width of a tooth compared with an implant fixture.

Diagnosis and Treatment Plan

Establishing a correct diagnosis is essential to the best treatment and accurate prognosis of any case. Sometimes it is not possible to make an accurate diagnosis because of an inability to recognize and identify causative factors. By approaching the problem rationally, it is usually possible to establish a selective differential diagnosis.

The initial treatment plan depends on a patient's chief complaints, financial concerns, duration of therapy, and type of procedures involved. The final diagnosis will determine the dental team's treatment plan.

After reevaluation and completion of all periodontal, endodontic, and orthodontic procedures necessary to eliminate, modify, or control the influential aspects of any deformities present, the case is again evaluated for restorative needs.

Today, implants are becoming increasingly common in dental care. They provide more therapeutic options, but also provide some unpredictable results. For example, it is more difficult to achieve esthetic results, especially to create or reform the papillae between 2 implants, and there are still some known and unknown factors that cause implant failure, including periimplantitis, age and hormonal factors, medical conditions and local oral diseases, medicines, and lifestyle factors.[30]

Periodontal/Periimplant Perspectives

Implants are engaged to the bone by means of osseointegration, which is thought to be as rigid as in ankylosis. Natural teeth are integrated to the bone by periodontal ligaments, which allow some movement and have varied mobility patterns. Another concern is that single-tooth implants will not erupt to compensate for wear, as will natural teeth.[4]

There is a 2.04 mm biologic width around natural teeth;[31,32] and a 2.5 mm biologic width around implant fixtures (Figure 1).[33] The biologic width around an implant is apical to the implant abutment connection, making it difficult to maintain or reform a papilla between 2 implants. Most implants currently on the market have flat platforms at the top, allowing the implant to almost always be positioned below the interimplant bone crest. This location of the implant platform places the biologic width subcrestally. The biologic width of a healthy natural tooth always forms supracrestally (Figure 2),[34] making it easier to maintain or reform a papilla between 2 natural teeth. The attached gingiva also is a concern because gingival recession must be prevented. The rough surfaces of implants have greater need for attached gingiva.

Esthetic Perspectives

In the traditional periodontal prosthesis, papillae reformation and/or reconstruction can be achieved by forced eruption, orthodontic therapy, soft-tissue augmentation, and/or hard-tissue augmentation. When using an implant-supported prosthesis, the papillae surrounding the single-tooth implant can be handled much better when the bone level of the adjacent natural teeth is in a favorable position. In Tarnow's study, if the distance between 2 implants is 3 mm or more, there is a better chance of preserving the crest bone between the implants. If the distance is less than 3 mm, the chance of preserving the crestal bone decreases.[35,36]

The initial treatment plan depends on a patient's chief complaints, financial concerns, duration of therapy, and type of procedures involved.

The average papillae height between 2 implants is 2 mm to 4 mm (3.4 mm average), 1 mm to 2 mm less than what is needed to duplicate the interproximal papillae of the adjacent teeth.[36] Therefore, esthetic failure

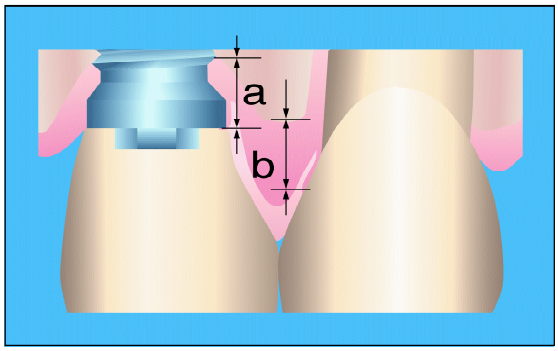

Figure 2—Interdental tissue does not have the same level of support on an implant (a) as it does on a tooth (b).

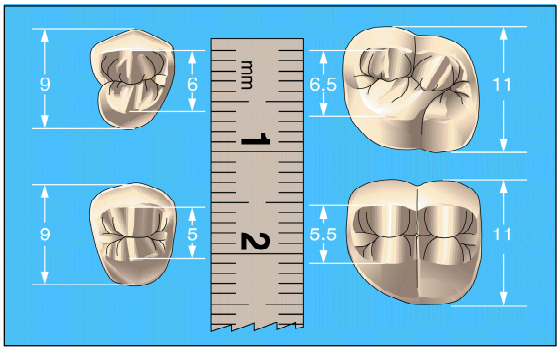

Figure 3—Mechanical modifications in occlusal form as a modified cusp in periodontal prosthesis. Note comparison between buccolingual width of occlusal table of unworn tooth and that of restored tooth.

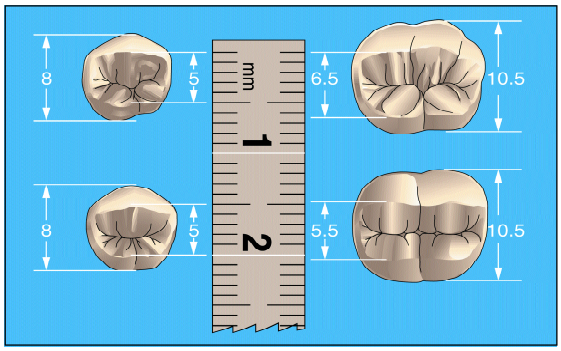

Figure 4—Comparison in a lower posterior tooth between unworn natural tooth and restored tooth with therapeutic cuspal modification.

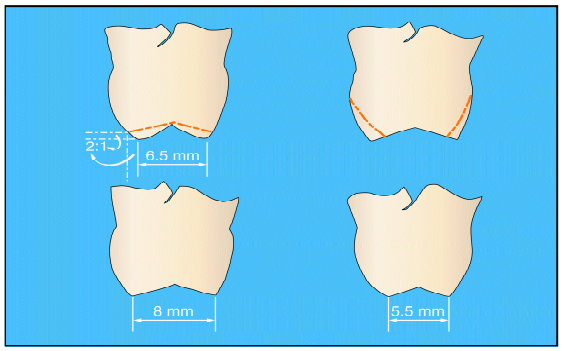

Figure 5—Decreasing posterior cusp height will cause occlusal table to be widened (upper left, lower left). After cuspal height reduction a compensatory narrowing of occlusal tables is necessary (upper right, lower right).

could result, despite the dentist performing all procedures properly.

A modified treatment plan may be necessary when the dentist is presented with an esthetic challenge. One solution is to place 1 implant and splint it to a cantilevered ovate pontic. A second option is placing a traditional fixed partial denture instead of an implant. Also, if the surgical site allows, immediate implant placement and/or immediate loading can be performed. The implants are placed right after the tooth is extracted, and the provisional is fabricated right after the implant placement. In this way, the provisional helps to support the papillae area and prevent collapse of the soft tissue.[37-39]

Periodontal Biotype Perspectives

According to Weisgold's study, there are 2 major periodontal biotypes: thin-scalloped and thick-flat.[40,41] Their characteristics are as follows:

Thin-Scalloped

- distinct disparity between height of gingival margin on direct facial and height of gingival margin interproximally
- 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
- 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 interproximally
- 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

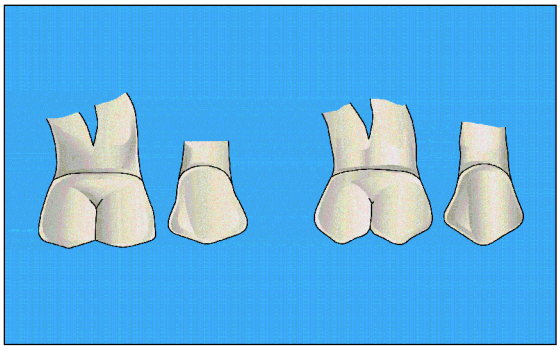

Figure 6—Comparison of cusp height of natural unworn tooth and that of restored dentition.

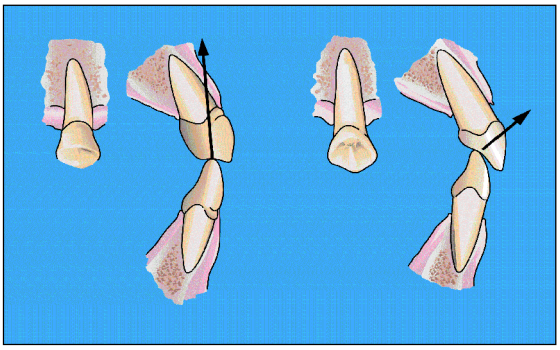

Figure 7—Left: Occlusal relations of unrestored canine, direction of transmission of occlusal load in this case is predominantly horizontal (arrow). Right: Centric hold created in restored canine permits occlusal load (arrow) to be transmitted axially.

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.

Surgical Perspectives

For traditional periodontal prosthesis cases, most ridge augmentation procedures can be improved by soft-tissue grafting or forced eruption. For implant-supported prosthesis cases, there is often a need for vertical or horizontal hard-tissue ridge augmentations to achieve site development. The site development techniques/procedures could include:

- orthodontic tooth movement (eg, separate adjacent implants, forced eruption)[42]
- hard-tissue graft (eg, sinus lift, ridge augmentation)[43-47]
- split technique[48-61]
- distraction osteogenesis[62-75]

Restorative Perspectives

Impression techniques are usually more complicated for traditional periodontal prosthesis cases than impressions for implant teeth. For implant-supported prostheses, if implants are installed in an ideal position, the impression (closed tray or open tray) will be much easier to fabricate than it would be if using natural teeth. If the implants are installed in a less than ideal position, it may be very difficult to achieve a functional and esthetic result. Sometimes implants are not even restorable, and eventually they will either be buried or taken out. Therefore, the basic periodontal prosthesis philosophies and techniques will be the best tools to plan and set up cases. It would help surgeons and/or prosthodontists to design the cases. The better the implant is positioned, the better the restorative results.

Amsterdam asserted that "All objectives must be achieved in the provisional phase before continuing with the final restoration."[3,4] If the sequence of therapy is properly applied and the response is favorable, there is justification for continued treatment leading to a definitive result. The restorative needs related to correction of tooth form and structure and the occlusal needs (including splinting) must now be established in the provisional restoration. Before continuing with the final restoration, all objectives must be achieved in the provisional phase and the results should be reevaluated. The final restoration is then constructed using materials more resistant to wear.[6]

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. 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, othodontics began to be used

Table 1—The Impact of Osseointegrated Implants as an Adjunct and Alternative to Conventional Periodontal Prosthesis Preoperative Bone Height

	Periodontal Prosthesis	Implant Prosthesis
Anchorage	Periodontal ligament: proprioceptor —Flexible	Osseointegration—Rigid (as in ankylosis)
Attached gingiva	Required	Required
Biological width	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)
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	Periodontitis, occlusal trauma, root caries, root fracture	Periimplantitis, fistula, fixture/screw failure, prosthesis failure.
Cosmetic concern Papilla preservation	Difficult*	Difficult,* especially with 2 implants adjacent to each other
Function of final restoration	Good	Good
Preparation of ridge	Orthodontic therapy to improve bony defect, GTR	Orthodontic therapy to build up implant site; increase bone and soft tissue volume, GBR
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 to 4 months; requires excellent oral hygiene	Every 6 months; requires excellent oral hygiene
Long-term follow up	Up to 50+ years	Up to 24 years

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.[5]

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 re-create lost interproximal papillae.

Occlusal and Splinting Perspectives

Because the periodontium is compromised in most periodontal prosthesis cases, the narrower occlusal table was suggested and the lateral occlusal forces reduced. In most 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 (Figures 3 through 7).[76,77] The same concept will fit the implant prosthesis. Weinberg and Kruger[78] 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.

Regarding bite strength, the biting force of bruxers has been determined to be as much as 6 times that of nonbruxers. When the forces are increased in magnitude, direction, or duration, ridge augmentation may be required to improve implant placement. Crown height should be reduced and implant width and numbers should be increased to compensate for the increased load.[79]

Implant Failures and Complications

The high success rate of achieving osseointegration with root-form endosseous implants is well documented.[80-83] Implant failures, however, do occur, and what causes them is not always clear. The most common reasons cited for implant failure before loading are infection, overheating the bone, habitual smoking, systemic disease, transmucosal overloading, excessive surgical trauma, and implant placement adjacent to teeth demonstrating periapical pathology or retrograde periimplant infection from retained root tips.[84-89]

Baumgarten and Chiche asserted that osseointegrated implants fail for a number of reasons.[90] Failures should be classified based

on when in the sequence of therapy they occur. When analyzing the causes of failure, consider the stages of therapy before and after implant loading.

Failures before implant loading: Failures during this period usually result in the complete loss of the implant because of infection,[91] undiagnosed systemic disease, transmucosal overloading, smoking,[92] or excessive surgical trauma.

Failures after implant loading: There are 3 types of failures after loading. The first is an esthetic failure, in which the implant and prosthesis are intact but the patient's esthetic needs have not been met. The second type results in the complete loss of an implant as a result of failure at the bone-implant interface. The third type is prosthetic failure, including set screw fracture, abutment screw fracture, implant fracture, screw loosening, porcelain fracture, and solder-joint fracture.[93-97]

Treatment planning and the sequencing of therapy are critical in implant-assisted and implant-supported cases.

Berglundh and colleagues[98] reviewed the incidence of biological and technical complications in implant therapy. The types of complications assessed were as follows: implant loss, sensory disturbance, soft-tissue complications, periimplantitis, bone loss $\geq$2.5 mm, implant fracture, and technical complications related to implant components and suprastructures. The study indicated that implant loss before functional loading is expected to occur in about 2.5% of all implants placed, including more than 1 implant and when routine procedures are used. Implant loss during function occurs in about 2% to 3% of implants supporting fixed reconstructions, while in overdenture therapy >5% of the implants can be expected to be lost over 5 years.

Other complications included mandibular fracture when the patients had severe degrees of atrophy in the mandible area, profuse hemorrhage, and infection.[99] Prolonged neurosensory disturbances also occurred after nerve repositioning procedures. These included parasthesia (an abnormal sensation that may be characterized as "pins and needles"), anesthesia (an absence of any sensation or pain), and dysesthesia (painful neuropathy, either spontaneous or evoked, with or without any background sensation, including hyperalgesia, hyperpathia, sympathetic mediated pain, and anesthesia dolorosa).[100-102]

Maintenance Perspectives

For periodontal prosthesis cases, 3 to 4 months of periodontal maintenance is suggested. The fixed partial denture can be retrieved if cemented with temporary cement. For the implant-supported restoration, 6 months of maintenance is suggested; it can be retrieved whenever necessary. The major difference between traditional periodontal prosthesis cases and the implant-supported restoration is that root caries will not be a problem around the implant fixtures.

Sequence of Therapy in Periodontal/Implant Prosthesis

Treatment planning and the sequencing of therapy are critical in implant-assisted and implant-supported cases. The implant prosthesis gives 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. The sequence of therapy in periodontal/implant prosthesis is outlined as follows:

Initial Therapy

- control of acute conditions
- initial periodontal therapy
- reevaluation
- endodontic therapy
- diagnostic wax-up
- orthodontic therapy
- extractions if necessary
- hemisection and/or root resections (not done as much with implant cases as with natural cases)
- osseointegrated implant fixtures

Provisional Restoration and Stabilization

- each implant must achieve primary stability
- evaluate esthetics, occlusion, gingival response, and phonetics

Definitive Periodontal Management Phase

- osseous surgery
- mucogingival surgery
- guided bone regeneration (GBR) (ridge augmentation, forced eruption, distraction

osteogenesis, sinus lift, or nerve reposition)
- reentry procedures (osseous grafts)
- reevaluation

Prosthetic Phase

- prosthesis design
- establishment of final tooth preparations
- establishment of final restoration t e mp l a t e using relined provisional restorations
- final impressions
- occlusal registration records
- casting try-in; removable try-in if needed
- frame try-in
- bisque porcelain try-in and removable partial denture wax try-in
- trial cementation period
- final cementation
- occlusal guard

Recall and Maintenance Phase

According to the varying treatment plans, the implants will be involved in different phases. For example, if implants will play the role of anchors during orthodontic therapy, the diagnostic wax-up should be done and the future implant site decided. The implants will then be installed in the initial phase. However, if the implants will be placed after implant site development, it should be done after the GBR procedure.

If immediate placement of the implants is preferred, then extractions and implant placement are often performed at the same time, and some natural teeth are retained during the treatment phase to act as abutments and support the provisional. This protects the implant sites until they are ready to be exposed and restored.

If immediate implant placement and loading were planned, then the occlusal vertical dimension should be decided according to the diagnostic wax-up. A modified Hawley bite plane is most helpful in determining occlusal vertical dimension. The denta-scan should be taken after the occlusal vertical dimension is determined. Provisional and surgical stents should be ready before the implant surgery. Therefore, extractions, implant placements, GBR, and provisionals can be completed in the same day. After osseointegration has been achieved, the final restoration is fabricated.

Discussion

The major difference in treatment planning between the past and today is timing. In the past, some of the patient's natural teeth would be saved to support the provisional restoration during osseointegration. After osseointegration, the rest of the patient's natural teeth would be extracted, then the final restoration would be finished.

Today, after the occlusal vertical dimension and diagnostic wax-up were decided, a provisional restoration would be fabricated in the lab before the surgical procedure. Instead of extraction and delayed implant loading, all the natual teeth can be extracted and the implants can be installed right away. Prefabricated abutments can be connected to the fixtures and the provisional restoration can be relined and refined in the same visit. The final restoration will be finished after osseointegration is achieved. The whole treatment time can be shortened, and for the patient's comfort, all the surgical procedures can be accomplished in 1 visit.

Implant prostheses give patients and dentists more options in treatment planning.

Conclusion

The developments of osseointegrated titanium implants have led to the success of contemporary dentistry. Implant prostheses 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.

Acknowledgment

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Graph designed by Chun Hsiung Chen, MFA.

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Quiz 3

1. **Early occlusal loading refers to an implant-supported restoration in occlusion how long after placement?**
   a. immediate placement after extraction
   b. within 2 weeks of placement
   c. between 2 weeks and 3 months
   d. greater than 4 months

2. **Implants are engaged to the bone by means of:**
   a. periodontal ligaments.
   b. hyperconduction.
   c. osseointegration.
   d. superconduction.

3. **Natural teeth are integrated to the bone by:**
   a. periodontal ligaments.
   b. hyperconduction.
   c. osseointegration.
   d. superconduction.

4. **The biologic width around natural teeth is:**
   a. 1.02 mm.
   b. 2.04 mm.
   c. 3.06 mm.
   d. unsubstantiated.

5. **The biologic width of a healthy natural tooth always forms:**
   a. infracrestally.
   b. subcrestally.
   c. supracrestally.
   d. variably.

6. **According to Weisgold's study, the 2 major periodontal biotypes are:**
   a. thin-scalloped and thick-flat.
   b. thick-scalloped and thick-flat.
   c. thin-scalloped and thin-flat.
   d. thick-scalloped and thin-flat.

7. **For implant-supported prosthesis cases, there is often a need for vertical or horizontal:**
   a. root planing.
   b. gingival recontouring.
   c. hard-tissue ridge augmentations to achieve site development.
   d. enameloplasty.

8. **What therapy could be used to create or develop the future implant site by using forced eruption of hopeless teeth?**
   a. periodontal
   b. orthodontic
   c. endodontic
   d. prosthetic

9. **The biting force of bruxers has been determined to be as much as how many times that of nonbruxers?**
   a. 2
   b. 4
   c. 6
   d. 8

10. **Types of failures after loading include:**
    a. esthetic failure.
    b. failure at bone-implant interface.
    c. prosthetic failure.
    d. all of the above

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