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Graftless solutions in implant dentistry (Part 2)

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And that’s what makes the publication you are holding right now so valuable.

For this issue of implants, we’ve assembled a collection of articles from a variety of respected names in dentistry. These expert clinicians are sharing their first-hand knowledge and expertise with you. In this issue, you can read about graftless solutions in implant dentistry, and you can also learn about new concepts in computer-guided surgery. We also have news on implant products and technology.

But there’s more.

Every issue of implants magazine also contains a C.E. component. By reading the set of articles (beginning on Page 6) on “Graftless Solution in Implant Dentistry: Part Two” by Drs. Jivraj and Zarrinklek and “New concepts in computer-guided surgery” by Dr. Telara and then taking short online quizzes about these articles at www.DTStudyClub.com, you will gain one ADA CERP-certified C.E. credit.

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Torsten Oemus
Publisher
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The treatment protocol for graftless solutions involves a number of requirements:

1) It has a reduced number of implants
2) The protocol has been popularized by the All on 4™ solution (Nobel Biocare). Clinicians should be aware that the graftless protocols may involve placement of more than four implants.
3) Anterior implants are placed straight
4) Posterior implants are tilted to avoid grafting procedures
5) The patient is provided with fixed rigid acrylic prosthesis which splints all the implants and provides cross arch stabilization
6) The prosthesis is immediately loaded.

This type of prosthesis is indicated for patients:

1) In which good lip support can be provided without a flange.
2) In which patient does not want to go through grafting procedures.
3) In which sinus is a limit posteriorly.
4) In which cost is a factor.

There are certain requirements that must be adhered to ensure clinical success.

The patient must be in good overall health. The patient must have a good understanding of the prosthesis design. In particular, the patient must be made aware that there will be pink acrylic replacing lost hard and soft tissue. For edentulous patients, this may be something they have become accustomed to.
For dentate patients, they must be made aware that alveolectomy will be performed and the lost tissue will be replaced by pink acrylic.

Practitioner requirements

All practitioners involved must have undergone significant hands-on training and be comfortable with immediate function procedures. Practitioners must have adequate inventory to ensure clinical success. This includes having additional implants, abutments and temporary cylinders on hand should they be required. Inventory planning should be carried out way ahead of time.

Dental laboratory support

From a laboratory perspective, the provisional complete denture must be ready. Denture base resin must be available and adequate instrumentation to finish and polish the prosthesis. It is the dental technician’s responsibility to complete all the non-clinical phases of treatment after the clinician has indexed the prosthesis intra-orally.

Case presentation

When a patient presents who is a candidate for graftless solutions, a comprehensive clinical and radiographic examination must be undertaken. This should include CBCT scan, periapical and panoramic radiography. Time must be spent on diagnosis and treatment planning to ensure a predictable outcome.

Key diagnostic determinants that the clinician must focus on are:
- Hard and soft tissue missing.
- Ridge display during smiling.
- Bone quantity and quality.
- Restorative space required.

Patient A presented for evaluation (Figs. 1, 2). She had not seen a dentist for the last 20 years and, like many patients, her fear was the thought of wearing complete dentures. She presented with a failing dentition and requested implant therapy such as fixed implant-supported restorations. All options were discussed with the patient. The patient’s desire was to proceed with implant-supported fixed dentures adopting a graftless approach.

Treatment planning required:
- Panoramic radiograph
- CBCT
- Clinical evaluation

Panoramic radiograph: On evaluation of the panoramic radiograph, the following was found: failing dentition with recurrent caries beneath multiple restorations, low sinus floor, posterior mandibular resorption limiting implant placement in this region and a high mental nerve (Fig. 3). On evaluation of the panoramic radiograph, it was apparent that there was bone availability in zones 1 and 2.

CBCT: This provides the clinician with more accurate anatomical measurements and 3-D topography of the osseous architecture. A safe guideline in
terms of osseous requirements is that there should be 5 mm of bone width and 10 mm of bone height in the maxilla and 5 mm of bone width and 8 mm of bone height in the mandible.

Clinical evaluation
The clinical evaluation had the following results:

- **Facial and lip support**: As a result of inadequate posterior support, the anterior teeth had flared and were over-supporting the lip.
- **Smile line and lip length**: Gingiva was visible when the patient produced an exaggerated smile.
- **Incisal edge position**: Conventional prosthodontic guidelines dictate that the incisal edge position should be determined by esthetics and phonetics. The incisal edge should be positioned just palatal to the vermillion border of the lower lip. Esthetically, there should be 2-3 mm of the incisor visible when the patient is in repose; this display is less for an elderly patient. Other guidelines for incisal edge position include the "S" position and the "F" sound. In this particular patient, it appeared the incisal edge flared forwards and over-erupted. The patient appears to be showing too much incisal edge, and this will need to be addressed when deciding its definitive position (Fig. 4).

- **Interarch space**: As a result of missing posterior mandibular teeth and a diagnosis of lack of posterior support, the interarch space had been compromised. Over-eruption of posterior maxillary teeth resulted in inadequate restorative space posteriorly. Over-eruption and flaring of both maxillary and mandibular anterior teeth resulted in a deep vertical overlap of anterior teeth and in adequate restorative space (Fig. 5).

Gaining restorative space
In patients who require extensive restorative therapy, restorative space constraints frequently arise. The treating clinician must decide how to gain space so restorations with adequate mechanical integrity can be fabricated.

There are a few techniques to gain space for the patient about to undergo full-mouth extractions and implant placement:

- Restoration of the vertical dimension of occlusion
- Alveolectomy
- Combination of the above.

Restoration of the vertical dimension of occlusion: This assumes the patient has lost vertical dimension, when in reality they may not have. Physiological adaptations to alterations in OVD (Occlusal Vertical Dimension) are highly individual. It can be extremely unstable in some patients but successful in others. We cannot predict in which patient it is likely to be successful; there are no scientific guidelines to do this. There is just clinician experience over time.

Guidelines were established by Di Pietro, who discussed the significance of the Frankfort Mandibular Plane Angle and its relevance to restorative dentistry. He mentioned in his article that patients with a low FMA are predisposed to a decrease in OVD; these patients are more likely to return to their former occlusions if the OVD is opened. Patients with high FMA angles are the opposite and can tolerate an increase in OVD.

So what limits are there to increasing OVD? There are, in fact, no specific measurements; the increase is dictated by restorative space required, esthetics and phonetics.

Clinicians are divided in theories regarding alteration of OVD. Some believe we cannot alter it, and if we do, it will go back to its pre-treatment position.
There is a consensus that if OVD alteration is required, it is altered as little as possible to achieve the clinician's restorative objectives. To summarize, it is possible to alter the OVD and from a muscular perspective and not suffer negative sequelae as long as the alteration occurs within the patient's physiologically adaptable range.

There is a consensus that if OVD alteration is required, it is altered as little as possible to achieve the clinician’s restorative objectives. To summarize, it is possible to alter the OVD and from a muscular perspective and not suffer negative sequelae as long as the alteration occurs within the patient's physiologically adaptable range.

Alveolectomy is often required when teeth have over-erupted and there is an excess of bone, which compromises the restorative space.

Decision making for Patient A

A majority of the space for Patient A was created by alveolectomy. The rationale for that being:
- Patient A’s lip was over-supported because of the lack of posterior support and flaring of the maxillary anterior teeth.
- Over-erupted maxillary and mandibular anterior teeth with excess bone.
- Maxillary incisal edge is in incorrect position. Requires repositioning 3 mm apically. This will allow the transition zone to be concealed. This will also require alveolectomy to provide adequate restorative space (Fig. 6).

A duplicate set of mounted diagnostic casts are required. One set of casts is used as a reference; the second set of casts is used for the diagnostic tooth set up. On this set, model alveolectomy is performed and communicated to the surgeon via a bone reduction guide.
Visit 4 — At this visit, the provisional complete dentures for the immediate load should be ready. It is critical that the restorative dentist meets with the surgeon to communicate bone reduction for restorative space, anteroposterior spread of implants and multi-unit abutment angulations required. It is recommended that the restorative dentist provide the surgeon with a duplicate denture of clear acrylic resin with the palate removed. This will allow the surgeon to visualize the abutment angulations in relation to the immediate load prosthesis.

**Implant surgery**

The goal of implant surgery includes:

1) Extraction of all of the remaining teeth (Fig. 7).
2) Alveolectomy.
3) Immediate implant placement to achieve a primary stability of 35 Ncm. This is achieved by under-preparation of the osteotomy site; use of longer implants to achieve greater bone-to-implant contact; and use of an implant design and surface that is conducive to increased biological stability.
4) Implants all placed at the same level. The posterior implants are placed tilted and parallel to the anterior wall of the maxillary sinus. The anterior implants are placed so that the transition line will not be visible (Fig. 8).
5) Multi-unit abutments placed to correct the angulations of the tilted implants. The selection of the healing abutments is such that after suturing, the crestal incision 1 mm of abutment is above the soft-tissue line (Figs. 9, 10).

If alveolectomy has been performed, tissue is trimmed. Plastic caps are placed on the multi-unit abutments. The surgeon then approximates the tissue around the caps so the restorative dentist can operate at a supragingival position (Figs. 11, 12).

In the mandible, the surgical goals are the same. Teeth are extracted, alveolectomy performed and the implants are placed. The posterior implants are tilted and the anterior implants are straight. The surgeon’s goal is to achieve as much of an antero-posterior spread as possible within the limitations imposed by the loop of the inferior alveolar nerve exiting the mental foramen (Figs. 13-16).

**Prosthetic considerations for immediate loading**

There is an abundance of literature that supports immediate loading of the edentulous patient. Immediate loading is defined as a protocol whereby the implants are placed and put into immediate function the day of surgery. There are a number of prosthetic considerations that must be understood prior to embarking upon the immediate load process. Meticulous
Attention to detail is required for the process to be successful.

An important prerequisite for predictable healing is absence of micromotion. Brunski\(^5\) reported that micromotion of 100 microns may constitute a threshold value for machined implant surfaces to osseointegrate adequately.

Favorable loading conditions can be achieved by splinting the implants together immediately after placement.

Micromotion at the bone implant interface is limited, thus facilitating the healing process.

The prosthesis should satisfy the following requirements:

1) Provide cross-arch stabilization with a screw-retained rigid prosthesis with no cantilevers.
2) No premature occlusal contacts.
3) No interferences in lateral excursion.
4) Minimal vertical and horizontal overlap.
5) Provide adequate esthetics.

Prosthetic technique for fabrication of the immediate load prosthesis

The patient arrives at the restorative dentist's office with implants placed and healing caps placed on the multi-unit abutments (Fig. 17).

There are several techniques for fabrication of the immediate load prosthesis including the direct and indirect techniques. In this article, the direct technique will be described.

Step 1: The position of the implants must be indexed within the intaglio of the maxillary denture. A variety of materials can be used to do this, ranging from temporary cylinders to rigid acrylic resin.

Fig. 21. Position of implants is indexed by placing occlusal registration material in the intaglio of the denture.

Fig. 22. Large holes are made in the denture.

Fig. 23. Temporary cylinders are connected to the multi-unit abutments and hand tightened.

Fig. 24. Denture is placed over the temporary cylinders. Occlusal plane and tooth display is verified.

Fig. 25. Temporary cylinders are connected to the denture using cold-cured acrylic resin.

Fig. 26. The intaglio of the denture is filled with cold-cured acrylic resin, finished and polished.
from wax to occlusal registration material. The purpose of this step is to locate the implant positions as they relate to the prosthesis (Fig. 18).

Step 2: With the use of a large acrylic bur, make holes in the positions of the markings. The holes should be big enough so as not to interfere with the circumference of the temporary cylinders (Fig. 19).

Step 3: Place the temporary cylinders on the multi-unit abutments (Fig. 20).

Step 4: Place the denture over the temporary cylinders and ensure it goes into place. The denture should seat passively around the temporary cylinders.

Step 5: Observe the patient from the front. Ensure the occlusal plane is level and the tooth display is what was planned (Fig. 21).

Step 6: Connect one of the anterior temporary cylinders with cold-curing acrylic resin, hold into place until it has set. Observe the patient from the front to ensure the occlusal plane is still level.

Step 7: Connect the remainder of the cylinders with cold-curing acrylic resin. Ensure the resin circumferentially is bonded to the temporary cylinder and engage the first two to three grooves of the temporary cylinders. The cylinders should be stable within the denture (Fig. 22).

Step 8: Unscrew the prosthesis and re-inforce the temporary cylinders within the intaglio with cold-curing acrylic resin. Follow appropriate disinfection protocols.

Step 9: Use cold cured acrylic resin to fill in the intaglio of the denture (Figs. 23,24). Use appropriate lab protocols to finish and polish.

Step 10: Evaluate the undersurface of the prosthesis. There should be no acrylic over the fit surface or the internal of the temporary cylinders. The undersurface of the prosthesis should be convex and well polished. There should be a space of 1.5-2 mm between the undersurface of the prosthesis and the soft tissue to allow for inflammation of the tissue (Fig. 25).

Step 11: Deliver the maxillary prosthesis and hand tighten the screws.

Step 12: The mandibular prosthesis is delivered in exactly the same way. The only reference for stability of the mandibular denture is the buccal shelf. Index the position of the implants with bite registration material.

Step 13: With an acrylic bur, make holes in the intaglio of the denture.

Step 14: Place the temporary cylinders on the multi-unit abutments.

Step 15: Place the denture over the temporary cylinders and ensure there is a passive fit. The occlusal aspect of the temporary cylinders should not be higher than the occlusal level of the teeth. If they are, section the temporary cylinder with a disc.

Step 16: Place the denture over the temporary cylinders and guide the patient into centric relation. Practice this movement a few times to ensure the patient goes to a repeatable position. Index one of the anterior temporary cylinders with a cold-cured acrylic resin. Guide the patient into centric relation and hold the patient there for two to three minutes until the acrylic resin has set. The denture should be stable; verify the patient can open and close in a repeatable fashion.

Step 17: Index the remaining temporary cylinders.

Step 18: Unscrew the prosthesis and re-inforce the temporary cylinders within the intaglio with cold-curing acrylic resin. Follow appropriate disinfection protocols.

Step 19: Use cold-cured acrylic resin to fill in the intaglio of the denture. Use appropriate lab protocols to finish and polish. Evaluate the undersurface of the prosthesis. There should be no acrylic over the fit surface or the internal of the temporary cylinders. The undersurface of the prosthesis should be convex and well polished. There should be a space of 1.5-2 mm between the undersurface of the prosthesis and the soft tissue to allow for inflammation of the tissue.

Fig. 27 Prosthesis is finished and polished.

Fig. 28 Undersurface of prosthesis is convex, highly polished and no debris on the fitting surface of the temporary cylinders.
Step 20: Deliver the mandibular prosthesis and hand tighten the screws. Adjust occlusion and provide postoperative instructions for the patient.

_Occlusal adjustment_

There is no scientific evidence to show that one type of tooth form or one type of occlusal scheme is preferred by patients or is more efficient.

The occlusion in the provisional immediate load prosthesis is designed to protect the implants in the weakest quality bone.

In static occlusion, there should be:
1) No premature contacts.
2) Minimal vertical and horizontal overlap.
3) Silver mylar should hold from canine to canine.
4) Silver mylar should drag through the posterior teeth.

The rationale for the above is that the further posterior we go, the higher the occlusal forces. As clinicians, our goal is to minimize occlusal load on the implants that are more posteriorly positioned and in the poorest quality bone.

In dynamic occlusion:
1) No interferences in lateral excursion.
2) No interferences in protrusive excursion.

_Postoperative protocol_

Steps of the postoperative protocol:
1) Soft diet is recommended for the first eight to 10 weeks. Biologically, this is when the osseointegration phase is at most risk.
2) Appropriate pain medication and antibiotics are prescribed.
3) Patient is asked to rinse with 0.12 percent Chlorhexidine gluconate mouthwash and clean with a soft brush.
4) Occlusion is evaluated at 24 hours and minor adjustments may need to be made to satisfy the protocol above. The occlusion is checked at one week, one month and three months postoperative appointments.
5) Patient is asked to report any complications immediately.
6) Once the initial healing has occurred and the surgical site has healed, the oral hygiene regimen should include the use of an oral water jet appliance twice daily.

Graftless solutions protocols are designed to provide immediate rehabilitation of completely edentulous patients using dental implants. The scientific literature shows that this procedure has an excellent prognosis.7,8

Several factors are involved in the success of these procedures. From the surgical perspective, the most notable are careful implant site preparation, establishing optimum implant sites,
providing maximal anteroposterior spread of the implants and the provision of adequate interocclusal space. From a prosthetic perspective, cross-arch stabilization by splinting all of the implants immediately after surgery, careful occlusal adjustment and eliminating distal cantilevers on the provisional prosthesis.

The immediate function protocol described minimizes surgical morbidity as a result of the reduced number of procedures and implants placed reducing overall treatment time and cost to the patient.

This ultimately results in increased patient acceptance and an increase in the number of patients treated.

References

You may contact Saj Jivraj at:
Saj Jivraj, BDS, MS.Ed
300 E. Esplanade Drive, No. 1600
Oxnard, Calif. 93036
saj.jivraj@gmail.com

Jivraj offers one-on-one dental implant training. To sign up, call his office to schedule your training: (805) 988-8985. CEUs will be provided. Tuition is free.

Saj Jivraj, BDS, completed his dental degree at the University of Manchester in England and his advanced prosthodontic training at the University of Southern California. He is the former chairman section of fixed prosthodontics and operative dentistry at University of Southern California, School of Dentistry. Jivraj has published numerous articles on esthetic and implant dentistry in peer-reviewed journals and has presented on aspects of implant dentistry and advanced prosthodontic procedures both nationally and internationally. He maintains a private practice limited to prosthodontics and implant dentistry in Oxnard, Calif.

Hooman Zarrinkelk, DDS, completed his dental degree at Loma Linda University. Following dental school, he was selected as research fellow in oral and maxillofacial surgery at the University of Texas Southwestern Medical Center, Parkland Hospital. Upon completion of his research projects, Zarrinkelk returned to California to complete his surgical residency training at Loma Linda University Medical with special emphasis on reconstructive jaw surgery. Zarrinkelk has been granted diplomate status by the American Board of Oral and Maxillofacial Surgery. He is a fellow of the American Association of Oral and Maxillofacial Surgeons and American College of Oral & Maxillofacial Surgeons. He is also a diplomate of the American Dental Board of Anesthesiology. Zarrinkelk is an associate professor of oral and maxillofacial surgery at Loma Linda University. He maintains a private practice with special interests in reconstructive jaw surgery and CT-guided dental implant surgery.
New concepts in computer-guided implantology

Accuracy in guided implantology is an issue. The ability to perform implant placement both safely and correctly, in order to load a pre-surgical CAD/CAM bar or cementable metal final framework prosthesis and to digitize the entire procedure, is widely researched. Accuracy is a value also in a classical II-stage protocol and respecting hard and soft tissues for long-term implant site stability.

There is an ongoing debate amongst clinicians regarding which is the best available system. Vercruyssem summarizes this debate. The article reviews only some of the published articles on this topic. All of these articles emphasize the error margins and that they can be considered clinically more or less acceptable, and determine accuracy in implant placement by means of superimposition.

In mathematical terms, "precision" means the repeatability of a measurement, and "accuracy" refers to the correspondence of this measurement to the truth. In our field, accuracy has been considered the correspondence of the placed implant to the planning.

Fortin defines "accuracy" as an ideal, at present somewhat impractical, when considering a definitive prosthesis for immediate loading, with the present systems only offering predictable results (and as such only long-term reinforced provisionals will be available), but does not quantify a threshold. According to Di Giacomo, at present a post-operative impression appears to be always necessary for immediate loading with a definitive prosthesis. Guided implantology is far better than a free-hand approach, however. A guardrail-like guide is certainly better than nothing.

Many systems are available today and, from a theoretical perspective, they have been categorized into semi-active and passive systems. The systems in the first category, whatever the technique used to make the surgical guide (STL or stone surgery), have metal smooth guiding sleeves, which the implant and the implant-driver must pass through, and the second systems, also called navigation systems, do not have any metal sleeves and the surgeon is guided by the monitor.

In this category, the surgical handpiece is indexed to spatial markers inside a surgical guide that is inserted into the patient’s mouth but not in the surgical area. These spatial coordinates are viewed by an infrared system, which transfers data to the computer, allowing the clinician to follow the surgical steps on the monitor. Alarm lights and sounds will warn the clinician of
deviations from the desired position. I propose a new definition of a passive system: a passive system must allow any operators (i.e., it must be operator independent) to achieve the same, repeatable results at an acceptable inaccuracy threshold. The accepted inaccuracy must allow clinicians to obtain a good metal-to-metal fit without placing tension on the implants. This “to what extent” predictability can determine the reliability of treatment. In fact, in fixed prostheses on natural teeth, passivity (at an acceptable gap) is about 40 to 50 μ in the arch; the same values could be considered acceptable for prostheses on implants. According to this definition, none of the systems on the market has replicable results and have metal or virtual smooth sleeves. They must thus be considered metal or virtual smooth semi-active systems.

I have developed a new device according to the mathematical concepts of thread timing and implant phase. This can be applied to the implant movement while being screwed, thus allowing clinicians passivity during implant placement. In the future, owing to the predictability of implant placement, the proposed device could be fundamental to achieving the desired goals in computer-guided implantology.

**Materials and methods**

The implants were placed using the bottle-neck-like device, which begins implant rotation before it can touch the bone, thereby avoiding bone interference with implant movement owing to bone density gradients (“bone guidance”). The prototype of the device (Fig. 1a) consists of:

- an internally threaded sleeve (“embedded sleeve,” with a “helical gear” feature at its top that is useful during implant placement; Fig. 1b);
- an externally threaded sleeve (“osteotomy sleeve”), which has to be inserted into the embedded sleeve and
serves as a regular sleeve for the osteotomy drills (because it is internally smooth; Fig. 1c);
• a modified extender for drills (Fig. 1d);
• an externally threaded sleeve, longer than the osteotomy sleeve, that acts as a “bottle-neck” and is screwed into it (Fig. 1e); and
• the “bottle-plug,” which is screwed onto the bottle-neck (Figs. 1f–h).

For the osteotomy, I used a regular surgical kit, not a dedicated one to precision, just modifying a plain extender to fit any osteotomy surgical kits (general and not guided surgical kits). The extender should match up with the sleeve before the drill touches the bone. The prototype was realized with no endo-stop features in the extender; only lines indicate depth.

The bottom end of the bottle-plug is provided with a helical gear (to match up with the corresponding embedded sleeve’s helical gear; Fig. 1j). The bottle-plug in the prototype device consists of two components, the cylindrical screwed part and the lid, and they are fastened together with a joint. The lid is integrated into the implant mounting component; thus, while the bottle-plug is being screwed onto the neck, the implant mount is entering inside the bottle-neck, forcing the implant downwards.

The implant mount has a hollow to allow for an implant-fastening screw (the same as used to fix implants and abutments, just longer, to allow for minimal screwdriver length, when it is necessary to unfasten the components at the end). The mount also has a gauge for a wrench at its top (but it can work for a handpiece driver as well). Once implant placement has been carried out, the mount can be unscrewed from the implant and vertically unfastened from the bottle-plug. At this point, the surgical guide can be removed easily, with no risk of hex undercuts.

The device must resist the vertical dislodging torque created when screwing the implant into the bone. A screwed bottle-neck performs well for this purpose and the lid must be fastened to the vertical part of the bottle-plug.

SimPlant Pro Crystal (Materialise Dental) was used only to plan the implant position (Figs. 2–3a, 3b), but instead of using a surgical guide, a STL digital cast with analogue implant holes for placing analogues was used in the first case reported (Fig. 4). A plain stone model with a (presumably) correct analogue position was used for the second case reported (Fig. 5). In both cases, the analogues were, screwed to the device, and then the device was secured to a bite-like thing (using plain relining resin for the provisional) to obtain a surgical guide (no surgical guide fixation to the bone was considered; Fig. 6).

No guided tapping drill was used. This is something that should be considered, especially in high-density bone. It could imitate the implant, with sharp threads and narrow body, to be screwed to the bottle-plug, or a bottle-plug dedicated to the tapping step, with the tap-
In both clinical cases, the device was assembled chairside to allow for minimal vertical clearance (Figs. 7a–7d). A base-plate resin was then used to create jigs to check accuracy between the models and the mouth.

**Results**

The case results were satisfactory. The device was easy to use (Figs. 8a, 8b) and jig correspondence between the abutments screwed on the analogue models and the clinical implant positions was obtained.

For the STL case, four abutments were modeled on the STL model, the resin jig was created directly in the mouth, and then its correspondence to the same abutments was checked on the STL model (Figs. 9a–9c). For the stone case, a transfer was screwed onto the analogue, the resin jig was created, and then its correspondence was clinically checked (Figs. 10a, 10b).

**Discussion**

The present systems do not offer sufficient and reliable accuracy because they do not consider the concepts of thread timing and implant phase. Their weak point is the smooth sleeve (whether metal or virtual), which does not have any control over the mechanics of a screw, which an implant is. Shooting a bullet makes sense, but shooting a screw does not.

**Smooth sleeve-dependent inaccuracy**

The first element to be considered is the gap between the implant mount and the sleeve. A twisting implant apex is the natural effect. When the implant is guided by a smooth sleeve, the position in the arch will be correct only if the implant mount does not ever touch the sleeve during the process, but when the dentist is working, there will always be contact, which will result in an error in B-L and M-V position. This is what I call the "position paradox effect" of a guiding smooth sleeve (similar to a guardrail).

Because the sleeve has a top and a bottom plane, this paradox effect is reproduced in both these two planes, and an axis deviation is a natural consequence (what I call the "axis paradox effect of a smooth sleeve"). The gap affects position and axis: these parameters go hand in hand. Depending on the gap entity, it is possible to calculate the implant apex twisting entity, using simple proportionality (Fig. 11a). At a 20 mm depth from the top of the sleeve (approximately 13 mm below the ridge), the linear deviation will be 0.8 mm (1.6 mm on the diameter that is the possible implant apex twisting entity). Trigonometry is an easy way to calculate the deviation angle of the implant axis (sine/cosine and tan/cot rules). If the gap is 0.1 mm (0.2 on the diameter), the axis deviation will be a deviation of 2 degrees 20 feet (Figs. 11b–d).

Tapered implants can engage bone at an even greater angle, particularly if the driver is conical at its first part. Consequently, it will work only at the end of the implant placement phase. According to the previous considerations, I suggest that it does not work efficiently. This cone-shaped driver limits too large an insertion torque because it may be damaging; however, the larger the axis deviation, the greater the torque perceived by the operator, who will be given an inaccurate sense of implant stability.

The good results reported in publications could have been affected by right-handed operators in isotropic
D2 and D3 bone or by working in sites in which cortical plates can directionally address implant placement. Excellent results reported could have been affected by working in low-density bone, where the marketed system allows for a good axis and depth, but the drills created a truncated cone volume devitalized area (depending on the drill blades’ cutting power and operator’s hand force), because the low-density trabeculae would be drilled 360 degrees around. The hex would be missed anyway.

The second matter to be considered is bone guidance. Depth and anti-rotational feature orientation depend on bone morphology and density. When the implant has started its rotation inside the bone, it is not possible to change the threading pattern: while screwing the implant, the platform will move increasingly deeper downward to the bone. Because it is possible to index a hex to a peripheral point along the circumference and a point along the same circumference can be indexed to the implant thread, the need to change the platform depth and hex orientation and control the threading pattern (implant phase) will be indicated. Any painted notch to index the hex and the sleeve is misleading information and naive, as it is approximate, that is, no implant phase, and dependent on notch size, point of view (parallax) and operator’s visual acuity.

Once the implant has started its rotation, it is not possible to correct the position by redirecting the implant, as the apex is inserted into the bone and will act as a fulcrum. Even if the operator redirects the implant axis, the implant body will remain displaced in position (B-L and M-D). Moreover, the redirection would be done by sight, which is dependent on the operator’s visual acuity and a parallax error is a possibility.

The axis deviation introduces another concept: bone response in terms of bone density and bone anisotropy. As a matter of fact, on the other side of the surgical guide, when the implant touches the bone, with a smooth sleeve it is impossible to predict when it starts being screwed. The moment the implant starts rotating depends on the bone friction, depending on the density (HU), and the progression of the osteotomy and the implant insertion will be dependent on the HU gradient (anisotropy), which describes how rapidly the density changes per unit of length along the three spatial coordinates inside the bone. Unless we use a device able to force implants in a precise position (referred to as the surgical guide) along a path engineered according to a particular mechanics, the bone will determine the implant threading pattern (bone density for initial screwing, whether or not a crestal bone drill has been used) and bone density gradient, or anisotropy for the subsequent axis.

Accepting inaccuracy, manufacturers and researchers have created depth-control systems in the hope of offering certainty about this parameter at least, but the gap will be responsible for not only position and axis deviations but also depth errors. In fact, the implant mount endo-stop will match up with the sleeve at an angle. The first contact will be beyond the desired depth, and continuing to screw the implant will create a great torque with surgical guide deformation and tension on the bone. The complete contact will correspond to a deeper implant position than desired. The correct depth may be halfway (maybe operator dependent and determined using the naked eye). Depth error, axis deviation and translation in crestal position in the axial deviation direction will be the results (Figs. 12a–e).

The likelihood of ideally positioning two implants is one out of 7 billion and 500 million possibilities (just a few million less, if it is any comfort to us). And this evaluation comes from a 0.1 mm mean deviation and 1

Figs. 12a–d. Missed implant position parameters in the depth-control systems owing to congruent triangle considerations (implant axis deviation and endo-stop angle).

Figs. 13a, 13b. Coca-cola screw plug analogy.
degree deviation, which implies insufficient inaccuracy. Fancy what the chances would be of achieving acceptable accuracy.

Fancy what the chances would be of achieving acceptable accuracy.

Thread timing and implant phase

From a mathematical perspective, it is possible to describe all implant spatial coordinates concentrated on the platform, where we can summarize everything, and calculate its trajectory to create kind of a spiral path, through which it is possible to start and stop an implant platform along all the parameters, thus being able to truly speak of implant-guided prosthodontics.

The idea is based on the following: when screwing a coca-cola plug onto the bottle-neck, the final position will always be the same (Figs. 13a, 13b). Once two final positions have been found, two threads will be inside the plug; once three final positions have been found, three threads will be present on the plug. The label written on the plug can be considered to be a hex (or a trilobe). So the hex, that is the platform, can easily be reproduced in its position because the thread pattern and hex are indexed to each other. This means that if we can control the threading pattern, we can consequently control the platform position too.

According to this consideration, all the parameters that define the platform position can be controlled. The parameters are the position in the arch (B-L and M-D), the axis, the depth and the anti-rotational feature (classically, a hex) orientation.

The mechanical engineering of a screw is quite different from that of a bullet (smooth sleeve) and was defined by Archimedes (applications of an endless screw are still in use today, like the meat mincer) and by Euler (Swiss mathematician, who died in St. Petersburg more than two centuries ago). In particular, Euler pointed out that the movement of a circle (in our field, the implant platform) can be described with mathematical formulas: a point along the circumference (in our field the perimetric projection of a part of the hex) can be projected along a plane orthogonal to the direction of the circle movement itself (in our field, the progression of the platform while the implant is being screwed in multiplanar reconstructions). The projection will describe a sine wave (in our field, the sine wave period can be identified with the implant thread pitch).

With this in mind, I developed the device discussed in this article, which controls the threading pattern. In mechanical engineering, this is called thread timing, and the hex position can be defined as hex timing. For both of them we can speak of phase control (i.e., we can speak of the phase of the implant, both for the thread and the hex). Along this spiral track, the implant can be theoretically and actually screwed and unscrewed as many times as we desire (back and forth), and it will always be possible to know the hex position at the end of the spiral path (final analogue and implant position; Figs. 14a–c).

As a spiral circular motion is transformed into a pure translation, a threaded device will respect also position and axis. The information needed to correctly (position and axis, anti-rotational feature and depth) place an implant is in its platform and inside its threads. By creating in the surgical guide a track along which the implant is screwed before its contact with the bone, it is logically possible to start and stop the implant with a final seating with all the parameters always reproduced. We can thus decide when to stop the implant during its fall along this spiral track. The final position will always be the same, that is repeatable, and operator independent. The device meets my earlier definition of a passive system.

The maximum precision possible will be what manufacturers can effectively offer (a 1/100 mm is expected to be realistic), which corresponds to the actual implant placement. With a threaded system, there is no axial deviation. Therefore, there will only be a 1/100 mm position deviation (in the arch, this will signify a possible 2/100 mm deviation), no axial deviation, depth and anti-rotational feature correspondence. This discrepancy is within the limits that allow the clinician to make a premade final prosthesis and allows for presumably optimal long-term tissue stability.

Some of the systems available also consider hex orientation position, but in order to seat the implant correctly with regard to the anti-rotational feature, an extra rotation may be needed. Speaking of “correctly”, at which angle resolution? If the feature described is in the shape of two points (painted or alike) to be vertically aligned, what is the point dimension? What is the eye resolution? Is it possibly a parallax error? Extra-rotation is an implicit admission of inaccuracy: the depth will not be respected as well, and the implant platform depth...
may be a little above or below the desired position (it depends on the degree to which the operator is out of phase, more or less than 180 degrees). It is easy to realize that, unless all this has been calculated, all attempts to find the anti-rotational feature position and depth are only guesswork — a waste of time! Thread timing and implant phase have not been respected. Forget any notches on the implant mount and smooth sleeves, if anti-rotational feature orientation is the goal. Notches are history in digital guided implantology.

Once we have set a threading pattern, it is possible to set the stop point simply making a helical gear (a helical gear is realized by contouring the thread along its 360-degree run; a vertical step will be present once we have gone 360 degrees around) both in the bottleneck plug and in the embedded sleeve (the coordinating feature inside the surgical guide), so that a vertical stop is realized in the device. When the two vertical parts match up, we can be certain that the hex is just where we have engineered it to be.

The device pitch must have the same implant pitch because differences will lead to bone stripping. In fact, a difference in implant and mount insertion speed (i.e., the distance covered in depth every 360 degrees) and a different wave period (i.e., thread pitch), will lead to something different from an out-of-phase working device; it will lead to bone stripping. In particular, a longer mounting period will force the implant downward into the bone, with consequent vertical bone stripping, whereas a shorter mounting period will force the implant to rotate horizontally, with consequent horizontal bone stripping. Self-tapping implants should show better torque control.

Rigidity

The device must be secured to the surgical guide to resist the rotational torque and vertical torque always present during the implant rotation inside the bone.

Components and undercuts

In the prototype device, a driver for a ratchet was used. It was completely redundant because the ratchet can cooperate directly with a plug-top feature for a ratchet at its top; thus, the driver is something that can be eliminated. Once the assembly has been fixed to the embedded sleeve, the plug can be screwed with the fingers, at least until sufficient torque is found, when a ratchet can be used.

When multiple implants have been planned, in case of divergent implants, hex undercuts could prevent the surgical guide from releasing itself from the bone, once the implants have been placed. In order to resolve this, the device, at least the mounting part, must be removed from the surgical guide. The device is thus divided in two components, and the lid, which is integral to the driver, can be unscrewed, leaving the surgical guide along with all the other components still fastened to it, but disengaged from the implants, freely and easily removable.

For single implant placement, the lid is not necessary, because there are no hex undercuts. In this case, a bottleplug with one component will be sufficient.

Crest module

The implant crest module morphology does not affect this guiding device because the bottleneck's internal diameter is just a little wider than the implant diameter at any point (platform or below the platform). By the way, additional threads in the crest module are not important either because, mathematically speaking, they are harmonic waves of the implant period (thread pitch).

Mastercast

The helical gear can easily be oriented vestibularly in the threaded guiding device before pouring the master model.

Vertical clearance

To make the correct surgical guide, the helical gear must be engineered in the planning at a multiple pitch distance from the bone, just equaling the implant length (the implant must start rotating before it touches the bone to avoid bone guidance). For instance, the distance will be 9 or 10 mm for 9 or 10 mm long implants with a 1 mm pitch, and the distance will be a multiple of 0.75 for a 0.75 mm pitch (9 mm will correspond to 12 implant revolutions and 10.5 mm to 14 revolutions). The average mouth opening values should be considered. In case of tapered implants, a short distance can be considered because the implant apex can enter the osteotomy hole without being engaged. To reduce vertical clearance, the device can be pre-assembled, thus obtaining a working length even shorter than that of the present systems (Fig. 15). A shorter vertical clearance is possible also with trans-mucosal implants because the platform results are more superficial._

Editorial note: This article was first published in Dental Implantologie & 374–82 (2004), Spitta Verlag. A complete list of references is available from the publisher.
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The evolution of sinus lift techniques

When Dr. O. Hilt Tatum performed his sinus lift technique in 1975, I wonder if he had any idea of how it would evolve or the controversies that would surround this procedure. I can say there exist as many techniques as there are opinions on how the procedure should be performed and who should perform it.

A sinus lift is a surgery that adds bone to the maxilla in the area of the molars and premolars. It’s sometimes called a sinus augmentation. The bone is added between the floor of the maxillary sinus and the Schneiderian membrane. To make room for the bone, the sinus membrane has to be moved upward, or “lifted.” Any dentist who is trained to do it can do a sinus lift. Tatum, the originator of the procedure, is a general dentist.

There are two basic methods for performing the sinus lift technique. The first method is the lateral window technique, which was described by Boyne in 1960. The procedure was used by Boyne to achieve an optimal intercrestal distance needed for denture making.

The sinus lift techniques have undergone numerous modifications through the years. In 1975, Tatum was the first to perform the lateral window technique in conjunction with autogenous bone grafting for the purpose of placing dental implants in the newly formed bone.

Although the lateral window technique is highly invasive, it is a necessary procedure. In 1994, Summers, who was in pursuit of a less invasive sinus lift method, made the surgical protocol easier by offering the crestal approach or osteotome technique.

Initially, the osteotome technique was used for compressing the soft maxillary bone to improve primary stability of implants and to increase success rates of implants placed in the posterior maxilla. After a period of success using the technique for bone compression, Summers started floor dilatation of the sinus, thus increasing the length of his implants. When the technique was first introduced, there were two significant disadvantages that limited this technique’s indications.

The first disadvantage was the limited height that the sinus could be raised. Initially, Summers was able to successfully lift the membrane 1–3 mms.

The second limitation was the inability to directly visualize the membrane. The technique was initially performed with convex osteotomes by using the sinus floor to lift the membrane. After the mem-

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brane is lifted, bone grafting material is used to hydraulically lift the Schneiderian membrane.

Today, using modern technologies such as piezoelectric units and balloons as well as crestal approach kits, which use saline, we are now able to achieve height gains that rival those of the lateral window technique, with little concern for membrane perforation.

So where are we today? Very few practitioners, including Tatum, routinely use autogenous bone for sinus augmentation. One of the main reasons is there are several excellent alternative bone-grafting materials available that don’t require a secondary surgical site and provide very similar results to autogenous bone.

So one question that is being asked a lot lately is: Is autogenous bone the “gold standard”? The jury is still out, but there is a lot of evidence out there that suggest it is not. Only time will tell.

The lateral window technique is being used more sparingly these days. There are several methods available that have allowed us to effectively raise the Schneiderian membrane 5–7 mms or more routinely and place the implant simultaneously, as long as we have enough crestal bone to get primary stability.

This technique is safer for the patient, and it reduces the chance that an infection will occur.

Lastly, with the evolution of safer and more predictable sinus lift methods, more dentists are able to successfully perform the procedure, which allows more patients to have implants in the posterior maxilla.

Andrew Kelly, DDS, is a graduate of California State University, Long Beach, and received his DDS degree from Howard University. He received his advanced implant training from the Core-Vent Institute in Encino, Calif., and the Medical College of Georgia in Augusta, Ga. He is a diplomate of The American Board of Oral Implantology/Implant Dentistry, a fellow of the AAD, a fellow of the AGD and a member of the ICOI, the AACD and the AO. Kelly owns and operates Dental Center of the Carolinas, a private cosmetic and implant dental practice. He is also co-owner of Dental Office Solutions, a dental staffing, consulting and training center for cosmetic and implant education.

‘With the evolution of safer and more predictable sinus lift methods, more dentists are able to successfully perform the procedure, which allows more patients to have implants in the posterior maxilla.’
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3) Baumgarten H., Meltzer A. Improving outcomes while employing accelerated treatment protocols within the aesthetic zone: From single tooth to full arch restorations. Presented at the Academy of Osseointegration, 27th Annual Meeting; March 2012; Phoenix, AZ.

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Dr. Kelly is a graduate of Howard University College of Dentistry. He maintains a private practice in Clemmons, NC where he provides cosmetic, implant, comprehensive and sedation dentistry. Dr. Kelly is an accomplished educator, mentor, and author. He has been placing and restoring implant since 1999 and continues to inspire dentists.

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Group Editor Robin Goodman
r.goodman@dental-tribune.com

Implants Managing Editor Sierra Rendon
s.rendon@dental-tribune.com

Managing Editor Fred Michmershuizen
f.michmershuizen@dental-tribune.com
Implants

the international C.E. magazine of oral implantology

U.S. Headquarters
Dental Tribune America
116 West 23rd Street, Ste. 500
New York, NY 10011
Tel.: (212) 244-7181
Fax: (212) 244-7185
feedback@dental-tribune.com
www.dental-tribune.com

Publisher
Torsten R. Oemus
t.oemus@dental-tribune.com

Chief Operating Officer
Eric Seid
e.seid@dental-tribune.com

Group Editor
Robin Goodman
r.goodman@dental-tribune.com

Managing Editor
Fred Michmershuizen
f.michmershuizen@dental-tribune.com

Implants Managing Editor
Sierra Rendon
s.rendon@dental-tribune.com

Designer
Kristine Colker
k.colker@dental-tribune.com

Managing Editor
Robert Selleck
r.selleck@dental-tribune.com

Marketing Manager
Anna Wlodarczyk-Kataoka
a.wlodarczyk@dental-tribune.com

Product/Account Manager
Humiberto Estrada
h.estrada@dental-tribune.com

Product/Account Manager
Will Kenyon
w.kenyon@dental-tribune.com

Product/Account Manager
Charles Serra
c.serra@dental-tribune.com

C.E. Director
Christiane Ferret
c.ferret@dtstudyclub.com

International Account Manager
Jan Agostaro
j.agostaro@dental-tribune.com

Feedback & General Inquiries
feedback@dental-tribune.com

Editorial Board

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