TRIPOD - A new protocol for immediate loading

Dr Jean-Nicolas Hasson et al looks at complete maxillary implant-supported prostheses

Immediate loading of complete maxillary implant supported bridgework is an increasing request by patients who have high aesthetic and functional demands and attach great importance to a neat appearance and their self-image. Since 1977, positive results have been obtained in immediate loading but these were limited to mandibular, bar-retained removable dentures. In 1997, Tarnow et al. published a study showing similar results for maxillary and mandibular full-arch, implant-supported bridgework, and, more recently, the focus has turned to the development of computer-based techniques for improved results. Highly sophisticated technical tools such as Nobel-Guide (Nobel Biocare) and the SAFE SurgiGuide® (Materialise Dental) have entered the market and related techniques such as All-on-4 (Nobel Biocare) are being promoted to help meet patients' demands. All techniques are based on full maxillary bridgework with a screw-based retention. The screws-retained bridgework allows all procedures to be performed during the treatment ie impression taking, bridge modification and repair for aesthetic or functional purposes.

Amongst the more challenging difficulties in carrying out such a therapy is implant positioning, especially for a single crown in the anterior region. Precise placement is essential in achieving good aesthetics, phonetics, function and cleanability. Most of the time, implant placement has to be within the limits of 0.5mm (Fig 1). Another factor to consider is the possible loss of alveolar bone after tooth extraction, leaving a minimal residual volume, and thereby increasing the difficulty of the procedure. The positioning of implants depends on the guide's positional accuracy in a definitive place at the time of the surgery and on the accuracy of the guide itself. In the case of NobelGuide, accurate positioning depends on the patient's ability to bite reproducibly and precisely, with even gingival thickness and consistency, and assumes that bone shows a similar degree of hardness at different screw-retention sites. Unfortunately, as recently reviewed by Schneider et al. and detailed by Valente et al., the deviation between entry point and orientation consistently differs between the

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planned and actual position of the implants. This generally accounts for the results obtained by guides used in flapless surgery. Other failure factors may be related to poor cooling ability during the drilling procedure.¹

As cited above, inaccuracies may arise from the positioning of the guide or of the patient, or be related to the radiological technique itself. In the case of flapless surgery, the position of the guide is conditioned by the thickness and density of the bone, as well as by the soft tissue, as well as by the patient’s ability to bite precisely in a replicable manner. In addition, there is always some degree of patient movement during the CT scan, which can hardly be controlled, an inaccuracy termed a ‘mechanical artefact’. Of course, any study performed on cadavers or models cannot reproduce this particular radiological aspect.² Other inaccuracies are related to the radiological equipment itself and include geometric, hardening and threshold artefacts. Geometric artefacts are related to the ability of software to reconstruct a 3-D space based on the serial addition of 2-D images that are filtered by the software.³, ⁴ Hardening artefacts are due to the different densities of adjacent objects. An X-ray beam is composed of individual photons with a range of energies. As the beam passes through an object, it becomes ‘harder’, that is, its mean energy increases because the lower-energy photons are absorbed more rapidly than higher-energy photons.⁵ The last significant artefact, the digital artefact, is due to the segmentation masks that are used to obtain volumes. In order to obtain a mask, an interval of radiodensity is defined by choosing the Hounsfield values at both ends of the tissue(s) under interest. By using this method, an area of lower or greater density can be discarded and missed in the final volume. This may be particularly true when digitally producing a surgical template based on hard or soft tissue. Finally, images produced by available techniques are too unreliable to be used directly for this type of treatment. We propose a new protocol in this article with the aim of reducing inaccuracies in terms of reliability, aesthetics and function.

TRIPOD: Description of a new clinical technique

Initially, a treatment plan is performed to adequately evaluate a case, propose alternate solutions and decide whether the patient is a suitable candidate for a fully implant-supported maxillary bridge. This requires a first assessment that includes a possible wax-up and a radiographic stent for visualising the crown position on the CT scan, as well as an evaluation of a potential need for bone- and soft-tissue augmentation procedures. Patients often present with their own cement-retained bridgework on natural teeth in place that, when adequate, may be used as a reference guide for implant placement. It is essential to evaluate the implant site within the maxillary bone precisely. In order to perform these measurements, a Positioning TRIPOD and a Computing TRIPOD need to be determined.

The term ‘Positioning TRIPOD’ is used to denote the selected pre-existing three fixed points (Fig. 2) in the mandible or maxilla, which can be based on:

- Teeth that are stable enough to support the surgical guide during surgery
- Implants placed in posterior areas
- Temporary mini-implants that will be removed at the end of surgery

The choice of appropriate bases for the Positioning TRIPOD is critical for its accuracy. Owing to its compressibility, soft gingival tissue has to be avoided. Problems with remaining teeth may arise due to advanced periodontal disease causing excessive mobility. In some cases, temporary mini-implants are used, but often the amount of maxillary residual bone is so reduced that these implants only interfere with definitive implant placement. Nevertheless, they may be useful when no other alternative is available. Anecdotal cases in which there is sufficient bone for temporary and definitive implants at the same time have been reported, but are rare. The best choice is to use posterior-placed implants before inserting anterior implants. In this case, an extremely precise positioning is not required since the large volume of the corresponding teeth provides some degree of freedom to the laboratory technician designing the prostheses. These posterior areas often require some bone reconstruction (such as sinus lift or onlay bone grafts), thereby prolonging time to loading. The corresponding implant is made as possible wax-up only the most precise positioning for radiographic templates and surgical guides, but also for the radiographic template fixed on the Positioning TRIPOD. The position of the standardised X-ray opaque reference pins is detected by the software, building the Computing TRIPOD (Fig. 3). This data is then set in the transfer table (Fig. 5a) to place the drill sleeves accordingly and transfer the radiographic template into a surgical guide (Fig. 5b).

Some days prior to the full-arch surgery, once an adequate TRIPOD has already been planned and initial implants placed, an initial impression (Fig. 6) will be taken for the model to prepare the impression tray, occlusal guide, surgical guide from the radiographic template, as well as the provisional prostheses. The surgical guides are produced in sterilisable resin with radiopaque sleeves (DePlaque). Special attention is given to the impression tray that will extend to all maxillary surfaces, but room for the impression material is exclusively limited to the planned implant sites. They must be ready at the time of surgery.

On the day of the surgery, the practitioner begins by reducing all remaining crowns that would interfere with the surgical guide, which is then placed on teeth or preferably screwed onto previously placed implants forming the Positioning TRIPOD (Fig. 7). A CT is performed to verify all drilling
sites. If any modification has to be done, there is still time to adjust the drill sleeves to adequate positions and to re-sterilise the guide.

The next step is the transfer of the occlusion to the articulator. Usually an occlusion guide is engineered before surgery and screwed into an adequate position. It is then adjusted and some silicone material is added to ensure a perfect bite (Fig 8). The transfer is made to the articulator before starting surgery. It is sometimes possible to retain a molar for the impression tray to be made (Fig 9). A modified plaster model is trimmed to leave space for the abutments, and to ensure that no radiopaque sterile silicone material remains.

The maxillary plaster model is trimmed to leave space for abutment analogues and plaster is poured to fill this open space after the impression tray has been secured to the trimmed model (Fig 11). The modified model is secured to the trimmed model (Fig 10). Once the impression tray has been removed, protective caps are positioned on the SPI®VARIO multi abutments in order to maintain gingival spacing during the last laboratory prosthetic phase. A panoramic X-ray is performed to ensure proper positioning of implants and abutments, and to ensure that no radiopaque sterile silicone material remains.

Everyday deserves a beautiful smile.
multaneously shows two parts: the first part corresponding to the initial impression and the other corresponding to the second impression (Fig 12). The provisional prostheses are fitted to the model and occlusion is validated. When this laboratory phase is over, the protective caps are removed, and the prostheses are screwed into position (Figs 15a & b). If well done, occlusal adjustments should be minimal, even perhaps none being required. Thommen SPI®VARIOmulti temporary caps on conventional implants were examined in future studies. Thereafter, the occlusal guide is actually suitable for drilling and, at the time, an additional system is placed on the gingiva at the time of open flap surgery. In addition, the bone becomes visible, which allows access to the implant positioning to visualise the depth marks of the drill right at the crestal ridge, making the instrumentation less expensive and easier, as no special drill with mechanical depth limitation is required. Site preparation may be modified by using piezoelectric bone surgery. This device can grind bone on a particular wall from the previous drilling, in contrast to conventional drilling, which grinds all walls from the previous drilling, with a preference for softer tissue and resulting in facial bone perforation. In some situations, one might also consider changing from drills to bone spreaders; this would complement the surrounding bone and provide additional stability to the corresponding implant. Finally, the implant could be adapted to a recipient site by choosing an appropriate, cost, diameter, length and even the profile (eg from conical to conical-cylindrical) once site preparation has almost been completed.

The previously placed implants do not add useful precision to implant site preparation with the guide, but also provide essential stability to immediately loaded bridgework in an area where stability in the initial healing phase is probably vital to success. Most patients are already older, with a history of periodontitis, tooth loss and associated impaired medical conditions, and possibly reduced healing capacity. Therefore, it is of major interest to be able to assess the healing capacity by the stability of previously placed implants, before undergoing and performing a full-arch maxillary bridge immediately loaded on implants, preferably with advanced surface technology. Most of the cases require some sort of bone grafting in the posterior areas and this technique leaves time for initial healing before occlusal loaded. In fact, some of the implants would be subjected to immediate loading, whereas others - the most critical in terms of bone volume availability and location - could be loaded according to a classical schedule. This should be considered when making a comparison with other procedures with surgical guides.

The INCELL® surface found on Thommen Medical implants showed more bone-to-implant contact and a higher removal torque at two weeks than unconditioned implants did. This aspect should be particularly useful in the early stages of healing and probably add additional security in this crucial phase. In addition, this company provides implants of various diameters, lengths and profiles to satisfy various implant site requirements and which provide the best possible stability.

Conclusion

The TRIPOD protocol is based on our latest clinical expertise the vast developments of implant placement planning software and computer-guided implant dentistry. The efficiency of the technique must still be validated by analysing implant survival in different clinical environments, specifically investigating adequate positioning between planned and final implant position and the need to verify the surgical guide after the learning process has been completed. Finally, a study on patients’ satisfaction with the procedure in terms of pain and aesthetic outcome needs to be performed. We must still determine whether the benefit for patients and the need for flap surgery in combination with surgical guides outweigh the related discomfort and pain for the patient: does this pose a major problem for patients, are the final aesthetics improved by preserving keratinised tissue, and does such a technique fulfill expectations and considerations that bone volume loss is often difficult to limit in these areas?

The proposed TRIPOD procedure is certainly more labour-intensive than current flapless guide systems, since a flap has to be raised and no definitive prosthesis is placed right after surgery. Nevertheless, it is also more versatile because maintaining or increasing bone volume in the treatment plan and is adapted to the individual situations. The risk of failure is considerably reduced by connecting immediately placed implants to osseointegrated implants. Furthermore, this procedure allows using the last millimetre, as typical cases show reduced bone volume and require the widest and longest implants within anatomical restrictions. Although knowledge and close collaboration with the laboratory technician are required, this procedure adds fundamental security and predictability for success, and will certainly be adapted to different practical situations and one-day procedures.

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