Article 5

Continuing Education

The Implant Abutment Connection: The Key to Prosthetic Success

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Learning Objectives

After reading this article the reader should be able to:

- describe the different types of connections that exist between endosseous root-form implants and their abutments.
- understand the parameters that affect the stability and accuracy of the interdigitating connections between implants and abutments.
- select the appropriate implant abutment for the various prosthetic applications for either internal or external hex implants.

The 1980s witnessed the incorporation of implant prosthodontics into the mainstream of conventional therapy with the requirement that all oral surgery, periodontic, and prosthodontic graduate programs include training in this discipline. The main impetus of this major development in dentistry was the publication of research supporting the concept that two-stage (submergible) root-form implants would become directly anchored to living bone, termed osseointegration, and that this type of interface could provide long-term support for fixed prostheses. The implant revolution was fueled by implant evolution during the last decade with a number of devices being introduced that could meet not only the anatomical limitations of the various locations in the jaws, but also the prosthetic requirements for stable, esthetic restorations.

The Spectra-System®,[a] of Osseointegrated Implants represents the author's efforts to develop implant products for the dental profession. When the author introduced the Core-Vent®,[a] Implant in 1982,[1] its primary application was to function free-standing in the symphysis to stabilize overdentures. This was revolutionary for its time, but is now common practice among all systems. The Core-Vent® Implant, made of medical-grade titanium alloy, originally had a hex-hole extending down from the top that served both to ratchet the implant into place and to accept a variety of cemented abutment posts.

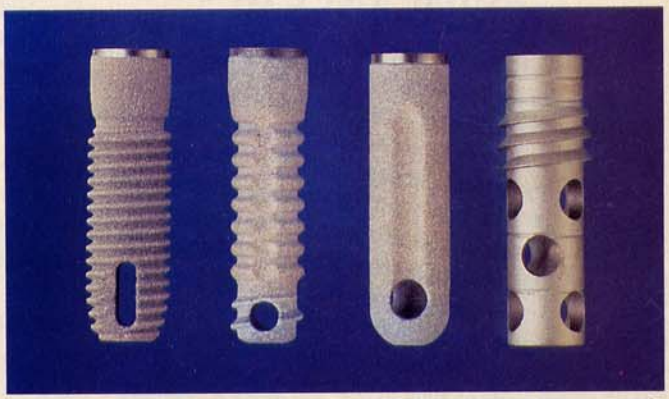

Figure 1—Internal hex implants, from left to right: Screw-Vent®, Micro-Vent®, Bio-Vent™, and Core-Vent® implants.

In 1986, both the Core-Vent®, and a new screw design made of commercially pure titanium called the Screw-Vent®,[a] Implant, were introduced with an internal design that combined a lead-in bevel, a 1.7 mm deep hex, and internal threads below. This became known as the Hex Thread®,[a] connection, a unique feature that accepts both cemented and thread-in abutments.

By designing the Screw-Vent® implants with an internal hex, the neck of the implant could be made 3.5 mm in diameter. Unlike external hex implants (such as Swede-Vent®,[a], and Branemark[b] implants) that require a 4 mm wide neck, the Screw-Vent® Implant eliminates the surgical step of countersinking the crest of the bone, thus preserving additional crestal cortical bone for support. In 1987, the narrow-diameter (3.25 mm) Micro-Vent®,[a] ledge-type implant with a hydroxyapatite coating was introduced. This implant incorporates a design and surgical protocol (push-in/screw-in insertion) that was specifically designed for use in the maxilla.

Finally, in 1989, the Bio-Vent®,[a], a hydroxyapatite-coated cylinder implant was developed to offer the simplicity of a push-in bullet design. The

[a] Core-Vent Corpration, Encino, CA 91436

1991

Bio-Vent®,[a] was made with only the internal Hex Thread® connection and by 1990, the Core-Vent®, Screw-Vent®, and Micro-Vent® implants were also available with only this connection. Together these implants comprise the Spectra-System® of Osseointegrated Implants (Figures 1 and 2).

Evolution of the Swede-Vent® System of External Hex Implants

In 1988, the Swede-Vent®,[a] external hex implant was introduced to provide a cost-effective clone to the Branemark implant. By 1990, the external hex implant line was expanded to include a conical, self-tapping screw design (CST Swede-Vent®,[a]) in pure titanium or hydroxyapatite-coated, and a cylinder implant (Bio-Vent X®,[a]) in 3.5 and 4.0 mm diameters (Figures 3 and 4).

Universal Prosthetics

As new thread-in prosthetic abutments were developed for the internal hex Spectra-System® implants over the last 4 years, counterparts were also made for the external hex Swede-Vent® System. As a result, many of the fixation screws, laboratory components, and hex tools are interchangeable between the Swede-Vent® and Spectra-System® abutments. All Swede-Vent® abutments are compatible with Nobelpharma[b], Steri-Oss[c], and IMZ[d] external hex implants.

Hex Lock® Innovation with Zero Rotation

Interdigitating hexes are only one factor in achieving a stable connection and accurate transfer, because manufacturing variations can result in up to a 1/10 mm space between the mating parts. This problem can be solved by tapering one of the mating hexes, a feature that is unique to Spectra-System® and Swede-Vent® abutments (patent claims approved, patent to issue). By tapering in the female hex of the Swede-Vent® two-piece tapered crown and bridge abutment, called Hex Lock®,[a] Abutment (HLAX—the letter "X" on a part's numeric code indicates

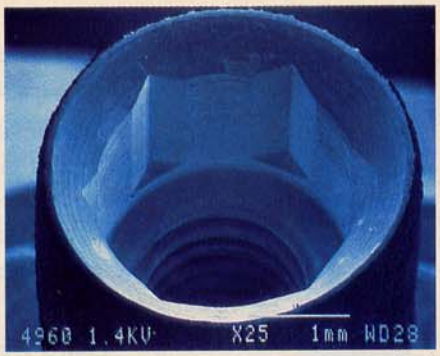

Figure 2—Scanning electron micrograph of internal Hex Thread® connection with lead-in bevel for lateral stability.

Figure 4—Scanning electron micrograph of external hex connection with flat shoulder for abutment support.

use with external hex), and by flaring out the male hex of the equivalent Spectra-System® abutment (HLA), the mating hexes interdigitate with frictional fit for added accuracy in the transfer procedure and increased stability in function. Independent studies[2] have proved the Hex Lock® to have zero rotation compared with rotational stability for Nobelpharma abutments of 198 µm, and 144 µm for Implant Innovation abutments.

Besides the frictional fit achieved by the taper-locking effect of Spectra-System® and Swede-Vent® abutments, the Spectra-System® abutments that fit into the internal hex afford greater stability than interdigitating designs with shorter mating parts. The two- and three-piece Spectra-System® abutments have male components that extend down 1.7 mm compared to the 0.7 mm interdigitation possible with external hex implants and the 0.5 mm of interdigitation provided by the Omniloc®,[e] implant with an internal octagon (Figure 5). Ohrnell and Branemark[3] suggested that the external hex of the Branemark implant should be extended to 1.2 mm to prevent loosening, which they noted was "a very common problem." A recent article by Jemt[4] documents 23 Branemark single-tooth replacements where 13 became unstable in the first year of function, demonstrating the need for more intimate interdigitation.

Figure 3—External hex implants[a], from left to right: Swede-Vent® Standard Implant, Swede-Vent® Conical, Self-Tapping Implant, Bio-Vent®X Cylinder Implant.

A significant advantage to using the internal hex connection with abutments that fit into the hex is added strength, which reduces maintenance complications such as loose or fractured screws. The center fixation screw that holds the titanium sheath in place is protected by the 1.7 mm hex of the abutment as it passes down through the top of the implant.

With two-piece abutments that attach to the external hex implant, lateral forces are transmitted to the retentive screw at the point where it enters the implant as the abutment tips on the shoulder of the implant. This can eventually cause loosening or fracture of the screw connecting the abutment to the implant. With the two-piece abutment for Spectra-System® implants that fits into the hex, the fixation screw does not emerge unprotected until it engages internal threads 2.4 mm below the top of the implant. Lateral forces

[b] Nobelpharma USA, Chicago, IL 60632
[c] Steri-Oss, Anaheim, CA 92805
[d] Interpore International, Irvine, CA 92714

[e] Calcitek, Carlsbad, CA 92008

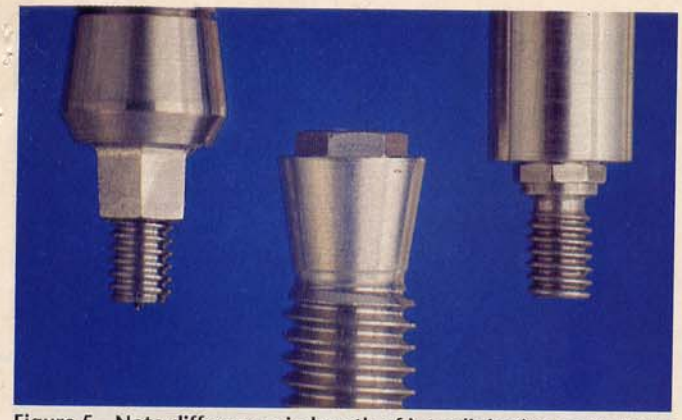

Figure 5—Note differences in length of interdigitating parts. From left to right: Spectra-System® internal hex with 1.7 mm length; Swede-Vent™ external with 0.7 mm length; Omniloc® internal octagon with 0.5 mm length.

Figure 6—The two-piece Hex Lock® abutment for the Spectra-System® can be modified and cast-to for angle changes.

are transmitted directly to the walls of the implant because of the length and intimate contact of the mating hexes. For further stability, the mating bevels of the Spectra-System® abutments and implants provide resistance to lateral stresses better than would be expected with the butt-joint connection of external-hex or internal-octagon implants.

Fixed-Prosthetic Applications

The key implant design element for the indirect approach to crown and bridge fabrication is stable interdigitation with an internal or external hex. This is not only important for antirotation with single-tooth abutments, but also for accurate transfer of the implant analogue to the working cast, which allows for indirect preparation and modification of the abutments by waxing and casting to achieve parallelism and esthetics.

Cemented restorations on implant abutments, following conventional prosthetics, have historically offered esthetic and maintenance advantages compared with screw-retained restorations. Restorations cemented with temporary cement offer retrievability without the need for screw escape holes.

Color-Coded Transfer Components

With fixed prosthetic restorations, the abutment usually requires modification on the working model, necessitating accurate transfers. For this reason, healing collars are available in 3 mm and 5 mm lengths for both internal and external hex implants. Healing collars should be attached at the time of surgical uncovering to maintain the tissue opening.

The restorative dentist can make a transfer impression once the tissues have healed. Color-coded aluminum transfer and implant analogues are now available that simplify the impression and transfer procedures. If extreme accuracy is achieved in the transfer, the abutment posts can be modified indirectly and used on the same working model as the removable dies for fabrication of the final prosthesis.

The Hex Lock®,[a] Transfer Components (HLT2, 3, 4, X) consist of a fixation screw and a color-coded sheath. During manufacturing, the tapered-bottom hex is oriented to one flat side on the post of the transfer so that all parts are interchangeable. When threaded into the implant, the HLT component functions as an impression post. Following the transfer impression, the Hex Lock® Transfer is removed and threaded into a matching color-coded Implant Analogue[a] (IA2, 3, 4, X), which functions as a transfer component.

The assembly is reinserted into the impression with the flat side of the sheath aligned to the flat side of the impression hole. This ensures that the rotational position of the hex of the implant will be transferred to the implant analogue in the working cast, which is essential when fabricating a custom cast abutment or using the preangled abutment as a removable die on the working cast. The two-piece (HLA2, 3, 4, X), titanium, tapered abutments also have one flat side and function as their own impression and transfer component with the corresponding implant analogues.

On the working cast, the dentist or technician can select from the following three abutment options that interdigitate with the internal hex. The Hex Lock® Abutment and the Preangled Abutment are also available for taper-locking interdigitation with the external hex implants.

1. The Plastic Castable Insert (PCT2,3,4): This one-piece plastic pattern is used when a cemented custom-cast post is desired. The cast abutment is excellent for single-tooth applications in esthetically critical situations (available with only internal hex implants).

2. The Hex Lock® Abutment (HLA2, 3, 4, X): This two-piece abutment, made of titanium alloy, can be shortened, prepared to remove an undercut, and cast-to in order to modify the angle (Figure 6). The Hex Lock® Abutment can be modified chairside for use with conventional impression procedures. It also functions as its own transfer with the appropriate implant analogue for indirect preparation and waxing or casting. Titanium alloy is used for added strength and because it provides a smoother machined surface.

3. The new Preangled Tapered Abutment: This three-piece abutment (Figures 7 and 8) consists of a hexagon/octagon transmucosal connector (HOB, HOBW, HOBX); a head angled at 15 degrees (AH15) or 30 degrees (AH30); and a fixation screw (AHS,

Figure 7—30 degree Preangled Tapered Abutment with intermediate hexagon/octagon base and fixation screw allows 24 adjustments every 15 degrees.

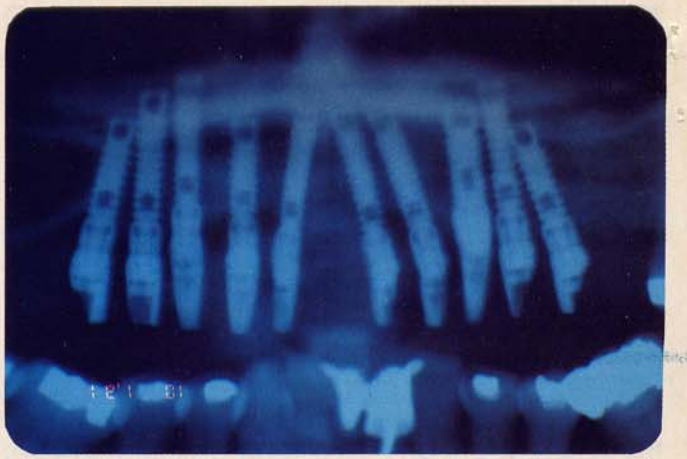

Figure 8—Radiograph of upper jaw with preangled abutments in 10 Micro-Vent® implants.

AHSX). These preangled abutments for crown and bridge applications, available for both Spectra-System® and Swede-Vent® implants, reduce the need for waxing and casting the two-piece Hex Lock® Abutments to modify the angle. The intermediate element or connector consists of a hex that taper-locks with the internal or external hex of the implant; a 1.8 mm high, smooth, transmucosal collar; and, projecting above this, a 1.2 mm long external octagon. The underside of the preangled head component has a female octagon that interdigitates and taper-locks with the male octagon of the intermediate connector. A center screw passes through the angled head, through the intermediate element, and attaches directly into the implant, locking the components together. The hexagon can be rotated in the implant every 60 degrees. The octagon on the underside of the angled abutment can be rotated 45 degrees backwards for 24 rotational adjustments every 15 degrees.

A fourth crown and bridge abutment, called the Titanium Coping Insert[a] (TCT, TCTW—"W" for use with wide implant; TCA for external hex implant), is available for internal and external hex implants. This one-piece abutment can be threaded into the implant, modified chairside, and treated as a prepared tooth by following conventional impression procedures. The Titanium Coping Insert can be used as support for a temporary bridge while other abutments are being customized indirectly on a working cast.

Bar Overdentures and Fixed or Detachable Applications

Fixed or detachable applications are indicated most often in edentulous jaws. The appropriate one-piece Titanium Straight or "TS" Series[a] screw-receiving abutment is usually attached to the implant at the time of uncovering. Two basic types of screw-receiving abutments are available for the internal and external hex implants: Titanium Straight Series Abutments and Titanium Rotatable Abutments.

Titanium Straight Series Abutments

Titanium Straight Series Abutments (TSI and TSIW [wide] for internal hex and TSA for external hex implants) accept fixation screws for retaining a superstructure. These are one-piece abutments that thread into the implant without engaging either the internal or external hex. This series has the basic straight-walled transmucosal part with a flat top in 3, 4, and 6 mm heights. It also includes a 3 mm high abutment with 1 mm of straight wall just above the implant, and a 2 mm tapered head (Figure 9). The titanium straight series abutments are designated by initials indicating the type of hexed implant they connect with, followed by a number that represents the height of the abutment (for example: TSI3, TSIW6, TSA1). These abutments are made of titanium alloy, as are all Core-Vent® abutments, to add strength[5] and provide a smoother surface for tissue health. The internally threaded shaft extending down from the top of these abutments is scored with a 1.77 mm hex to facilitate carrying the abutment to place and threading it into the implant.

Titanium Rotatable Abutments

With the one-piece thread-in abutments, the fixation screw projects in the long axis of the implant, potentially interfering with esthetics or proper contours. A rotatable tapered head (RTH) and a rotatable straight head (RSH) are now available that can be united using conventional casting procedures, to a thread-in base (TSIR, TSIRW for internal hex implants, and TSAR) for external hex implants).

A one-piece aluminum transfer with one flat side (TT3, TT4, TTX) is used to transfer the rotational position of the threads of the implant to an implant analogue in the working model (unlike the two-piece Hex Lock® Transfer that transfers the rotational position of the hex). This two-piece abutment consists of a thread-in base with a receptacle in its upper end that can accept either the tapered or straight head, exactly matching the tops of the TSI series abutments. The base is selected to fit the appropriate implant and screwed into the implant analogue in the working cast.

The selected head is attached to the base by Duralay[f] acrylic or cyanoacrylate at the desired angle so that the fixation screw will project through the prosthesis without compromising es-

[f] Reliance Dental Manufacturing Co, Worth, IL 60482

Figure 9—Titanium one-piece screw receiving tapered and straight abutments for Spectra-System® implants bypass the hex as they thread into the implant.

Figure 10—Custom-angled rotating abutment showing the progression of rotating, waxing, and casting the two components together.

thetics. The connected parts are then unthreaded as one over-waxed to allow for subsequent polishing, and cast together with silver paladium noble alloy (such as Palliag M®[g]), permanently uniting them into one, strong, custom-angled component (Figure 10).

[g] Degussa Corp, South Plainfield, NJ 07080

Conclusion

The main differences in types of interdigitating implant/abutment connections are described with an explanation of the biomechanical differences and clinical realities that should be considered.

The Spectra-System® and Swede-Vent® Systems of internal and external hex implants offer a full range of implant designs and materials while giving the restorative dentist the option of reconstructing with either of the two most popular types of implant abutment connections. The universal system of prosthetic abutments offers the restorative dentist and the laboratory the option to use the same type of

abutments, screws, and transfer components for most of the commonly used endosseous implants available, thus simplifying the instrument and inventory requirements needed to restore a variety of implants.

Dr. Niznick is the President of Core-Vent Bio-Engineering Corporation.

References

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Article 5

Review Questions

This article qualifies for 1/2 hour of Continuing Education credit from the University of Pennsylvania School of Dental Medicine. Record your answers on the enclosed answer sheet. If you do not have an answer sheet, submit your answers on a separate sheet of paper. You must be a paid subscriber to participate.

1. What design feature is common to all Spectra-System® implants?
a. They are all coated with hydroxyapatite.
b. They all have internal Hex-Thread® connections.
c. They are all made of pure titanium.
d. They all have external threads.

2. What is the common feature of the Swede-Vent™ family of implants?
a. They employ external hex connections.
b. They are Branemark implant clones.
c. They are all pure titanium implants.
d. They are made in Sweden.

3. What is universal about Core-Vent® prosthetic components?
a. One abutment fits both internal and external hex implants.
b. The top of the abutment projecting through the tissue is the same regardless of whether an internal or external hex implant is supporting it.
c. All the abutments cost the same.
d. They are made from pure titanium.

4. Why is an interdigitating connection to the internal hex more stable than to the external hex?
a. The internal hex provides more than twice the length of mating parts.
b. The taper-lock feature provides frictional as well as interdigitational stability.
c. The fixation screw is protected by the internal hex from lateral stresses.
d. The internal bevel provides resistance to lateral forces.
e. all of the above

5. The distinguishing feature of the taper-locking hex is:
a. The taper-locking hex provides a friction fit between mating parts on full seating.
b. The taper-locking hex is only available on internal hex implants
c. The taper-locking hex improves esthetics.
d. none of the above

6. What is the reason for using an internal bevel on the top of an implant vs butt-joint shoulder?
a better fit
b. increased resistance to lateral stresses
c. easier to manufacture
d. prevents tissue ingrowth

7. Titanium alloy is used for abutments because it:
a. is more flexible than pure titanium
b. is more biocompatible than pure titanium
c. machines to a smoother surface than pure titanium
d. is less expensive than pure titanium

8. Core-Vent® preangled crown and bridge abutments can be rotationally adjusted every:
a. 15 degrees
b. 30 degrees
c. 45 degrees
d. 60 degrees

9. Use of titanium rotatable abutments requires accurate transfer of:
a. location of the implants
b. the rotational position of the implant's internal threads
c. the rotational position of the implant's external hex
d. the rotational position of the implant's internal hex

10. The main advantage of the rotatable abutment is that it:
a. allows subgingival margins for esthetics
b. allows redirection of the fixation screw from the trajectory of the implant
c. eliminates the need to preplan the implant location
d. allows fabrication of detachable bridges