Dynamic navigation in fully edentulous maxilla

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Literature

Preoperative planning is the most important part of a successful implant rehabilitation and requires multiple parameters to be considered for the precise placement of implants. The implants should be placed not only within anatomical boundaries but also be strategically located to support a prosthesis that will fulfil both functional and aesthetic requirements.

3-D virtual images are being used through computer software, which transforms CBCT scans into 3-D virtual models. However, after a precise planning or virtual realisation of the treatment, the osteotomy should also be executed precisely according to the plan and would likely require guidance of the drills and the implant.

For years, stereolithographic static guides have been used successfully for implant osteotomies, using detailed information implemented through 3-D virtual images.[1,2] Static guides on the other hand present several disadvantages. The loss of tactile feeling during osteotomy and the fact of being limited to the predesigned drilling trajectory are considered to be their major drawbacks.

Real-time navigation

A recent technology, which provides dynamic guidance through a real-time navigation for implant osteotomy, offers not only accuracy, but also additional valuable advantages during an operation.[3,4] With this technology, the location and diameter of implants can be modified and a flap can be incised intraoperatively whenever needed.

Furthermore, dynamic navigation enables the surgeon to adjust the surgical plan during surgery. In case of an unexpected low bone quality, an additional implant could be planned with the software and placed additionally. Moreover, one of the most significant benefits of dynamic navigation is the ability to use it also for alveoloplasty and reshape the alveolar crest's topography during the same surgery, together with the implant placement.

Fig. 1: Patient wants a screw-retained fixed prosthesis.
Fig. 2: Radio-opaque tooth set-up for prosthetic planning.
Fig. 3: Scan prosthesis at try-in to check its fit, aesthetics and maxilla mandibular relation.
Figs. 4a & b: Navident H-Arm **(a)** and V-Arm **(b)**.


Fig. 1


Fig. 3


Fig. 2


Fig. 4a


Fig. 4b

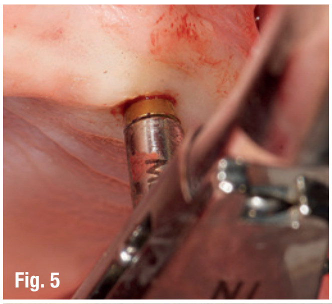


Fig. 5

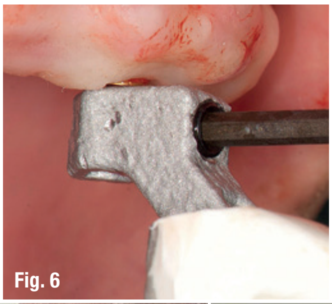


Fig. 6

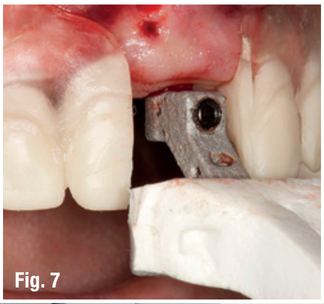


Fig. 7


Fig. 8


Fig. 9

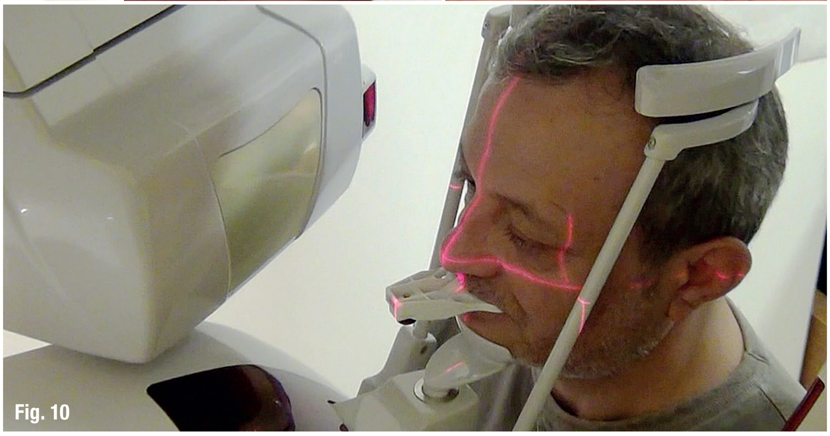


Fig. 10

Fig. 5: Placement of an SDI as anchor mount.
Fig. 6: Connecting the NaviStent Arm to the SDI.
Figs. 7 & 8: Adjusted scan prosthesis for combined scanning.
Fig. 9: Connecting the CT marker to the NaviStent.
Fig. 10: Patient positioning in the CBCT scanner.

The precise location of implants is case-specific and determined by different factors. If an edentulous case is to be restored with an implant-supported screw-retained fixed prosthesis, implant locations should be critically examined whether they can provide screw access holes within occlusal or palatal/lingual parts of the restoration. Frequently, alveoloplasty is required for the recontouring of the ridge in order to obtain sufficient bone thickness at the level of the implant's collar.

This crestal trimming of bone may also be necessary in order to increase the inter-arch space and provide a sufficient volume for the restorative material, since dentogingival prostheses are frequently required to enhance aesthetics. In such cases, dynamic guidance can be used to level the alveolar crests as planned on virtual images, followed by precise multiple osteotomies.

Case

The following case report describes the treatment of a 65-year-old male with an one-year history of maxillary partial edentulism (Fig. 1). He was discontent with the stability of his prosthesis and expressed that through the unstable prosthesis situation he has lost social self-confidence. In the initial appointment he thus stresses his need for a "fixed solution".

His medical history did not reveal any specific systemic disease or condition that contraindicates oral surgery. The patient's soft tissues on the edentulous ridges were healthy and panoramic X-rays showed expanded sinuses at both sides and irregular alveolar ridges. The treatment plan, carried out for a maxillary screw-retained fixed prosthesis, included two implants at the pre-maxillary region and two tilted in the posterior maxilla to avoid a sinus lift surgery.

Stent placement

In order to acquire both anatomical and prosthetic information prior to the surgery, a scan prosthesis was manufactured by duplicating the maxillary denture (Fig. 2). It is important that the scan prosthesis has the same aesthetic and functional information as the complete denture or set-up. Thus, the scan prosthesis was checked for its fit, aesthetics and maxilla mandibular relation (Fig. 3). The scan prosthesis was then used together with a Navident Edentulous Kit for CBCT imaging.

The Navident edentulous protocol consists of a SDI (Small Diameter Implant of 2.2 mm or 2.5 mm diameter), which is inserted into the alveolar ridge of the arch to be operated, prior to the acquisition of the CT scan. This temporary SDI serves as a mount for the CT marker and for the Jaw Tag used for the registration of the CT scan to the patient and for tracking the patient's jaw during surgery.

The SDI can be placed either in a vertical position or in a horizontal position in relation to the alveolar crest. A special plastic arm with a proprietary aluminium bracket is then used for the connection of the CT marker and Jaw Tag to the SDI. Two types of arms are available: one for a vertically placed and another for a horizontally placed SDI (Figs. 4a & b). In the presented case, the SDI has been placed vertically to achieve the required stability (Fig. 5).

The CT marker, containing the fiducial marker used for the registration of the CT scan to the patient, was attached to the V-type arm on the fix-plate at one end. At the other end, the assembly was placed over the SDI's square head and secured to it using a setscrew which was embedded in the aluminium bracket, with this creating a complete "NaviStent" (Fig. 6).

The scan prosthesis was then modified to accommodate the aluminium bracket before it was placed over the maxillary edentulous ridge (Figs. 7 & 8). For accuracy purpose, it is imperative that the scan prosthesis is stable, while at the same time it should not interfere with the NaviStent.

CT scan

The following CBCT imaging protocol for Navident dynamic navigation was applied during CT imaging. Before the scanning procedures, both the modified scanning prosthesis and the NaviStent had been placed into the patient's upper jaw (Figs. 9 & 10). A CT marker was then connected to the NaviStent. A scout view had been acquired prior to the actual scan to verify the presence of the CT marker in the CT scan. In order to allow for accurate registration, at least three corners of the fiducial marker must be present in the scan. In order to maintain a high level of accuracy during navigation, it is mandatory that the slice thickness must not exceed a maximum of 0.4 mm. In this case, the slice thickness had been set to 0.3 mm. Afterwards, the scan was exported in DICOM format, then imported into Navident.

Osteotomy planning

When the CT scan is imported into Navident, a proprietary algorithm detects the fiducial's image in the scan, then registers it with a mathematical model of the fiducial that is stored in the computer memory. This enables Navident to map the Jaw Tag, which is

Fig. 11: Prosthetic implant planning using the Navident software. **Fig. 12:** Real-time feedback is provided by Navident using a Jaw Tag and Drill Tag during surgery. **Fig. 13:** The alveolar crest was levelled by a rongeur. **Figs. 14–16:** Implants are placed exactly as planned.

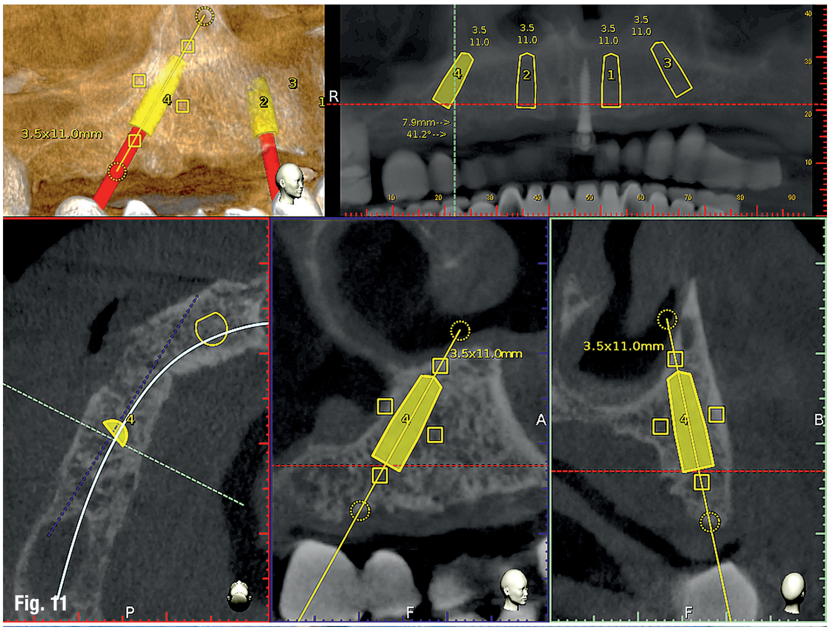


Fig. 11


Fig. 12

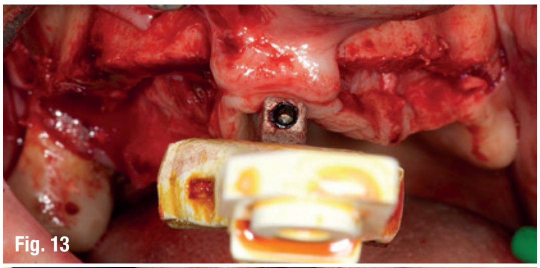
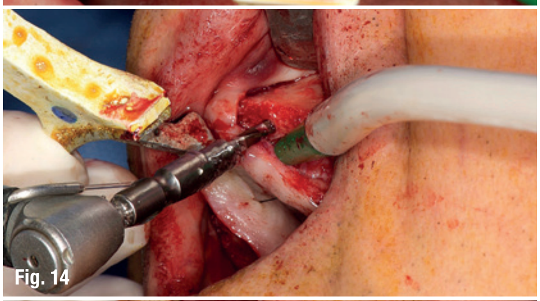


Fig. 13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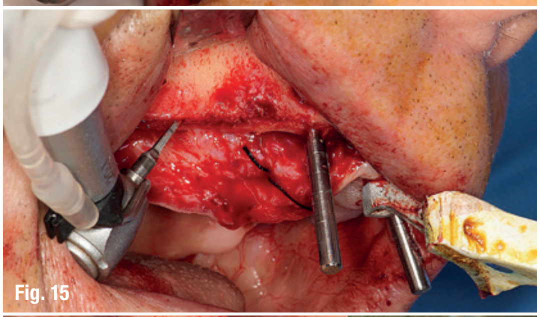
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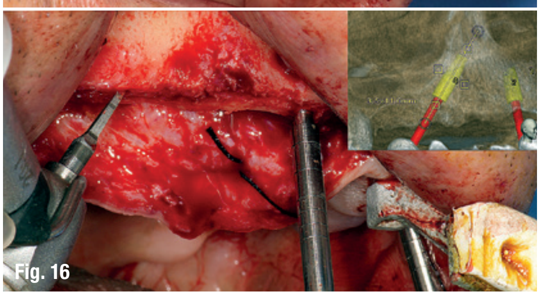
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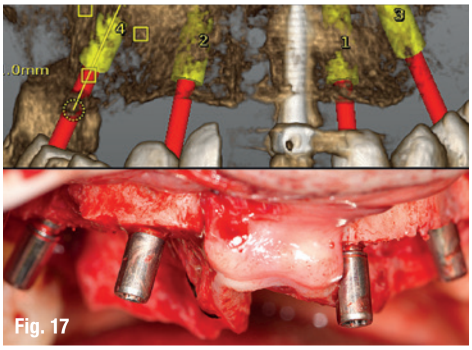
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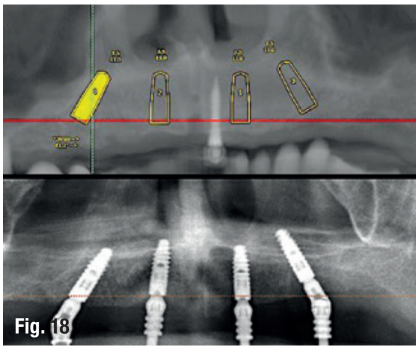
Fig. 18

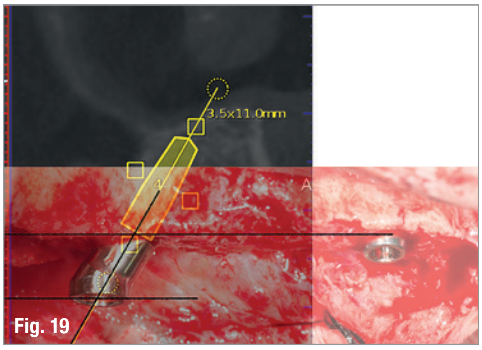

Fig. 19

Figs. 17 & 18: Optimal surgical result. **Fig. 19:** Exact angular position of posterior implants for angulated abutments.

the tag mounted onto the patient, to the CT image during navigation.

For this case, Ankylos dental implants had been selected. The implants with a diameter of 3.5 mm and a length of 11 mm were planned on the locations 15, 12, 22 and 25 using the Navident planning software (Fig. 11). The following parameters were considered when osteotomies were planned:

1. Alveolar ridges, though they had a sufficient bone height, were narrowing at the crestal 1/3. Without waiving or compromising the restorative information, the implant locations were planned to be deeper where at least 2 mm of buccal plate thickness could be achieved.
2. Straight implants were placed at 12 and 22 and tilted ones at 15 and 25.
3. Angulated distal implants were planned 1 mm mesially to the sinus wall.
4. The angle of distal abutments was planned to be 30 degrees to the occlusal plane to have the retaining screws access holes placed in the denture's occlusal aspect since screw-retained abutments have 30 degree joints.
5. The plane of the implant collars was planned to be parallel to the occlusal plane.

Surgery

Before surgery, the CT marker was disconnected from the NaviStent Arm and replaced by the Jaw Tag, which is detected by the Navident camera. A Drill Tag was installed onto the handpiece (Fig. 12). Together with the Jaw Tag, they provide real-time feedback during surgery, enable the surgeon to communicate with the software and place the implant as planned.

A crestal incision was made at either side. Pilot drills were used to start osteotomy followed by the Ankylos dental implant drilling protocol. All drills were navigated according to the planned trajectory, until real-time feedback confirmed that its tip has reached the apical end of the planned osteotomy. The alveolar crests were levelled by a rongeur (Fig. 13). Between each trimming attempt, the pilot drill was touched to the trimmed surface of the crestal bone and its level was checked on the virtual image.

The trimming of the bone was completed under the guidance of dynamic navigation and the pilot drill was again touched to the newly formed alveolar crest. Implants were inserted in the osteotomies as planned (Figs. 14–16), the gingival tissue placed back and sutured with coated poly-glactin 910 sutures. The patient was medicated with antibiotics and chlorhexidine mouth rinse and was released with NSAID's.

Conclusion

The Navident navigation surgery system achieves a successful guidance both in alveoloplasty and implant osteotomies in the edentulous maxilla (Figs. 17–19). In the presented case, the proposed protocol was highly efficient in gathering 3-D prosthetic and anatomical information for the planning. Dynamic navigation provided a precise guidance in the execution of the planned osteotomies through a flexible surgical operation._

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