

PRINCIPLES OF ATTACHMENT SELECTION FOR IMPLANT-SUPPORTED OVERDENTURES AND THEIR IMPACT ON SURGICAL APPROACHES

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INTRODUCTION

The oral and maxillofacial surgeon often manages fully edentulous patients with dental implants. Unlike other dental implant treatments, the referral pattern for the fully edentulous patient typically comes to the oral surgeon directly from the restorative dentist. In the last two decades, periodontists, being in a leading position to assess failing teeth, have been able to take a major role in the management of the partially edentulous patient with dental implants. However, in recent years, the demographics of dental implant patients have changed in comparison to the 1980s and 1990s. Baby boomers are reaching retirement age, and dentists are facing a major influx of fully edentulous patients and patients with generalized compromised teeth who ask for cost-effective full mouth rehabilitation. The fixed restorative option, while being the most desirable, is often beyond the financial means of many edentulous patients. In addition, this option invariably needs multiple implants and complicated laboratory procedures that may be beyond the knowledge and skills of the average general dentist. In contrast, the overdenture choice is significantly less expensive and is within the reach of many patients that are on a limited budget, and a patient restored with an overdenture supported on two implants in the mandible or four implants in the maxilla will likely be greatly satisfied with his or her prosthesis.

While oral surgeons are at ease with various complex surgical reconstructive procedures, they are not as familiar with prosthetic options and attachments that are available to provide a satisfactory overdenture. Additionally, a successful implant-supported overdenture depends on proper positioning and distribution of the supporting implants. These factors have a direct impact on attachment selection for each particular scenario.

In this review, we will address the diagnosis and principals of attachment selection for implant overdenture therapy. This should enable the oral surgeon to establish a well-informed interaction with

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the restorative dentist during the treatment phase. Additionally, it will help the oral surgeon avoid errors of implant positioning and distribution that are related to different attachment assembly designs.

PRINCIPLES OF ATTACHMENT SELECTION

Factors upon which attachment selection depends are listed in Table 1. Patients with advanced resorption of the alveolar ridge are good candidates for bar or telescopic attachment assemblies because these attachments offer considerable horizontal stability. Patients with minimum alveolar

TABLE 1: FACTORS OF ATTACHMENT SELECTION
Available bone
Patient's prosthetic expectations
Financial ability of patient to cover treatment costs
Personal choice and clinical expertise of dentist
Experience and technical knowledge of the lab technicians.

ridge resorption are good candidates for studs or magnetic attachment assemblies. However, magnets provide the least amount of retention compared to the other attachments, and they very soon lose their initial retention capacity. Studs are ideal for patients with a narrow ridge because in these cases, a bar would interfere with the tongue space.

Different types of attachment assemblies are listed in Table 2. Rigid telescopic copings transfer most of the masticatory force to the supporting implants. This increases the risk for implant fatigue and eventual fracture of the implant or its components. With rigid or minimally resilient attachment assemblies there is minimum load transfer to the posterior alveolar ridge. Therefore, patients experience the least amount of alveolar bone resorption.

Biomechanical Considerations

Factors that influence the design and resiliency of the attachment assembly are listed in Table 3. One hypothesis suggests that the bar connecting the implants should be parallel to the hinge axis. Although this rule has been followed by many clinicians, no

TABLE 2: DIFFERENT ATTACHMENT ASSEMBLIES
Clips and bars
Studs
Magnets
Telescopic copings (rigid and non-rigid)

TABLE 3: FACTORS INFLUENCING THE DESIGN AND RESILIENCY OF THE ATTACHMENT ASSEMBLY
Shape of the arch
Distribution of the implants in the arch
Length of the implants and degree of implant-bone interface
Distance between the most anterior and most posterior implants

studies have supported this claim. One long-term study (5 years) analyzed the influence of placing the bar parallel to the hinge axis on peri-implant parameters, including the clinical attachment level.¹ The outcome of the type of retention (i.e., splinted versus unsplinted) was also assessed. No significant correlations were found.

Distal Extension to the Bar

Distal extensions provide a high level of stability against lateral forces, particularly in the mandible, and can protect the denture bearing tissue from loading forces. Distal extensions should not extend beyond the position of first premolar of the mandibular prosthesis, and they cannot compensate for a short central segment. When distal extensions are used, the implants' splinting

effects for better force distribution disappear, and the force patterns will be similar to those of unsplinted implants.

Load Distribution of Stud Attachments vs. a Bar

The in vivo study by Menicucci et al. showed that ball anchors are preferred because they provide better load distribution than bar attachments on the posterior mandibular bone.² Stern et al, through a series of three-dimensional force measurements with two infra-foramina Strauman implants in fully edentulous patients, showed no significant force differences when different attachment assemblies and retention mechanisms were compared.³

Biomechanics of Maxillary Overdentures

A pilot study by Mericske-Stern et al. compared repeated in vivo measurements of 3-D forces in maxillary implants supporting either a fixed denture or an overdenture with a rigid bar connection.⁴ They found comparable force magnitudes and patterns, suggesting that, when loaded, a rigid bar with a connected overdenture performs in a way similar to a fixed prosthesis.

STUD ATTACHMENTS

Stud attachments have been on the market for several decades. They are very straightforward to use and provide reasonable retention and stability for implant overdentures.^{3, 5-26}

Important Considerations Regarding Stud Attachment Alignment

Relationship of the Stud Attachments With Each Other

It is important to have all of the stud attachments parallel to each other. Some universal joint (ball and socket) attachments may be as much as 5° to 7° out of parallel with each other and still function properly.

Relationship of the Stud Attachments With the Path of Insertion

The attachments should not interfere with the path of insertion of the overdenture.

Height of the Stud Attachments

It is more difficult to achieve an ideal alignment with taller attachments than shorter ones.

LOCATOR® OVERDENTURE ATTACHMENT

The Locator® overdenture stud attachment was conceived by R&D Specialist Scott Mullaly of Zest Anchors, LLC (Escondido, CA) and became commercially available for natural teeth (roots) in February, 2000 and for implants in September of that same year. The Locator® was designed for ease of insertion and removal, dual retention, a low vertical profile and a unique ability to pivot, thus increasing its resiliency and tolerance for implant divergency. (Fig. 1)

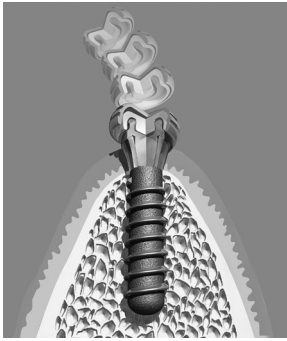


Figure 1. The Locator® attachment.

Due to these design features, the Locator® rapidly became one of the most popular stud attachments and, as of 2010, was available for approximately 350 different implants from 70 manufacturers.

Design Features of the Locator® Overdenture Attachment

Self Alignment

The majority of overdenture attachments can become distorted upon insertion if the patient does not carefully align the male and female elements of their appliance along a set path-of-insertion. Many patients have a tendency to “bite” their overdenture into place at an angle, causing damage and requiring replacement. To address this issue, the Locator® attachment was designed to be self-aligning. The rounded occlusal contours of the female element work in conjunction with the skirt of the nylon male to guide the attachment into place in a way similar to the guide planes of partial dentures. (Fig.2A)

Dual Retention

To maximize retentive capability and longevity, the Locator® was designed with

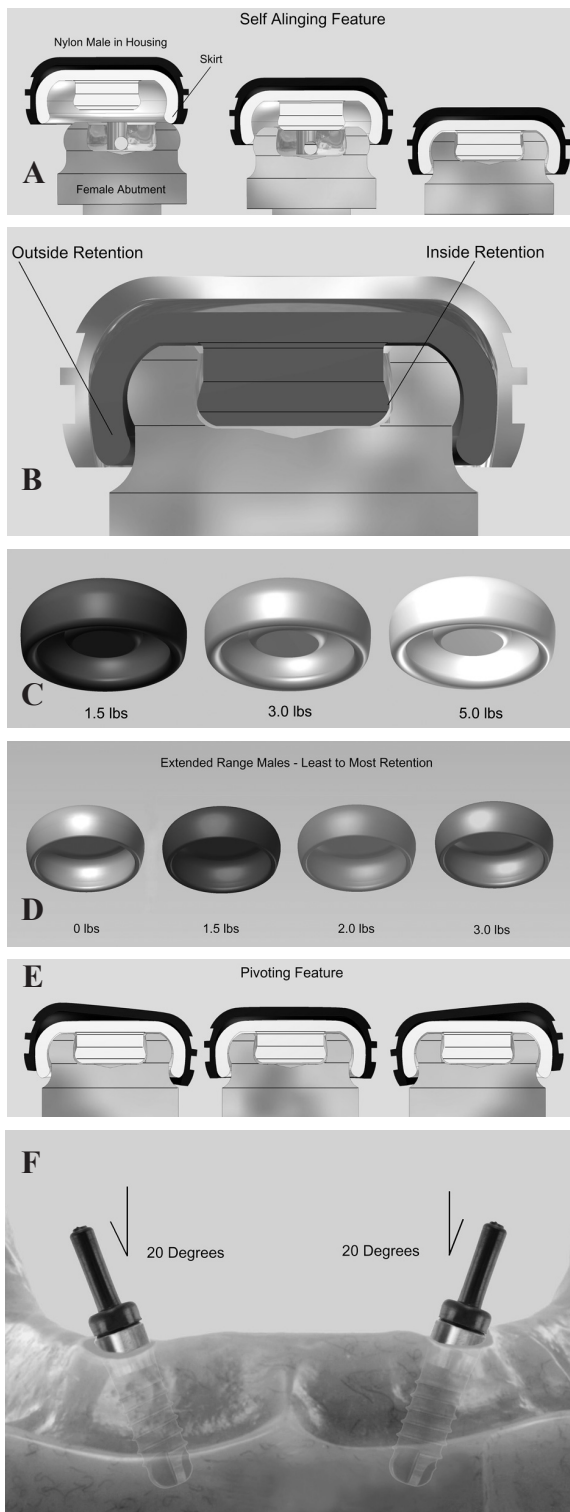
dual retention. The nylon male element engages the inside and the outside contours of the female abutment. (Fig. 2B) This feature doubles the surface area for retentive contact. Cyclic durability and longevity tests have shown that the standard nylon males maintain significant retention for more than 110,000 cycles.²⁷ The standard nylon color-coded males provide from 1.5 to 5 lbs of retention. (Fig. 2C) Gray zero-retention inserts are also available to reduce retention when desired. (Fig. 2D)

Pivoting Feature

Another well-known challenge with overdenture attachments is divergence. Divergence between implants is an all too common cause of excessive wear and may prevent the appliance from seating completely. The Locator® male insert was uniquely designed to pivot within the metal housing upon insertion, removal and mastication. This ability to pivot allows the standard male to accommodate 10° each, for a total of 20° between implants. (Fig. 2E)

To allow for greater divergence between implants, Extended Range males were designed without the center nipple. Tests have shown that this concept allows for a

Figure. 2. (Facing page) Features of the Locator® attachment. **A.** Self-aligning feature. This self-aligning feature also increases the longevity of the Locator® compared to other attachments distorted by misalignment upon insertion; **B.** Locator® dual retention; **C.** Locator® standard inserts; **D.** Nylon male insert is in complete contact with female element as the metal housing pivots during function; **E.** Pivoting feature of the Locator® male attachment; **F.** Maximum of 20° between implants.



divergence of up to 20° each for a total of 40° between implants. (Fig. 2F) Rigorous cyclic testing showed significant retention up to 60,000 insertion/removals at this degree of divergence.²⁷

Resilient Function

An important element in attachment design is resiliency. Resiliency allows movement between the implants and the restoration, transferring stress from the implants to the tissue bearing areas. The pivoting feature, combined with the use of the black processing insert, provides rotational and vertical resilient function to minimize stress transferred to the implants. (Fig. 3A on P. 6)

Vertical Space

A critical consideration when case planning an attachment restoration is vertical space. Adequate space is required to allow room for the attachment and the acrylic/denture tooth over the assembled complete attachment. Selection of an attachment with excessive height can result in a restoration that is over-contoured or has a thin, weak area subject to breakage. The Locator® was designed to have a lower vertical profile compared to other existing attachments. (Fig. 3B on P. 6)

The Locator® metal housing with nylon male inset requires only 2.27 mm above the tissue. The female abutment is only required to extend 1.5 mm above the tissue for the male element to seat without impinging on the tissue. (Fig. 3C on P. 6)

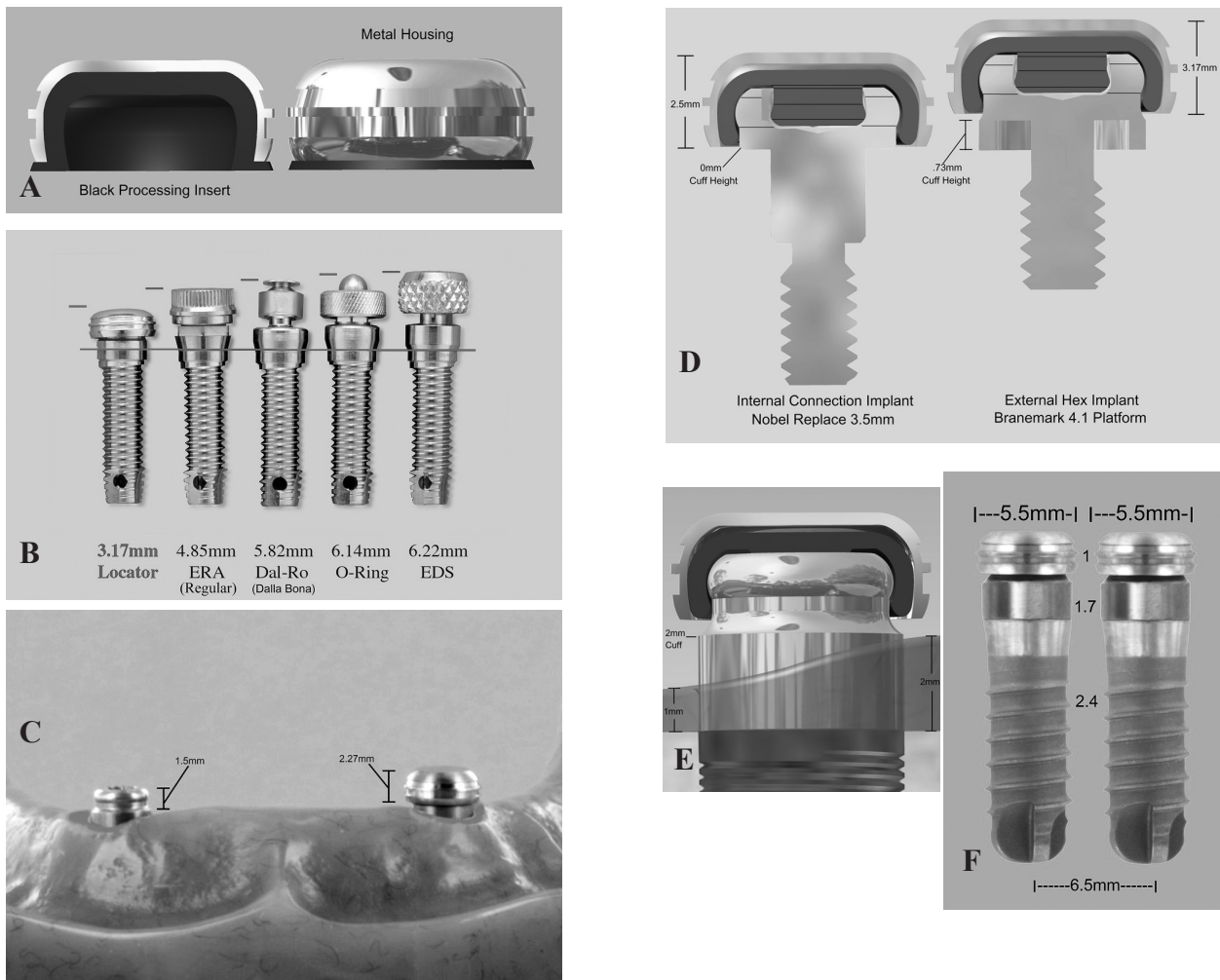


Figure 3. Comparison of heights of implants. **A.** The processing male. Cross-section showing black processing insert (left) and complete male with metal housing (right); **B.** Height of the Locator® attachment compared to other attachments. Overall height is measured from the implant platform to the top of the mating element. Attachments for external hex implants shown; **C.** A denture with the Locator® attachment (left) and with metal housing (right); **D.** Comparison of the overall heights from the implant mating surface of the Nobel Replace Select® and Brånemark implants; **E.** The Nobel Replace Select® implant with a 2 mm female housing; **F.** Dimensions of Locator® implants with housing.

Less than 3.2 mm of interocclusal space is required for the assembled Locator® attachment above the mating surface of externally hexed implants, and as little as 2.5 mm is needed for internal-connection implants. Female abutments of 0 mm are available for many of the internal-connection or flat-top connection implants. The 0 mm Locator® female abutments are indicated

when the implant interface is above or even with the tissue. (Fig. 3D)

Abutment Height Selection

Tissue depth is frequently non-symmetrical at the implant site. Use the deepest measurement between the mating

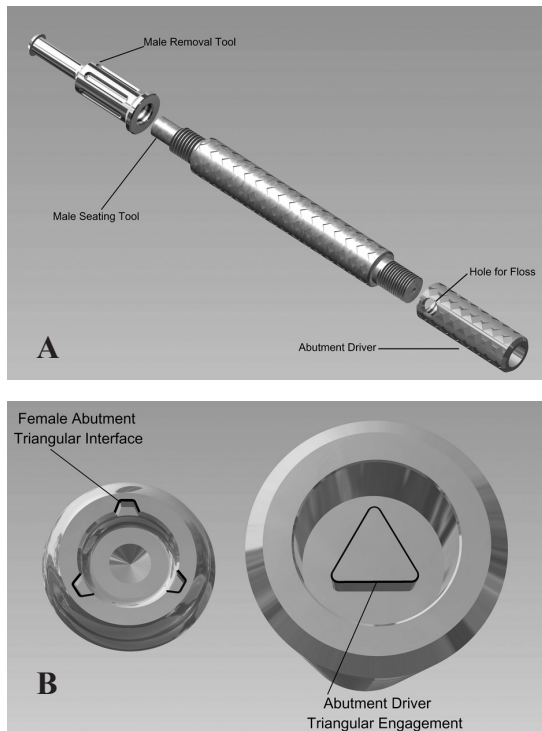
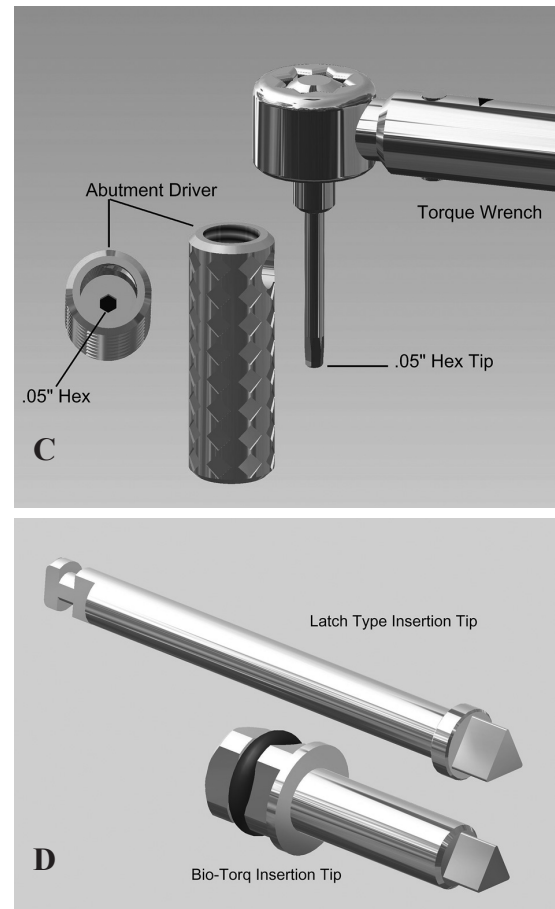


Figure 4. The Locator® tool. **A.** Exploded view of Locator® tool; **B.** Locator® abutment driver and its triangular engagement mechanism; **C.** Locator® tool assembly; **D.** Locator® insertion tips.



surface of the implant and the crest of the gingiva to select cuff and collar height for the female abutment. This method prevents impingement of the tissue by the male housing. (Fig.3E)

Buccal/Lingual – Mesial/Distal Space

Diameter must also be considered. The Locator® metal housings are 5.5 mm wide, and this dimension should be factored in when planning implant site locations. When creating a drilling guide for implants with Locator® abutments the implant centers should be spaced 6.5 mm or more

apart. In the example in Figure 3F, 4.8 mm platform implants would be spaced 1.7 mm or more interproximally. This leaves 1 mm interproximally between the metal housings.

Locator® Core Tool

The three-piece multi-purpose Locator® tool is used to insert the female abutments, remove the processing males (used during the retrofitting step to lock the position of the metal housing inside a denture base) or worn males and insert new nylon males. (Fig.4A) The gold-plated abutment driver has a positive triangle that engages the internal

triangle of the female abutment. (Fig. 4B) The abutment driver is initially used to insert the female abutment with finger pressure. The opposite end of the abutment driver then accepts a .05" hex tip for a torque wrench. (Fig. 4C) Insertion tips are also available for Bio-Torq® and Dyna-Torq® wrenches and for latch-type torque controllers that interface directly with the female abutment. (Fig. 4D)

The abutment retention sleeve is used to secure the female abutment during insertion. The sleeve is placed over the end of the abutment driver and the Locator® female is then placed through the sleeve. (Fig. 5A) To remove processing or worn nylon males, the male removal tool (Fig. 5B) is slightly unscrewed from the middle section of the male removal tool. The inverted conical tip is inserted into the worn male and pulled straight back for removal. The male removal tool is then screwed completely into the middle section to protrude the plunger and kick off the male insert. A new nylon male is placed on the middle male seating section and inserted into the metal housing. (Fig.5C)

Locator® Procedures

Using the Laboratory Indirect Technique

The following steps are used in the laboratory indirect technique with the Locator® overdenture attachment.

- Remove healing caps. (Fig. 6A)
- Measure the tissue depth (deepest point) from the mating surface of the implant to the crest of tissue. (Fig.

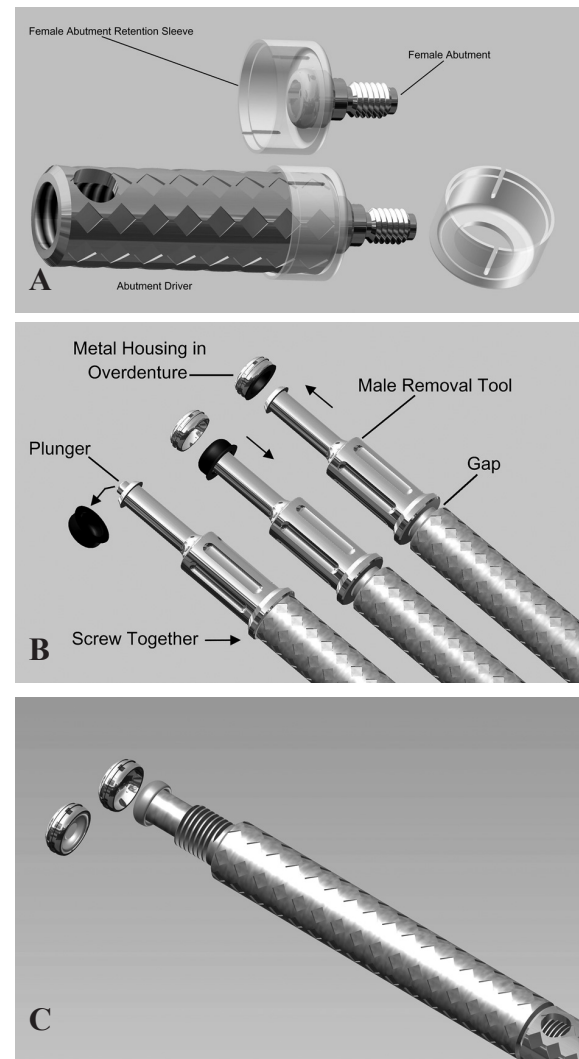
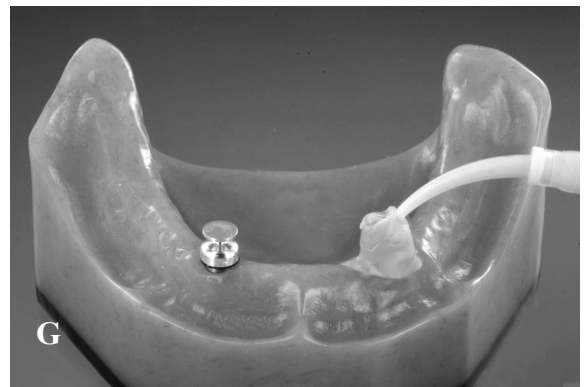
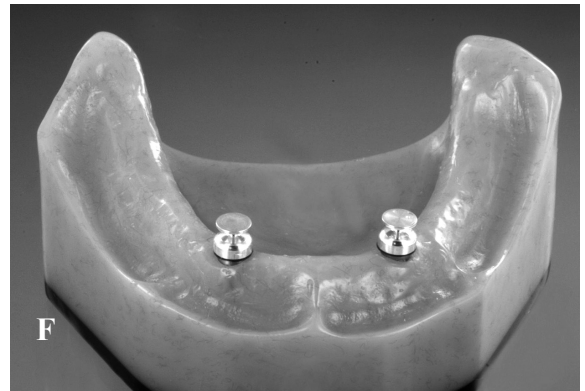
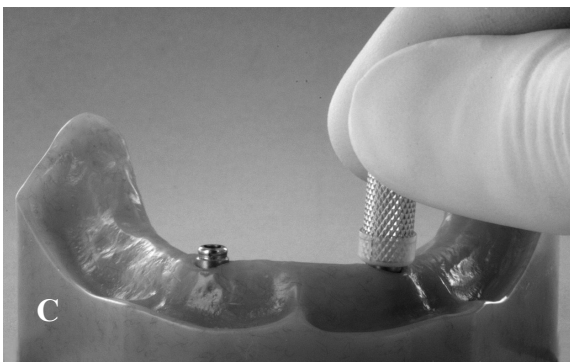
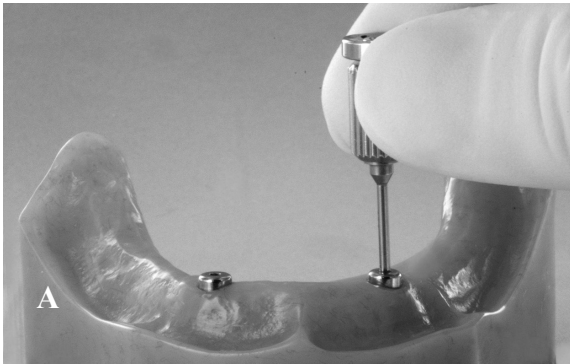
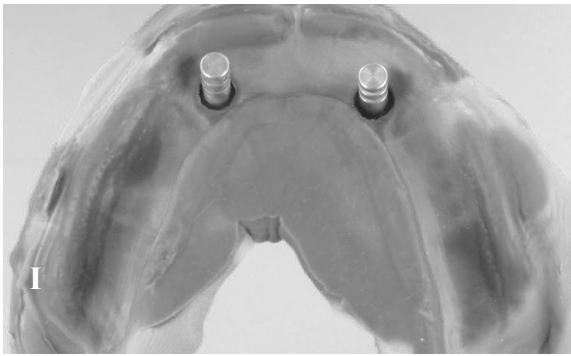


Figure 5. The Locator® insertion and removal tool. **A.** Retaining sleeves for abutment delivery; **B.** Exploded view of Locator® insertion and removal tool; **C.** Inserting a male into the housing.

Figure 6. (Facing page) Placing housings in denture. **A.** Removing the healing caps; **B.** Using a perioprobe to measure thickness of the gum; **C.** Inserting a female abutment; **D.** Applying torque to the female abutment; **E.** Female abutments in place; **F.** Insertion of lab-processing male caps; **G.** Applying PVS impression material over pick-up males; **H.** The pick-up impression; (Continued on P. 10)





I. Lab analogs inserted in the impression; **J.** Working cast with the Locator® model; **K.** Working cast model with the males in the metal housing; **L.** Base plate on the model; **M.** Intaglio surface of base plate with black processing male inserts; **N.** Waxup; **O.** Analogs on the model top.

6B) (Continued on P. 11)

- Insert the female abutment with finger pressure using the gold handle and the clear abutment retention sleeve. (Fig. 6C)
- Torque the female abutments to 30 N/CN with a .05” hex tip. Follow the implant manufacturer’s torque level recommendations. (Figs. 6D, 6E)
- Place the impression males over the female abutments. (Fig. 6F)
- Inject light-body impression material around the impression males. (Fig. 6G)
- Place heavy-body impression material in the stock tray and allowed it to set simultaneously with the light-body material.
- Once it is set, the impression, including the impression males, is removed. Use a Bard-Parker type blade to remove any impression material that is covering the black processing inserts if necessary. (Fig. 6H)
- Securely insert the female abutment analogs into the impression males. (Fig. 6I)
- Fabricate the model with female abutment analogs in place. (Fig. 6J)
- Place metal housings with black processing inserts over the abutment analogs. Use plaster, putty, or latex material to block-out underneath the processing males, if necessary. **Do**

not use the white spacers. (Fig. 6K)

- Create a baseplate that will be used for the bite block and try-in with auto-cure or light-cure resin, incorporating the metal housings. (Figs. 6L, 6M)
- Following the bite registration, try-in the wax-up and complete it for processing. (Fig. 6N)
- Flask the completed wax-up in the usual manner. (Fig 6O)
- To increase adhesion with the acrylic, attach the male metal housings to the female analogs and sandblast. We recommend applying a metal primer to the metal housings prior to acrylic processing if possible.* (Figs. 7A, 7B on P. 12)
- Place the metal housings with black inserts over the female abutment analogs. Use plaster to block-out undercuts if necessary. (Latex may be used for block out with packing or pour systems.) **Note: do not use the white spacers.** (Fig. 7C)
- Once the acrylic is polymerized, finish the denture and use the inverted conical portion of the Locator® tool to remove the black processing male inserts. (Unscrew the top portion slightly to allow the plunger to retract). Then tighten the top portion to the middle section of the tool to remove the processing insert from the tool. (Fig. 7D)
- Place the final males on the top of the middle segment of the tool

*Metal Primer 2 , GC America

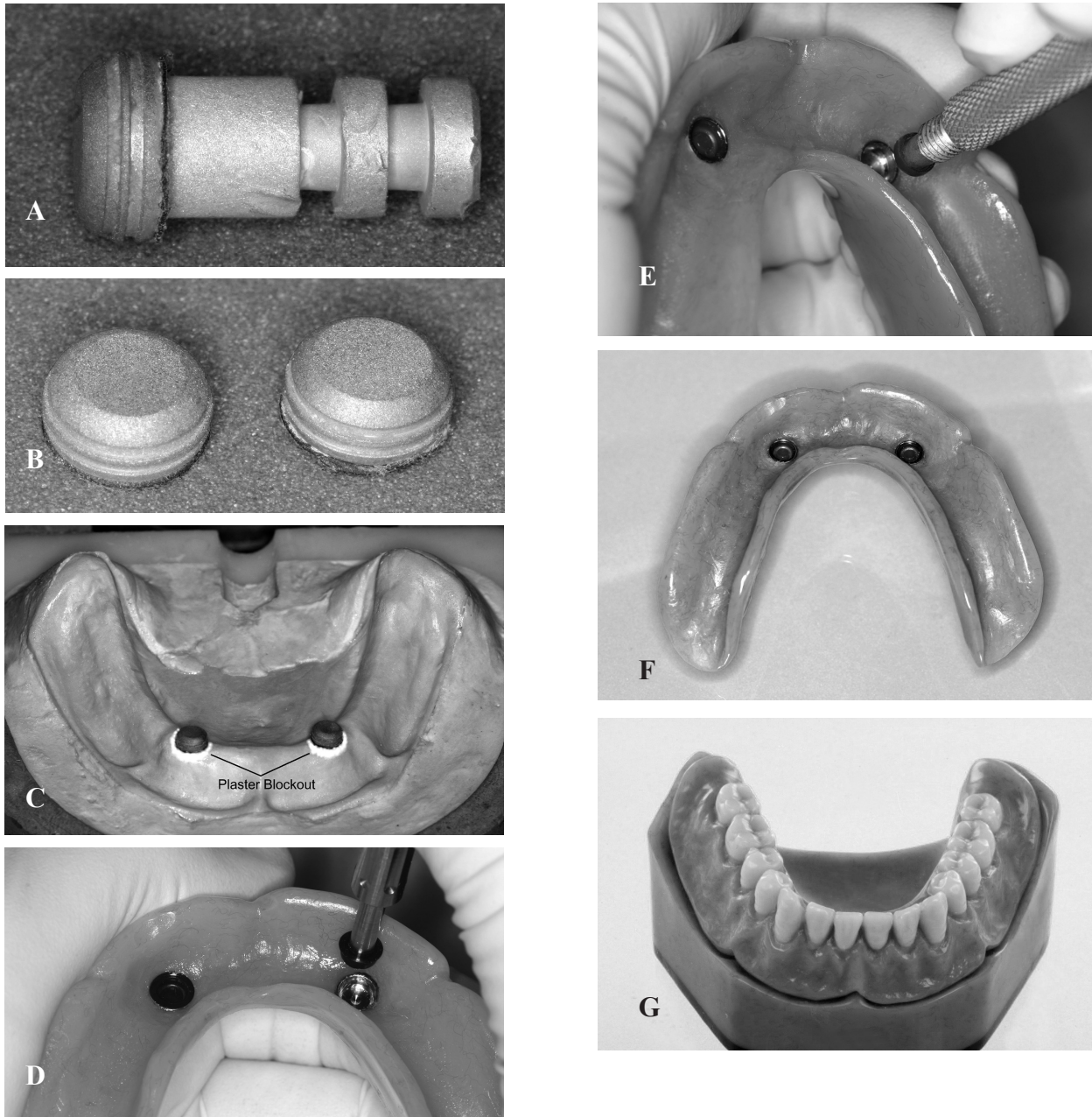


Figure 7. **A & B.** Sand-blasted housings. Side view (A) and caps (B); **C.** Males on analogs during flasking; **D.** Removing black inserts; **E.** Inserting blue males; **F.** Intaglio view of final denture; **G.** Final denture on pink model as delivered to patient.

and insert them into the housings. We recommend beginning with low retention males. (Figs. 7E, 7F) (Continued on P. 13)

- Deliver the definitive overdenture to the patient. (Fig. 7G)

Using the Chair-side Direct Technique with processing spacers

The following steps are the **Direct Technique** used when auto-curing Locator® males at chair-side after using processing spacers in the lab. Processing spacers are available to create ideal space in acrylic for direct auto-polymerizing of male elements at chair side. (Fig. 8A)

- Place the processing spacers onto the Locator® female analogs prior to acrylic processing. If necessary, block-out any gaps under spacers with plaster or putty. (Fig. 8B)
- Process and finish the acrylic in the usual manner. Then remove the processing spacers with the removal tip of the Locator® core tool. (Fig. 8C)
- At chair side, place a white spacer sleeve over a Locator® female abutment. Then place the metal housing with a black insert. If possible, pre-air abrade the metal housings. (Fig. 8D on P. 14)
- If necessary, block-out any gaps beneath the white spacers.
- Create a vent hole lingually to allow expression of excess acrylic. Place a thin mix of auto-cure resin over the metal housing. (Fig. 8E on P. 14)

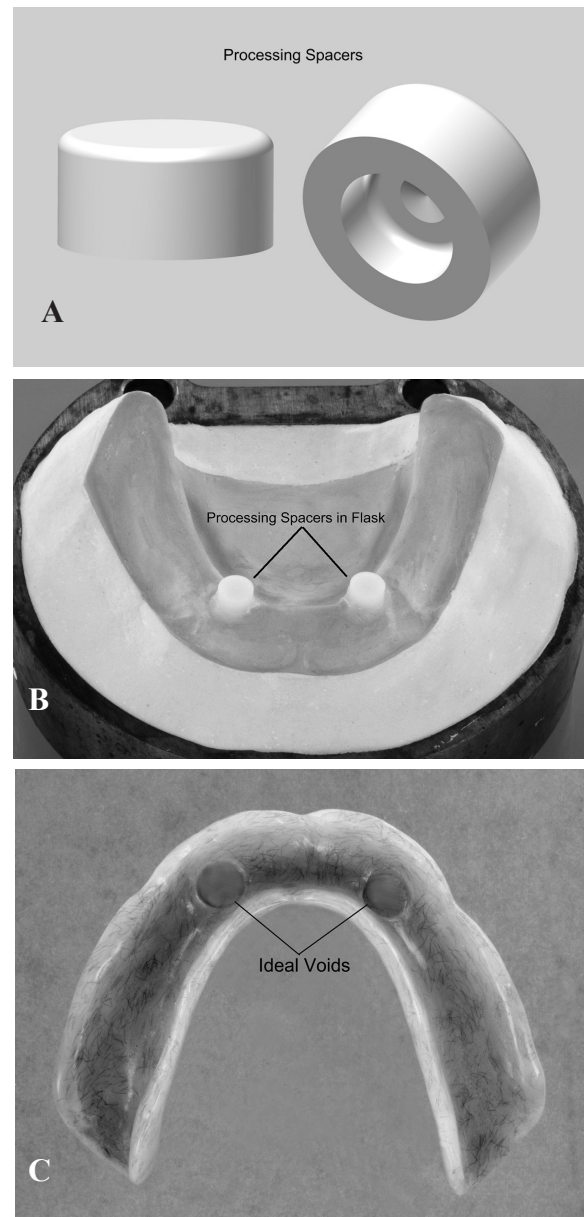
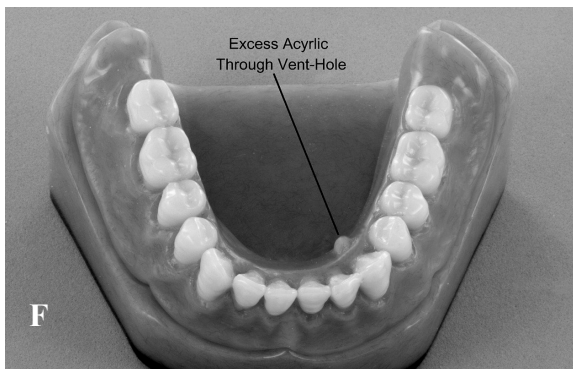
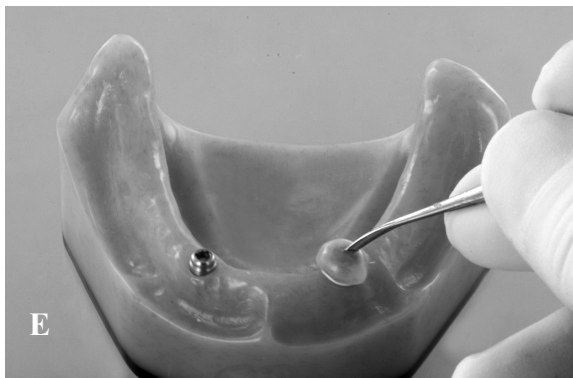


Figure 8. Using processing spacers. **A.** Locator® processing spacers; **B.** Processing spacers in flask; **C.** Inside of denture after using spacers. Ideal voids are created by processing spacers; (Continued on P. 14)

(We recommend doing one at a time.)

- Place a thin mix of acrylic into the void in the denture. Seat the overdenture, and ask the patient to close



D. Metal housing a spacer for self-cure pickup; **E.** Applying self-curing acrylic; **F.** Exiting of self-curing acrylic through lingual hole.

in light centric occlusion, allowing the excess acrylic to express through the

vent hole. Allow the auto-cure resin to fully polymerize before removing the overdenture.

- Add any remaining Locator® housings in a similar manner.
- Finish the lingual of the overdenture, and fill in any voids on the intaglio surface with auto-cure resin. (Fig. 8F)

Direct Technique for Adding Locator Males Without Processing Spacers

Use the following steps to add Locator® males to a finished overdenture that were not processed using processing spacers.

- We recommend making holes through the acrylic to visually verify that adequate space exists around the metal housings and white spacers. We recommend air-abrading the metal housings, if possible. Place the white spacers over the Locator® females, and place the metal housings with black processing inserts. (Figs. 9A, 9B, facing page)
- Prepare a thin mix of auto-cure resin. (Fig. 9C)
- Quickly place the resin over the Locator® metal housings, and ask the patient to close in light centric occlusion until the resin is completely polymerized. (Fig. 9D)
- Once the auto-cure resin is set, remove the overdenture. Finish the lingual aspect of the overdenture, and fill

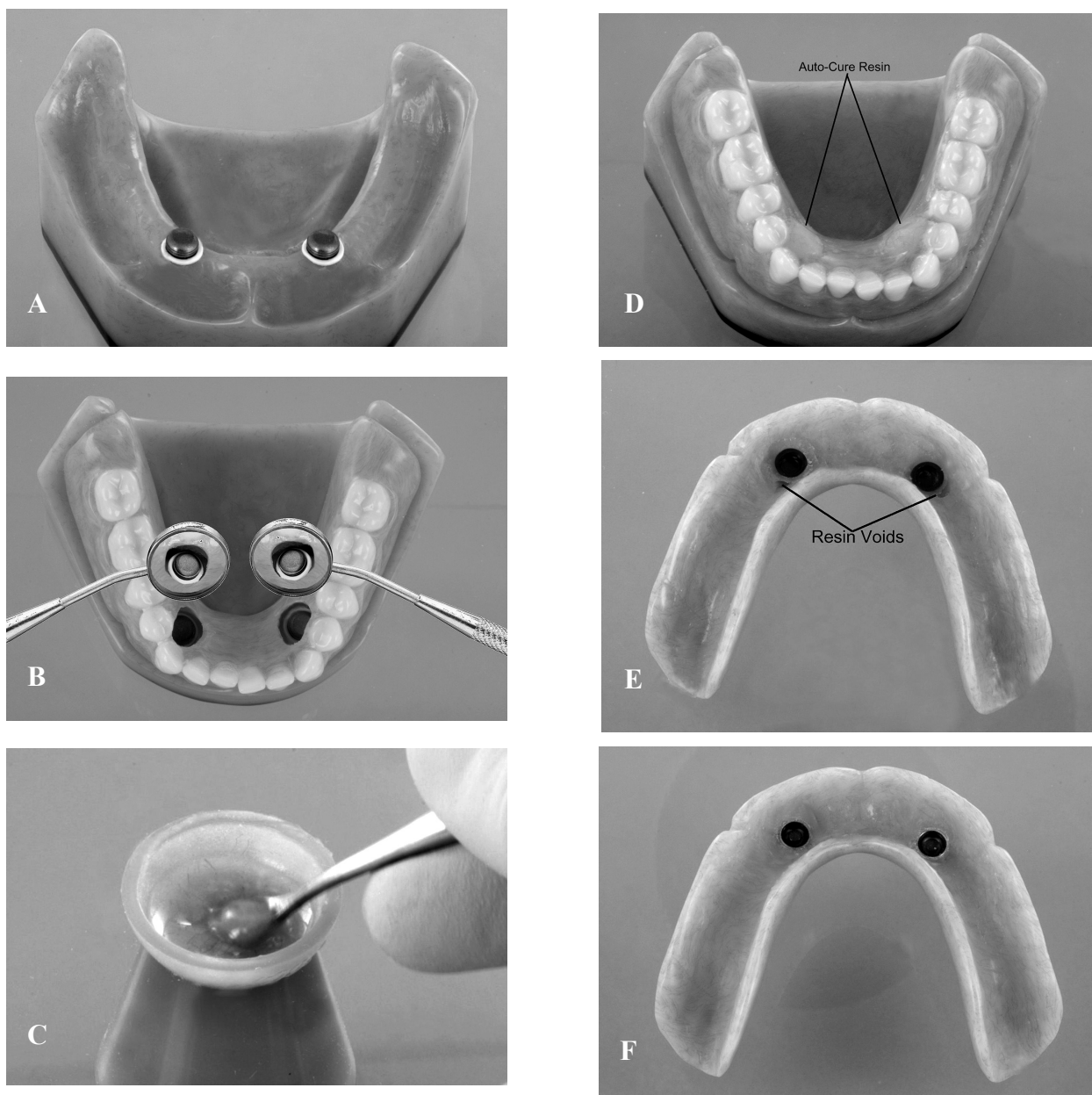


Figure 9. **A.** Two metal housings and spacers with black processing inserts over the white spacers; **B.** A mirror is used for chair-side verification that there is no contact between the metal housings and the denture base; **C.** Mixing self-curing acrylic; **D.** Chair-side repairing of the lingual holes in the denture base; **E.** Voids in the acrylic after pick up; **F.** Lingual side of the final denture ready for delivery with two male Locator® attachments.

in any voids in the acrylic as necessary in the intaglio surface. (Fig. 9E)

- Replace the black processing inserts with the final retentive male inserts. We recommend low retention initially (Fig. 9F)

BAR ATTACHMENTS

Bar Materials

Bar attachments can be prefabricated from type-IV gold, like the original 1.6 mm Dolder® bar.²⁸⁻³⁴ Prefabricated type-IV gold bars should be soldered to the abutments with a low fusing solder. Other types of bars come in castable, pre-milled plastic patterns. These bars are available in 0.2° and 4° for telescopic milled restorations. The bar castings should only be made with hard alloys. A minimum Vickers hardness of 200 and at least 95,000 psi ultimate tensile strength is required. Non-precious alloys are contraindicated for implant reconstruction.

Examples of castable bars are given in Table 4. Bar clips or riders are available in different materials and configurations. The metal clips and riders are fully adjustable. Plastic Hader/EDS clips are non-adjustable,

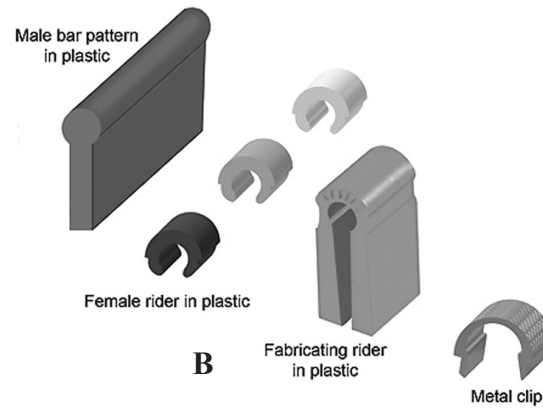
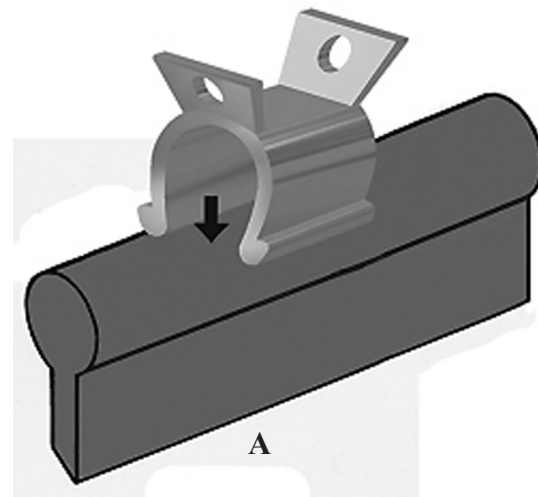
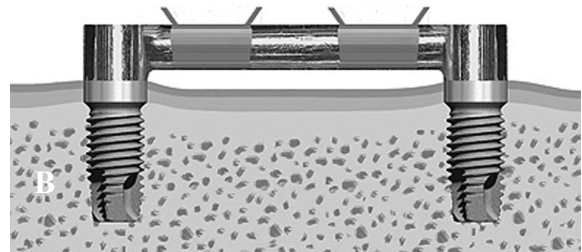
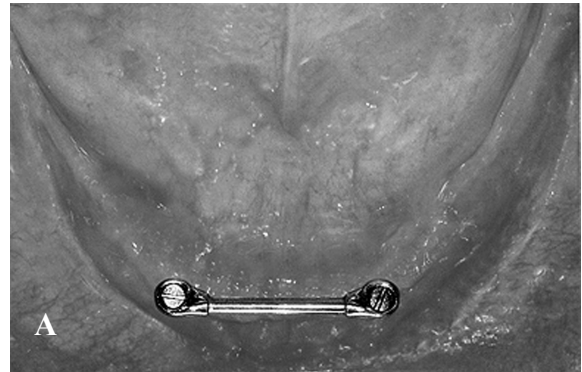
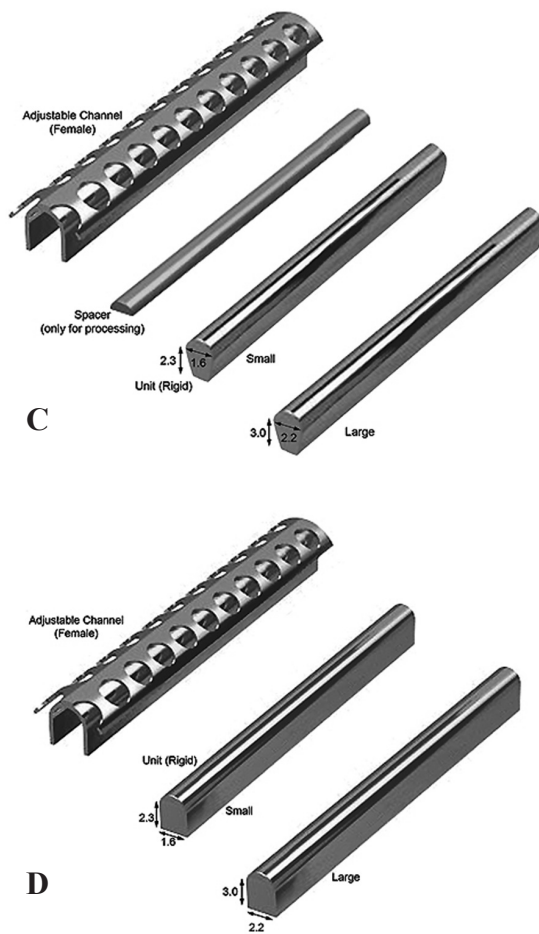


Figure 10. Bars and clips. **A.** Hader bar and clip; **B.** Hader bar complete set; (Continued on facing page) **C.** Resilient Dolder® bar; **D.** Rigid Dolder® bar.

TABLE 4: EXAMPLES OF CASTABLE BARS
Round bar
Plastic Dolder®
I-bar
EDS bar
Hader bar

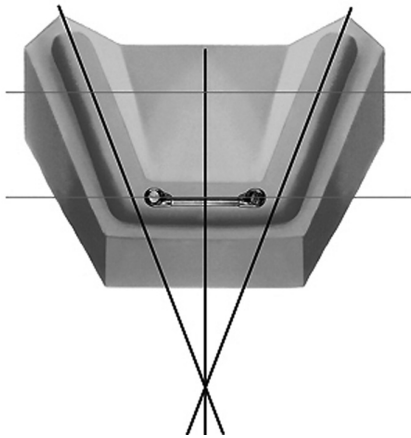
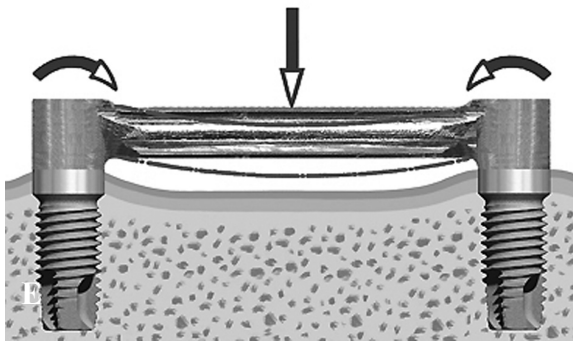
TABLE 5: FACTORS THAT INFLUENCE THE FLEXIBILITY OF THE BAR
Length of the bar between the two implants
Number of implants that support the bar
Height of the bar
Physical property of the alloy
Magnitude of the masticatory load



but they can easily be replaced at chair side. We strongly recommended using a metal housing with Hader/EDS plastic clips.

Bar attachments can be classified by their cross-sectional shape as round (Figs. 10A, 10B), egg-shaped (Fig. 10C), and parallel-sided U-shaped (Fig. 10D). Bars that are resilient, providing vertical resiliency, hinge resiliency or both, are termed **bar joints**. (Fig. 10C) Bars that are non-resilient are termed **bar units**. (Fig. 10D) Factors that influence the flexibility of the bar are listed in Table 5.

Figure 11. Examples of bar lengths and orientation. **A.** Perfect bar length and position; **B.** Ideal bar length with two clips; **C.** A short bar; **D.** A very long bar which will interfere with tongue space; (Continued on P. 18)



E. A long bar with a risk of bending; F. A diagonally oriented bar; G. Ideal bar orientation.

FUNDAMENTALS OF BAR ARRANGEMENT

Distance Between Implants

As a general rule, if a single bar is utilized, the ideal length would be 20 mm to

TABLE 6: FACTORS INFLUENCING DISTANCE BETWEEN IMPLANTS

Size and curvature of the mandibular arch
Type of attachment assembly

22 mm to accommodate two clips or riders. This will place the centers of the implants 24 mm to 26 mm apart if standard diameter 4 mm implants are being used. (Fig. 11A, 11B) If two implants are too close together a short bar cannot provide enough retention and stability for the overdenture. (Fig. 11C) Factors influencing the distance between implants are listed in Table 6.

If the implants are placed too far distally, not only will a long straight-line bar interfere with the tongue space and create problems in fabricating the prosthesis, but it will also be at risk of bending. (Figs. 11D, 11E) If the bar is positioned diagonally, it will not allow friction-free anterior hinge movement of the prosthesis. This condition creates excessive torsional loading on the supporting implants. (Fig. 11F) As a general rule, the bar should be perpendicular to the line that bisects the angle formed by the two posterior mandibular arch segments. (Fig. 11G)

Vertical Relationship of Bar to the Alveolar Ridge

A wide gap of 2 mm or more between the bottom of the bar and the soft tissue will allow easy passage of saliva and food particles as well as cleaning tools. (Fig. 12A) Hygiene maintenance in this situation is very easy. A small gap of 1 mm or less between the bottom of the bar and the soft tissue will cause plaque and calculus accumulation,

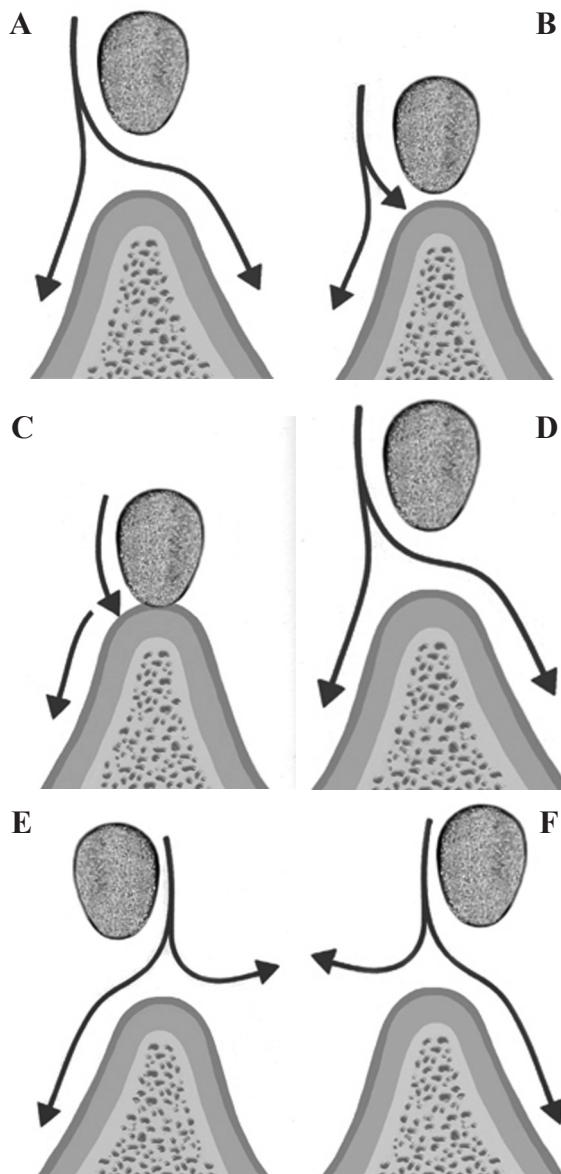


Figure 12. Graphic examples of bar position and resulting spaces. **A.** A large gap between the bar and gum; **B.** A small gap between the bar and gum; **C.** Bar pressing on gum; **D.** Bar perfectly placed above ridge; **E.** Bar lingual to ridge; **F.** Bar labial to ridge.

making oral hygiene maintenance very difficult to perform. (Fig. 12B) Compression of the mucosa by the bar will cause hyperplasia of the gum. (Fig. 12C) It will also be impossible to clean underneath the bar. To

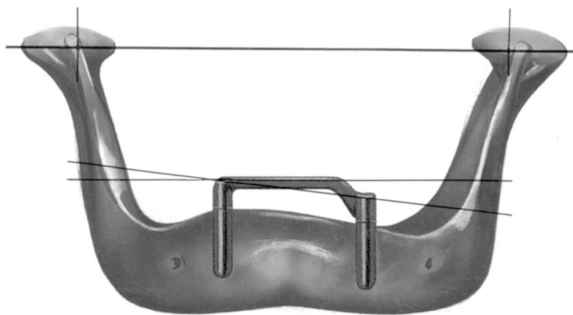
solve this problem the bar should be replaced or modified.

Sagittal Relationship of the Bar to the Alveolar Ridge

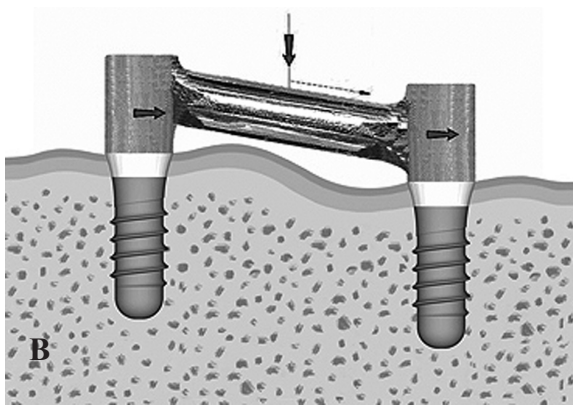
The bar should be positioned directly above the crest of the ridge. (Fig. 12D) This position makes it easy to clean the bar and fabricate the prosthesis above the bar. If the bar is positioned lingual to the crest of the ridge, it will interfere with the tongue space, impeding function and speech. This problem is common in patients with a narrow and pointed alveolar ridge. One way to prevent this situation is to relocate the bar further anteriorly. Another solution is to use individual attachments. (Fig. 12E) If the bar is positioned labial to the crest of the ridge, it will interfere with lip support. Both labial and lingual scenarios will make fabrication of the prosthesis very difficult. (Fig. 12F)

Sagittal Relationship of the Bar to the Hinge Axis

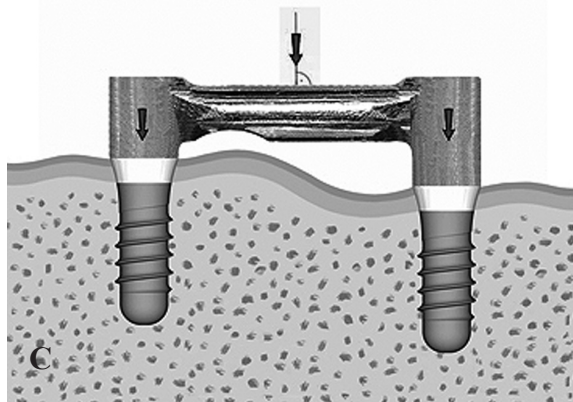
Ideally, the anterior bar in the edentulous mandible should be parallel to the hinge axis. (Fig. 13A) However, this relationship should be considered another reference for better positioning of the bar, because this orientation can't be achieved in every case. Many clinicians have followed this rule, but as mentioned earlier, no studies have supported this claim. One long-term study (5-15 years) analyzed the influence of placing the bar parallel to the hinge axis on peri-implant parameters, including the clinical attachment level.³⁵ The outcome of splinted versus unsplinted attachment was also assessed. No significant correlations were found.



A



B



C

Figure 13. Graphic representations of relationship of bar to hinge axis. **A.** Summary of relationship of bar to hinge axis; **B.** A tilted bar; **C.** A modified bar.



Figure 14. AP spread.

Sometimes the anatomical shape of the alveolar ridge will not allow the surgeon to position the implants with the bar parallel to the hinge axis. In this situation, the lab technician and restorative doctor can modify the bar design to achieve this goal. (Figs. 13B, 13C, on P. 20)

The Anterior-Posterior Distance Rule

The Anterior-posterior Distance Rule is good for determining the distal cantilever extension of the bar or distal extension of the hybrid (fixed detachable) prosthesis from the most posterior implants. (Fig. 14)

- Draw a line through the center of the most posterior implants on each side of the arch.
- Draw another line through the center of the most anterior implants on each side of the arch.
- The distance between these two lines is the anterior-posterior spread (A-P distance).
- Generally, the distal cantilever should not exceed one and a half times

the A-P distance.

If the patient has a small mandible, with limited room for four implants, putting the distal implants as far back as possible distal to the mental nerve can enhance the A-P distance. In addition, the anterior implants should be brought forward as far as possible. These steps will improve the A-P distance to ensure that the basic biomechanical rules of avoiding an excessive cantilever, minimizing lateral forces on the supporting implant, and maximizing compressive forces, are not violated. The maximum cantilever in these cases is generally 8 mm to 12 mm.

If the patient has a square arch, the implants will be in a straight line in the anterior segment of the mandible. In this situation, any cantilever design must be avoided because the A-P distance will be small or non-existent. We suggest resilient bar assemblies for these patients. The prosthesis should be implant- and tissue-borne so that the buccal shelf and retromolar pad will each receive a share of the occlusal load. To minimize the compressive load on the bar, the denture base can be relieved in the area over the distal extensions.

Guidelines for Denture Base Extension

For mainly tissue-supported implant overdentures, the anterior borders of the overdenture should not extend to the end of the sulcus. There should be minimum extension in the anterior region but maximum extension in stress bearing areas such as the buccal shelves. The denture base should extend distally onto the retromolar pads and

lingually onto the mylohyoid ridge.

For tissue-implant-supported overdentures the borders of the overdenture are significantly shorter than in conventional dentures; however, they can't be eliminated because this type of prosthesis is still partially tissue-supported. For fully implant-supported overdentures flanges can be eliminated because the prosthesis is completely implant-borne.

Hader Bar

In 1973, Helmut Hader, master technician and dental manufacturer, developed a unique attachment system that even today is mainly known in the USA as the Hader bar or the Hader vertical. The Hader bar is a semi-precision bar attachment that provides hinge movement as long as a single Hader bar has been utilized in the attachment assembly design. This function of this bar is based on the mechanical snap-retention concept. (Figs. 15A, 15B, on P. 22)

There are three color-coded clips/riders with three retentive strengths. In order, from lightest to strongest, they are white, yellow and red. We strongly recommend using a metal housing with Hader plastic clips/riders. In addition to plastic clips/riders, the adjustable gold alloy clips/riders are an available option. (Figs. 15C, 15D)

Hader Clip Placement

Hader clips can wear out prematurely due to improper bar design and overloading. The denture base should sufficiently contact

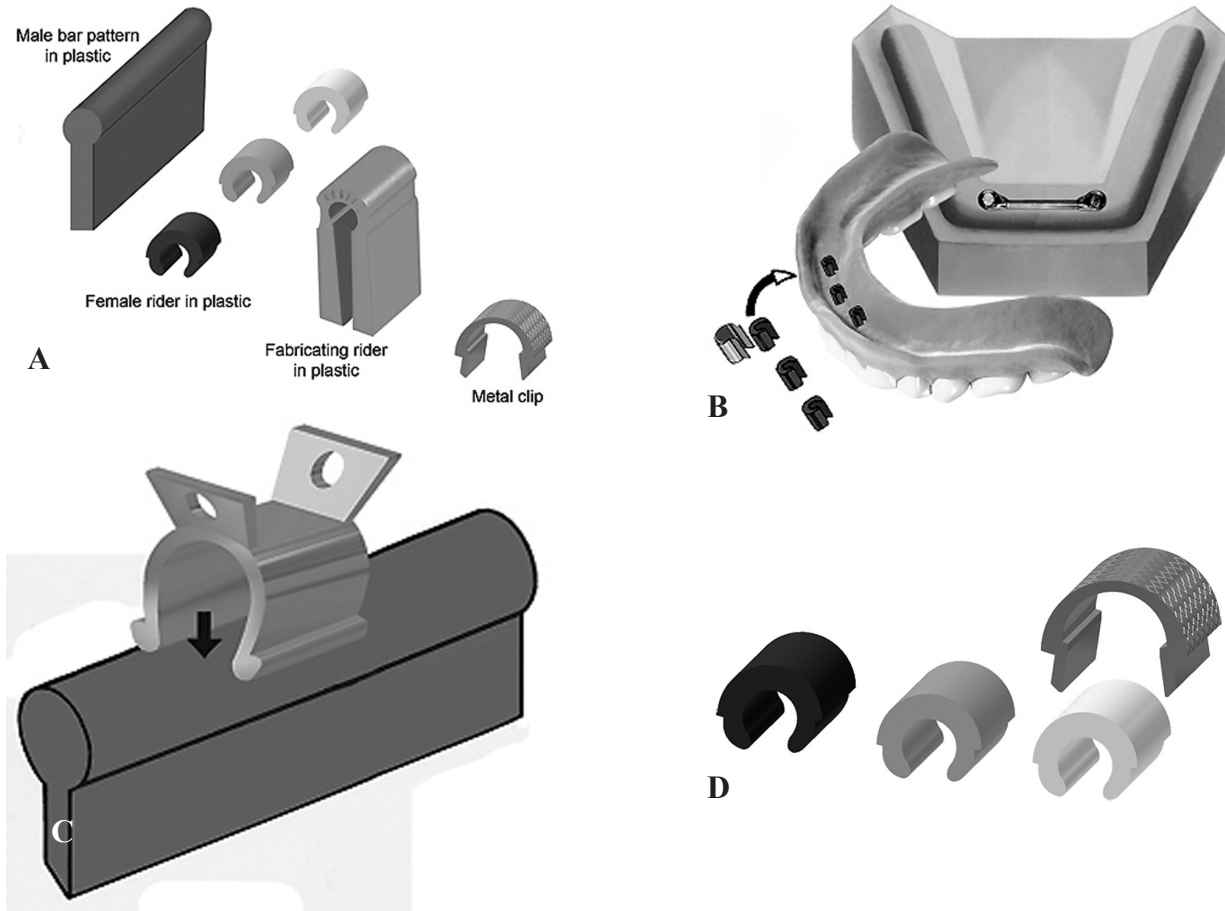


Figure 15. The Hader bar **A**. The Hader bar kit; **B**. The Hader bar in a denture; **C**. The Hader bar and clip; **D**. Different clips and housings.

the top of the bar and avoid concentrating force on the clips. To achieve this contact, the denture base should be relined precisely. Hader clips can be replaced chair side using the following steps.

- Remove the worn clip with a hand instrument. The clip usually comes out very cleanly and in one piece.
- Place a new Hader clip on the insertion tool.

- Place the clip into the undercut area of the recipient site and gently roll until it snaps into place. **Note: Do not push straight down into the recipient site because clip insertion has a rotational path.**

- The clips should hold their properties for at least 6 to 9 months if they are well designed.

Plastic Hader versus Metal Clips

TABLE 7: ADVANTAGES AND DISADVANTAGES OF METAL CLIPS
ADVANTAGES
Metal clips have more wear resistance compared to plastic clips
The bar dimensions can be smaller with metal clips
DISADVANTAGES
To replace a metal clip, it has to be cut of the denture base with a bur
Metal clips do not come out as cleanly as plastic clips
Metal clips require chair-side pickup with self-cure acrylic

TABLE 8: TROUBLE SHOOTING FOR BAR ATTACHMENT ASSEMBLY		
PROBLEM	POSSIBLE REASON	SOLUTION
Failure in achieve a one-piece casting of the bar and abutments	Plastic bar pattern was not connected well to the abutments with wax, or the connection broke loose during investing.	Use adequate wax to connect plastic bar to abutments. Invest carefully without excessive vibration.
Failure to the plastic riders to stay in the receptacle in the acrylic denture base	The laboratory clips/rider were placed over the bar prior to raking the impression rather than the actual retentive clips/riders, causing the gingival extension of the laboratory clips/riders to expand and cause an oversized receptacle to be processed in the resin.	Position the actual clips/riders, not the laboratory clips/riders, on the cast bar prior to taking the impression for the duplicate processing cast.
Insufficient retention of the plastic clips/rider on the bar	a) The round bar was reduced in diameter due to over finishing and polishing. b) The plastic clips/riders are worn.	a) Do not use stones or rubber wheels on the round bar when finishing; i.e., polish only. b) Replace plastic clips/riders, or use gold alloy clips/riders that have retention adjustment capability/
The prosthesis is difficult to insert and remove	a) The plastic retention clips/riders have been processed into the resin incorrectly. The denture acrylic base is preventing the flanges of the clips/riders from flexing. b) The prosthesis was designed to engage a severe labial undercut. This causes the prosthesis to be positioned labially at time of insertion, thus the plastic clips/riders are not properly aligned to snap on to the bar.	a) Use rebasing procedure to replace clips/riders. b) Remove from the prosthesis the labial flange area that engages the severe undercut

TABLE 9: DOLDER® BARS ARE AVAILABLE IN LARGE AND SMALL SIZES					
DIMENSIONAL SPECIFICATIONS					
TYPE	HEIGHT	WIDTH	LENGTH	C o m b i n e d Height of Bar and Sleeve	Outside width of sleeve wings
Small bar unit	2.3 mm	1.6 mm	3 cm or 5 cm	2.8 mm	3.5 mm
Large bar unit	3.0 mm	2.2 mm	3 cm or 5 cm	3.5 mm	4.5 mm
Small bar unit	2.3 mm	1.6 mm	3 cm or 5 cm	3.5 mm	3.5 mm
Large bar unit	3.0 mm	2.2 mm	3 cm or 5 cm	4.5 mm	4.5 mm

The advantages and disadvantages of metal clips are listed in Table 7. Trouble shooting steps for the bar attachment assembly are listed in Table 8.

Dolder® bar

The Dolder® bar is a prefabricated precision bar attachment developed by Dr. Eugen Dolder in Switzerland. (Continued on P. 24)The Dolder® bar comes in two forms. The rigid form is U-shaped with parallel walls, and is also called a **bar unit**. (Fig. 20C) The resilient form is egg-shaped in cross-section and provides both vertical and hinge resiliency. The resilient Dolder® bar is also called a **bar joint**. (Fig. 10D)

The Dolder® bar and its sleeve are made of gold alloy (Elitor®). The Dolder® bar is adjustable so the clinician can control the amount of retention provided by the bar. The Dolder® bar should be soldered to the abutments and the sleeve should be secured in the denture base with self-cure acrylic. The various sizes of available Dolder® bars are listed in Table 9 and are shown in Figures 10C and 10D. Indications and contraindications for using the Dolder® bar are listed in Table

TABLE 10: INDICATIONS AND CONTRAINDICATIONS FOR USING THE DOLDER® BAR
INDICATIONS
Overdenture patients with adequate or relatively large inter-ridge space
When minimum resiliency and maximum retention from a removable denture is expected, the Dolder® bar is the attachment of choice.
CONTRAINDICATIONS
Patients with minimum inter-ridge space
Patients with poor compliance in maintenance and oral hygiene
Patients with financial limitations

10.

Relining an Overdenture with a Dolder® bar

For the unit attachment assembly:

- Fill the sleeve with petroleum jelly and take the final impression. Place the processing jig in the sleeve in the impression and pour the model. Reline

the prosthesis with the usual technique.

- **Note: Dolder® bar matrix must cover the entire length of the bar.** This will maximize the absorption of horizontal forces.

For the joint attachment assembly:

- Use sticky wax to secure the spacer wire in the sleeve and fill the sleeve with petroleum jelly.
- Take the final impression.
- Place the processing jig into the sleeve in the impression and pour the model. Reline the prosthesis with the usual technique and remove the spacer wire before delivery.
- **Note: Always insert the spacer between the matrix and the Dolder® bar joint before incorporating the matrix into the denture base.** This will ensure the vertical resiliency of the overdenture.

OVERDENTURE IMPLANTS

In recent years, a new generation of dental implants, called overdenture implants, has been introduced to the field of implantology.^{4,36-43} Currently, there are several different types of these implants available on the market. The main design difference between overdenture implants and traditional implants is that a part of the stud attachment, either male (Fig. 16A, 16B) or female (Fig. 16C) (depending on the manufacture), has been combined with the implant body. In traditional restorative

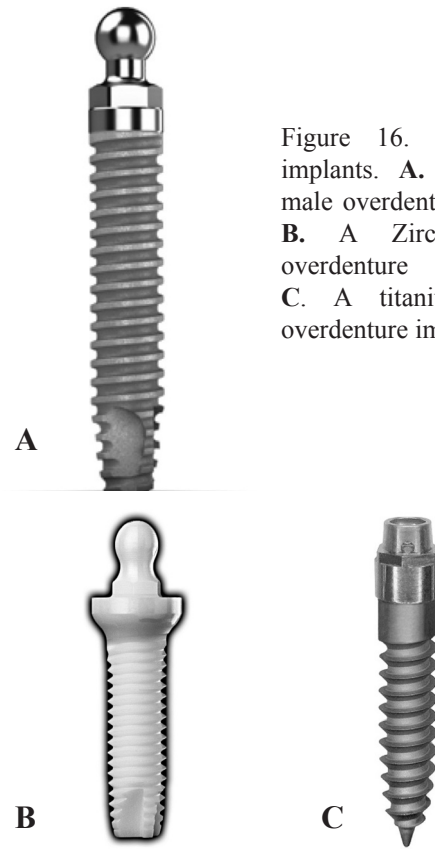


Figure 16. Overdenture implants. **A.** A titanium male overdenture implant; **B.** A Zirconia male overdenture implant; **C.** A titanium female overdenture implant.

implants, the stud attachment would be screwed into the implant body as a separate component.

Overdenture implants are available in different diameters and lengths. Based on FDA guidelines, any overdenture implant which has a 3 mm or more diameter can be considered as a permanent implant; any overdenture implant which is less than 3 mm in diameter should be considered a transitional implant. The latter can be used for denture stabilization but not as a permanent implant.

Classification of Overdenture Implants Based on Attachment Design Features

Implants With a Male Attachment

The OS™ (Biohorizons, Birmingham, AL; biohorizons.com) is a parallel sided implant, and the male part of the stud attachment is part of the implant body. The MDI ® Implant (3M ESPE; solutions3m.com) is tapered. The Z-Look3 Lock Ball implant (Z-systems USA, Inc., Halifax, MA; usa@z-systems.biz). This is an all Zirconia overdenture implant.

Implants With a Female Attachment

The ERA® implant (Zimmer Dental, Inc; www.zimmerdental.com) is a tapered implant and the female part of the stud attachment is part of the implant body.

These types of implants make implant overdenture treatment more cost-effective and simpler. They are narrower than most narrow-diameter traditional implants, so they can be used in cases with a deficiency in the width of the bone, avoiding a horizontal bone augmentation procedure.

Overdenture implants are used for two basic purposes: providing immediate stabilization and anchorage for an implant overdenture and acting as transitional implants during the initial healing phase of traditional implants. Although the FDA has never approved a dental implant under 3.0 mm in diameter for permanent use, overdenture implants are often used as a less expensive and simpler alternative to traditional implants for stabilizing an overdenture over a longer period

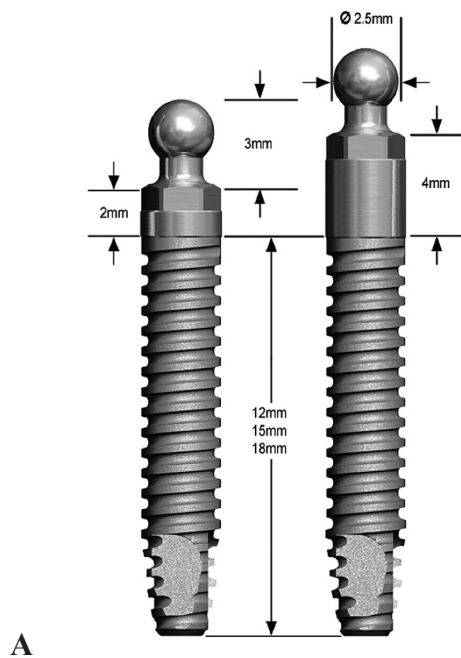
of time. However, we strongly recommend utilizing overdenture implants that are 3 mm or more in diameter. Placement of 3 mm or wider implants should be limited to the anterior mandible between the two mental foramina unless the patient has no bone loss in the posterior region.

When transitional implants are needed, using permanent overdenture implants is contraindicated. Use only mini-overdenture implants for this clinical scenario because their small size allows them to be placed between traditional implants. They often fit best if placed slightly lingual to traditional implants.

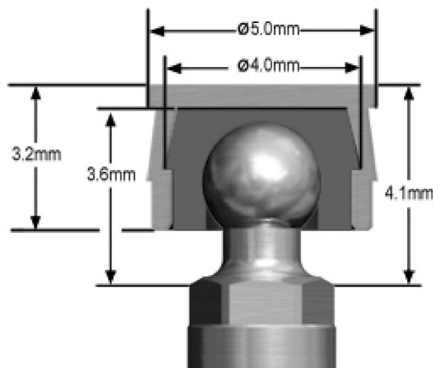
If bone augmentation is part of the treatment plan, overdenture implants provide a positive vertical stop and lateral stability to limit the force applied to the augmented area. This procedure greatly improves the success of new bone growth and limits the amount of force applied to the traditional implants.

After completion of the healing period for traditional implants, the overdenture implants have served their transitional purpose and should be unscrewed. The resulting small bony defects usually heal with no further treatment. With this treatment scenario, we strongly recommend using a machined surface instead of advanced surfaces, such as acid-etched or resorbable blast textured (RBT), because these latter surfaces enhance implant-bone interface, making implant removal more difficult than with a machined surface.

The surgical procedure for overdenture implants usually consists of only a few simple steps. However, the same anatomical and



A



B

surgical considerations one would apply to implant surgery utilizing traditional implants still apply here. More detail information about the two different types of permanent overdenture implants follows.

The OS Overdenture Implant

The OS overdenture implant is a 3.0 mm

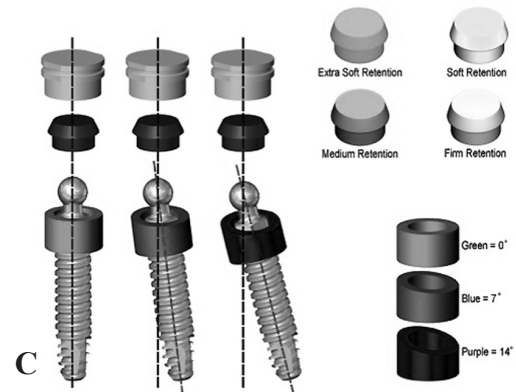


Figure 17. The OS overdenture implant. **A.** Dimensions of the OS implant; **B.** Dimensions of the OS cap; **C.** The OS implant kit.

diameter implant made of titanium alloy. A 2.5 mm ball attachment has been added to the implant body. This implant is available with two different gingival cuff heights (2.0 mm and 4.0mm) and three different lengths (12.0 mm, 15.0 mm, and 18.0 mm). (Figs. 17A, 17B)

A number of unique features are associated with this implant. Its square-thread pattern provides better force distribution and stability than traditional V-shaped treads. The surface of this implant has been blasted with an apatitic blast medium such as (tri-calcium phosphate) to create a surface roughness, and then the surface has been cleaned and passivated with acid solution to produce the RBT surface. The female component is available in four different retention levels from softest to firmest (Green: extra soft retention, Yellow: Soft retention, Pink: medium retention, White: firm retention) (Fig. 17C) Having a parallel body provides more surface area compared to a tapered implant with a similar length and diameter. However, its apical

portion is tapered, enhancing penetration in the bone and faster stabilization.

Clinical Considerations Regarding the OS Overdenture Implant

Always start with the least retentive female attachment during the initial healing phase to minimize the chance of jeopardizing the initial stability of supporting implants. After eight weeks, one can switch to more retentive female attachments.

If the implants have been placed in Type-III bone (such as a maxillary overdenture case) or if the implants' primary stability is not optimum, avoid utilizing the female attachments on the day of implant placement. Instead mark the location of the implant heads inside the denture and relief the acrylic base in those areas. Then relin the inside of the denture with tissue conditioner for the first two weeks, replace the tissue conditioner with a soft liner starting on week three, and keep the soft liner until end of week eight. Utilize the female attachments eight weeks after implant placement.

OS implants should always be utilized with a well-fitting denture and accurate occlusion.

Avoid utilizing the OS as a transitional implant because its RBT surface characteristics will cause an expansive implant bone interface, making it very difficult to unscrew the implant without leaving a large bony defect and risking implant fracture during the unscrewing process.

A minimum of four OS implants should be used for a lower-implant overdenture, if the bone quality is ideal. With poorer bone

quality we recommend five or six implants.

The OS implants should all be placed perfectly parallel to each other. We strongly recommend utilization of a paralleling device or an accurate surgical guide. (See SROMS Vol. 17, #2; Vol. 17, #3 & 4; Vol. 17, #6) The maximum correctable discrepancy in the trajectory of each implant from the sagittal plane is 14°. A proper directional ring can be used to offset a discrepancy of 14° or less. There are three directional rings available with the Maximus® OS: 0°, 7°, and 14°.

The implants should be placed at least 6 mm apart from center to center. However, to simplify the implant spacing, the distance between the two mental nerve loops can be divided into five equal columns. Then, when placing five implants, one implant can be placed in the center of each column. When placing four implants, skip the middle column and place one implant in each side column. (Fig. 18)

Prosthetic Steps With the OS Overdenture Implant

Chair-side Utilization Procedures

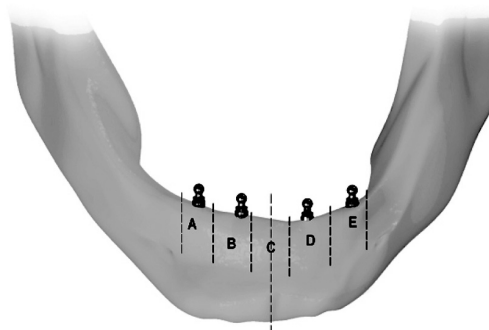


Figure 18. Distribution of implants between two foramina.

- Use directional pins to determine the relation of supporting implants with each other. Snap the 0° directional pin (i.e. reference pin) that has the best trajectory relative to the ideal path of insertion for the overdenture onto the implant.

- Use that implant as a guide to choose the directional pins that will be parallel to the reference pin. There are three color-coded directional pins similar to the directional rings. (Fig. 19A)

- After achieving parallelism of all of the directional pins choose the appropriate directional rings based on the color of the selected directional pins.

- If none of the implants are positioned in the correct path of insertion, make a pick-up impression and a master cast. Then use a surveyor to determine the discrepancy among the trajectory of the supporting implants.

- After choosing the proper directional rings, snap a metal housing that has been pre-loaded with a black female positioning cap onto each ball attachment. **Note: The directional ring covers all of the undercuts.**

- However, if a flap surgery has been performed and the tissue has been sutured, we recommend using a rubber dam to protect the sutures. Cut a small square of the rubber dam (½ inch X ½ inch) and punch a small hole in the middle of the square. The ball attachment and the hex of the implant should pass through the rubber dam hole. Make sure the rubber dam seats

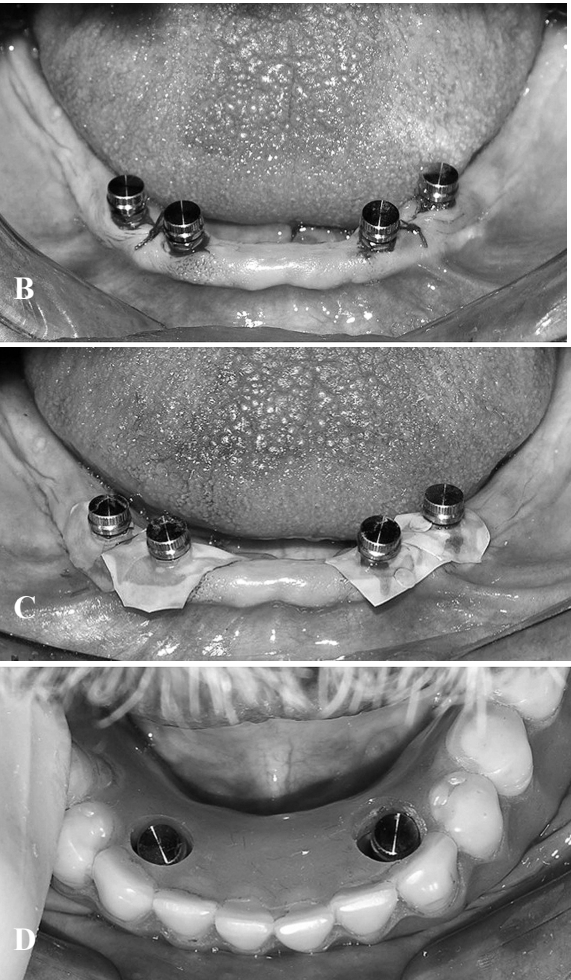
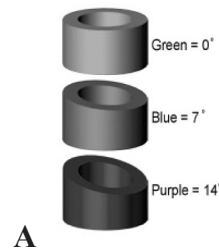
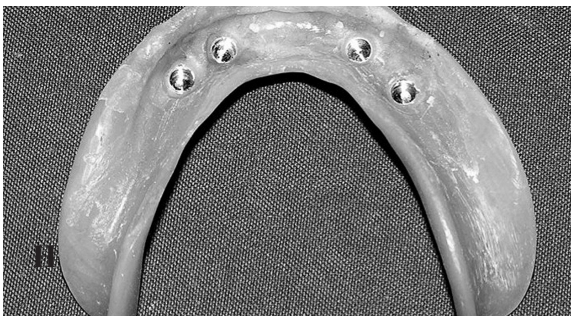
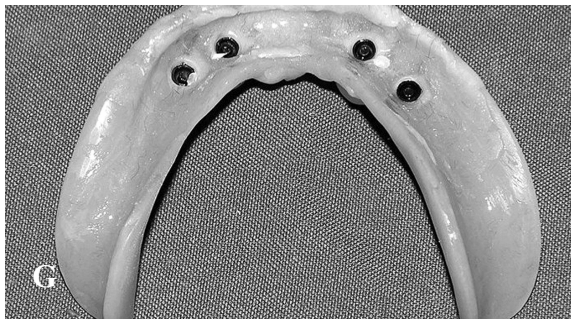


Figure 19. Prosthetic steps with the OS overdenture implant. **A.** Directional rings; **B.** Black positioning rings and female housings in place; **C.** Rubber dam covering sutures; **D.** Visual access holes; (Continued on P. 30)



E. Mixing acrylic; **F.** The final overdenture; **G.** Retrofitting denture with black caps; **H.** Empty metal housings.

over the soft tissue and covers all of the stitches. (Figs. 19B, 19C)

- Use a large laboratory round

carbide bur to cut a hole in the denture base exactly above each implant. Continue the hole toward the lingual flange and create a window. This hole should be large enough to insert a pre-loaded metal housing over the implant with no contact between the metal housing and the denture base.

- Insert the denture and verify that there is no contact between each attachment and the denture base. If there is interference, trim the denture base. (Fig. 19D)

- Apply self-curing acrylic (Fig. 19E) around and above each metal housing as well as inside each hole in the denture base. Ensure that the external retention ridge on the outside of the metal housing is completely covered with acrylic.

- Insert the denture into the patient's mouth over the attachment and guide the patient into maximum intercuspation. Note: do not allow the patient to close firmly, because this could cause improper positioning of the males relative to the females. (Fig. 19F)

- After the acrylic is set, remove the overdenture, fill any void with acrylic, and finish and polish the prosthesis.

- Replace each black female nylon cap with an extra-soft green final female cap. If the patient desires additional retention, replace the yellow female cap with a more retentive female cap six to eight weeks after implant surgery. (Figs. 19G, 19H)

TABLE 11: RETENTION LEVEL OF COLOR-CODED FEMALE CAPS
Green: Extra-soft retention
Yellow: Soft retention
Pink: Medium retention
White: Firm retention

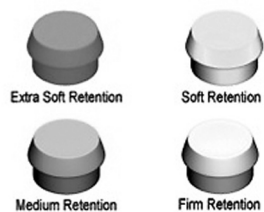


Figure 20. A selection of different female caps.

- The retention level of each color-coded female cap is listed in Table 11, and shown in Figure 20.
- Verify the occlusion and perform any necessary occlusal adjustments.

Zirconia Overdenture Implant

Zirconium dioxide (ZrO_2), commonly known as Zirconia, was discovered in 1789 by the German chemist M. H. Klaproth. However, it was only introduced into dentistry a few decades ago. It has since become a product of choice because of its high esthetic potential and strength compared to traditional

metals. In dental implant manufacturing, titanium has been the mainstay; however, Zirconia has become a viable option because it possesses superior properties, including a higher tensile strength, compressive strength, and modulus of elasticity when compared to either titanium alloy or commercially pure titanium (Table 12).

The commercial grade Zirconia used in dentistry today has several modifications that enhance it compared to the zirconium dioxide discovered in the 18th century. Pure zirconium dioxide has a low shear strength and is very brittle, essentially making it useless as a dental material. The addition of small amounts of aluminum oxide and yttrium oxide increase the modulus of elasticity and help to stabilize the material. This combination of oxides is mixed in the powder state and placed in a sintering oven to produce a monocline crystal structure, with equally spaced, non-overlapping particles. (Fig. 21A) Although the monocline crystal is strong, cracks can propagate easily in it, making it less desirable for long-term implanted prostheses.

In order to eliminate this issue, today's Zirconia is also put through a process known as hot isostatic pressing (HIP). The high pressure causes condensation of the

TABLE 12: COMPARISON OF MECHANICAL PROPERTIES OF TITANIUM AND ZIRCONIA				
FEATURES	BONE	TITANIUM ALLOY	COMMERCIAL PURE TITANIUM	ZIRCONIA
Tensile Strength (MPA)	104-121	993	662	1000
Compressive Strength (MPA)	170	970	328	2000
Modulus of Elasticity (GPA)	10-15	114	103	200

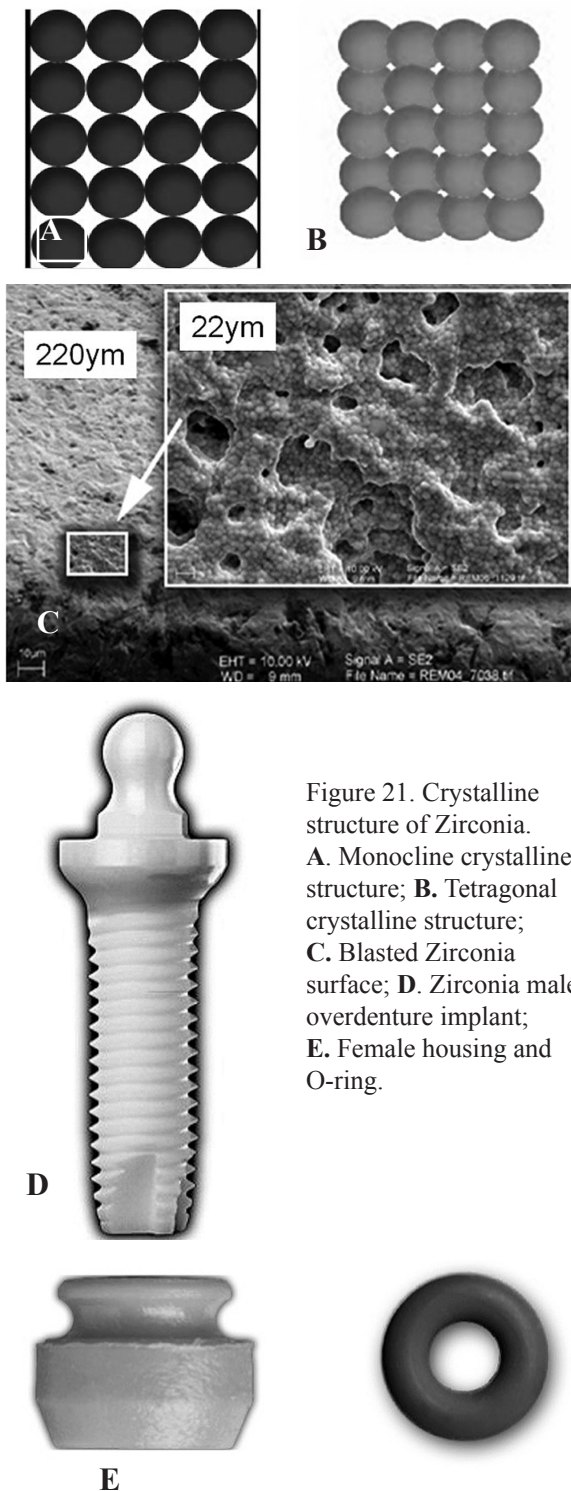


Figure 21. Crystalline structure of Zirconia. A. Monoclinic crystalline structure; B. Tetragonal crystalline structure; C. Blasted Zirconia surface; D. Zirconia male overdenture implant; E. Female housing and O-ring.

monoclinic Zirconia particles and results in a tetragonal crystalline structure, where the particles appear to overlap. (Fig. 21B) This innovation imparts the ability to stop crack propagation. When the surface of HIP-processed Zirconia is prepared, any micro-cracks that might result are quickly stabilized because the tetragonal particles expand to the monoclinic structure and fill the void. This self-repairing property is also known as the “airbag effect”. The additional stability gained by the HIP process has enabled Zirconia to be used for multiple medical prosthetic devices, including auditory, finger, and hip prostheses. Zirconia has proven its utility in dental implants through a series of animal and human clinical studies wherein it has been shown to successfully osseointegrate into bone and be highly biocompatible.⁴⁴

Zirconia dental implants have been available commercially since 2004. The current major player in the United States is Z-Systems® with their Z-Look3® Lock Ball overdenture implant. The Z-Look3® is an FDA-approved permanent implant system. This implant is made of HIP Zirconia and its surface has been blasted to increase surface area and osseointegration. (Fig. 21C) Its diameter is 4.0 mm with a 2.9 mm ball attachment. (Figs. 21D, 21E)

Clinical benefits of the Lock Ball implant include its one-piece construction, so there is no micro gap, and there are no wrong or missing parts regarding the attachments. Its white color eliminates any “tattoo” effect or grey shadow. It has a very good soft tissue response, and because no second surgery is needed, time is saved.



Figure 22. Zirconia surgical kit.

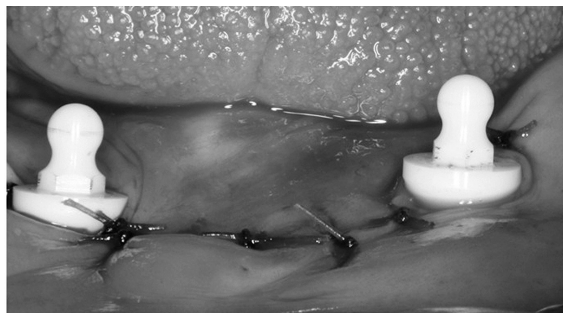


Figure 23. Two Zirconia implants in place.

The surgical kit for Zirconia implants is shown in Figure 22. All of the components in the surgical kit are made of Zirconia, and the surgical steps are very similar to those for any other permanent titanium overdenture implant. (Fig. 23)

The prosthetic steps for using Z-Look 3® Lock Ball are very similar to any other permanent titanium male overdenture implant. We strongly recommended that female caps not be retrofitted into the denture until at least 6 weeks after implant placement. During this period the denture should be relined over the ball attachment with tissue conditioner. **Note: There should be absolutely no contact between the denture base and the Zirconia ball attachments.**

CONCLUSIONS

Implant surgeons who desire to work with dentists providing implant supported overdenture therapy must have complete understanding of different attachment assembly designs and their correlation with the number of supporting implants. Additionally, surgeons should understand the biomechanical aspects of this treatment modality as well as the relationship between

height of available bone and the appropriate attachment assembly.

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