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KEYWORDS

Oligodontia, dental implants, computer aided design

Oligodontia is characterized by the genetic absence of at least six permanent teeth (except the third molars (1). Epidemiologically, it affects 0.08–0.16% of the European population. Dental agenesis may be isolated or associated with malformation syndromes, such as ectodermal dysplasia, and alters the oral function by resorption of the alveolar bone in absence of local stimulation and by maxillary hypo-development. Currently, there is no consensus on the rehabilitation of these patients, and complex multidisciplinary treatments are often required, combining pedodontic, orthodontic, and surgical therapies, including implant and pre-implant surgery (1–3).

Traditional surgical planning of pre-prosthetic surgery

Severe oligodontia leads to maxillary retrusion with Class III dentofacial deformity (3). In these cases, surgical treatment can included a Le Fort I osteotomy with bilateral calvarial bone grafting in the sinuses to improve intermaxillary relationships and increase the bone volume (3,4). Preoperative planification then required traditionally a dental set-up based on the articulator study, which included a provisional prosthesis to guide the maxillary position during the Le Fort I osteotomy. After achieving the ideal maxillary and mandibular positions, intermaxillary splints or dental prostheses were designed by the prosthetist to ensure correct positioning during the surgical procedure (5). It was important that these prostheses replicate the exact movement of the jaws and predict the position of the future fixed prostheses without the false gingiva. This traditional planning technique remains prosthetist dependent, and the results obtained required experienced surgeon. Indeed, the positioning of these devices during osteosynthesis is difficult and, unlike digitally-designed cutting guides that remain fixed, their endobuccal stability is not enough to optimally maintain the occlusion intraoperatively. In addition, the bone harvesting was not planned and performed by considering the preoperative bone volumes using a presurgical CT-scan. Dental implant placement was planned with tracings after a bone volume assessment 5.5 months after the orthognathic surgery.

Toward a digital pre-prosthetic surgical planning

The development of digital technology has simplified the management using customized pre-implant and preoperative implant planning, allowing precise prosthetic restoration and optimal aesthetic and functional rehabilitation (1). Indeed, in patients with edentulism, terminal bone resorption, or large jaws discrepancies because of maxillary retrusion, reduced facial height, and resorption of the mandibular and maxillary alveolar ridges, computer-assisted design facilitates complex restorations and reduces the number of surgical steps to provide quicker and safer dental rehabilitation. It combines the three essential elements of global therapy, pre-operative surgical planning, safety of movement, and reduced working time. SimPlant® (Columbia, MD, USA), was the first implant planning software developed in 1993. Subsequently, several companies, including Nobel Biocare with the NobelGuide® software, Materialise with SimPlant®, Bluesky plan, Dental Wings and its co-diagnostic software, Sirona and its Cerec® solutions, Align Technology with its iTero® scanner, and 3D system Shape®, have developed digital printing and democratized guided implant surgery (6).

Based on these new technologies, it is now possible to accurately determine the three-dimensional (3D) position of implants and to transfer this information to the surgical guide.

The first step towards digital planning has firstly concerned the implant simulation. Therefore, digital impressions of the prostheses were made and the .STL files were matched with the 3D DICOM images using the “dual CT scan” technique to obtain a match between the clinical and radiological conditions. This allowed an evaluation of the inter-arch relationships and demonstrated insufficient bone volume in the entire maxilla. Pre-implant surgery, including Le Fort I osteotomy and calvarial bone grafts, was traditionally planned with the help of the prosthetist. A pre-prosthetic set-up was performed on an articulator using the patient's anatomical impressions to determine the ideal maxillary position and the displacement required during the Le Fort I surgery. This simulation allowed to design the transitional prostheses with the planned occlusion. These prostheses served three purposes: 1) Creation of an implant surgical guide using duplicate of the mandibular prosthesis. 2) Immediate loading of the mandibular implants. 3) Control of the final maxillary position during surgery using the prosthetic occlusion. In the same way as for the full-traditional method, bone grafting using calvarial bone grafts was performed without digital pre-surgical planning. 5,5 months after orthognathic surgery, dental implants were placed using surgical guide, create by from a digital simulation of implants placement. Bone-supported guides ensured parallelism between the implants and limited the risk of angulation and deviation at the implant emergence or apex during placement (7) (Figure 1). Finally, this approach was more accurate than the fully traditional method because it allowed to better positioning the dental implant after a traditionally planned pre-prosthetic surgery, but this does not improve the pre-implant part of the pre-prosthetic procedure, which remains dependent on the surgeon's experience.

Fully digital pre-prosthetic surgical planning

Today, computer-aided design and manufacturing (CAD-CAM) of surgical cutting guides is widely used in oral and maxillofacial surgery. Our team has previously reported the use of autologous calvarial bone graft with a CAD-CAM support (8,9). This digital pre-planned bone graft can therefore be used in addition to digital pre-planned orthognathic surgery, mandibular osteoplasty with bilateral nerve bypass and digital pre-planned implant surgery in a fully digital pre-prosthetic surgery (Figure 2). The advantage of this approach is that the surgery is more precise and less invasive, as only the required amount of bone is harvested. The guide for Le Fort I osteotomy ensured reproducibility of the surgical procedure and precision of the direction and depth (10). Prefabricated plates were also designed by computer after osteotomy simulations because of their numerous advantages. They allow precise alignment of the osteotomy and three-dimensional skeletal repositioning, and have improved mechanical properties (5). The combination of cutting guide and prefabricated plates ensured the control of each surgical step, correct maxillary positioning, and facial height management in accordance with the prosthetic plan. The computer-assisted pre-implant surgery provided a reliable basis for implant placement and final implant-supported rehabilitation.

Unlike traditional surgeries, computer-assisted surgeries follow the key principles of prosthetic planning and guarantee ideal implant positioning. The use of surgical guides was essential to achieve optimal implant positioning and ensure aesthetic and functional rehabilitation. Immediate loading can be performed, with the prostheses placed 24 hours postoperatively based on the preoperative prosthetic planning. A literature review (11) published in 2010 examined the complications of guided surgery and found that, the mean implant deviations at the shoulder and apex were 1.42 mm and 1.77 mm, respectively. The mean difference in angulation was 2.67°, with a maximum of > 7° (11). Accumulated errors at any stage of treatment, ranging from three-dimensional imaging to the endobuccal surgical guide placement, may have caused these differences between the planned and final implant positions (11). Koop *et al.* suggested that these deviations may be due to the freedom of movement of sleeves and drills in the surgical guides (12). In consideration of these positioning deviations, it is advisable to maintain an average safety distance of 2 mm from the adjacent anatomical features. Other studies have also examined the complications of guided surgery, including a study by D'haese *et al.* published in 2012 (11). However, the complications reported in their study, such as postoperative pain, cover screw loosening, and fracture of the supra-implant crown ceramic, are not related to the guide, but are inherent in all implant rehabilitation cases (11). High complication rates (42%) have been reported in cases of flapless surgery because of the lack of guide stability and reduced access to the surgical site because of its volume (11). Nevertheless, flapless surgery could not be always performed because of the need for osteosynthesis removal. Guided surgeries have the advantage of not being operator dependent. The surgery is completely safe and reproducible. There is no "blind intervention" because every step follows a precise protocol. Another advantage of the digital workflow is the reduced consultation time. In fact, because of early prosthetic planning, the fabrication of final prosthesis is simpler, faster, and requires fewer appointments.

CAD-CAM have significantly improved patient management. The integration of digital technology in the initial diagnostics and its association with 3D imaging has established a link between two fundamental concepts in implantology: anatomy and the prosthetic outcome. The convergence of biological imperatives, dictated by the patient's bone and gingivae, and prosthetic project imperatives, dictated by the laboratory, is required to achieve an aesthetic and functional prosthetic rehabilitation. The use of surgical guides simplifies the operative steps, ensures reproducibility, and decreases morbidity by making the surgery quicker and less invasive. The postoperative period is limited and the time required for prosthetic rehabilitation is shorter.

Guided surgery, based on pre-implant planning, provisional prosthetic planning, and precise osteotomies and graft harvesting, allows improved prosthetic rehabilitation in patients with severe edentulism, in whom it may be difficult to identify anatomical landmarks for aesthetic and functional prosthesis designing. This is particularly important in edentulous patients for whom stackable guides are being increasingly used.

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FIGURE CAPTIONS

Figure 1: Digitally designed surgical guide for maxillary implant rehabilitation of a young patient with severe oligodontia and operative view of its positioning.

Figure 2: Three-dimensional planning of pre-implant surgery for a young patient with severe oligodontia, with simulation of osteotomies, bone osteoplasties and bilateral nerve bypass, design of pre-drilling guides, maxillary and mandibular wax-ups. Digital planning of the calvarial harvesting and Le Fort I osteotomy with bone grafts. These simulations were carried out with the help of Materialise®.

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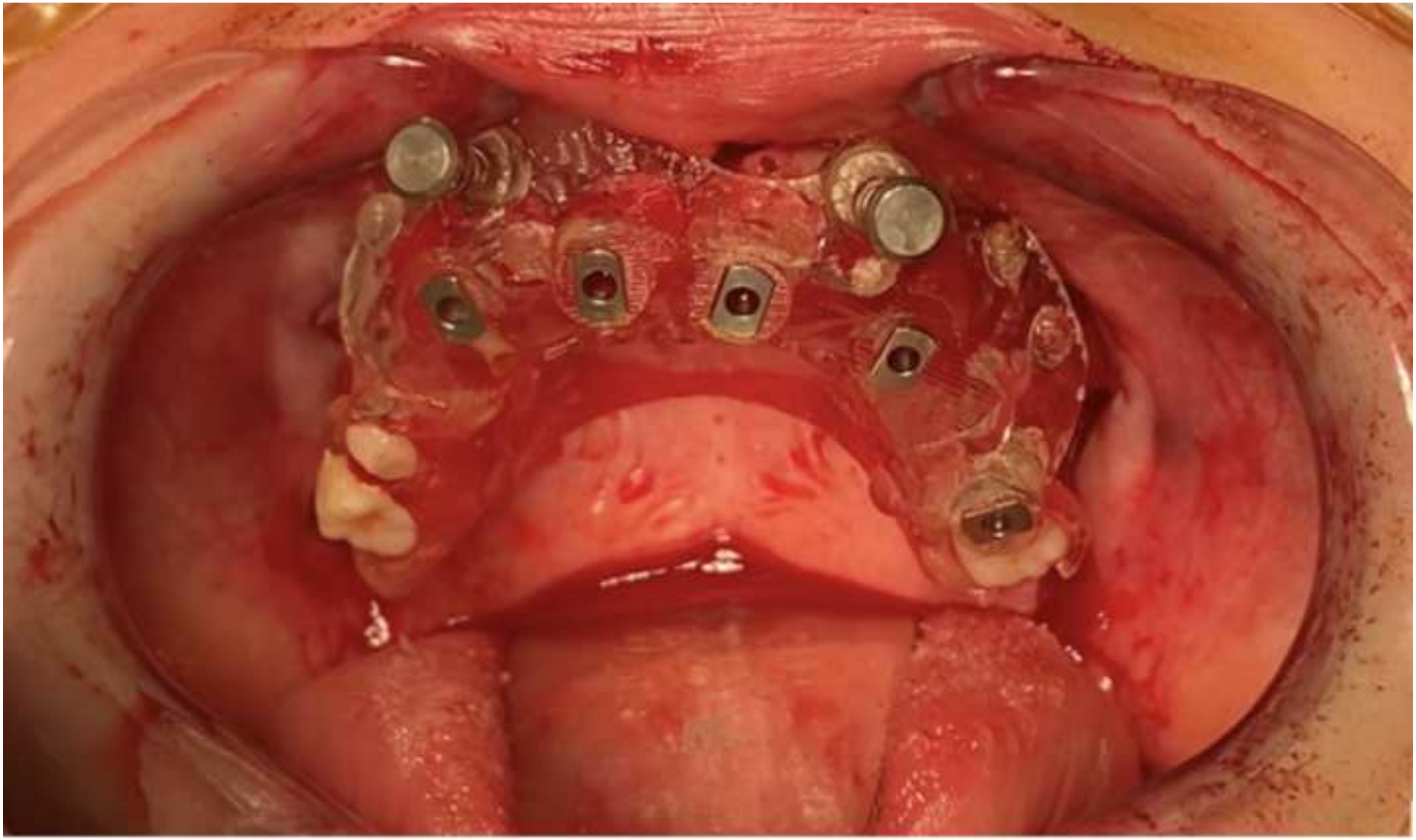
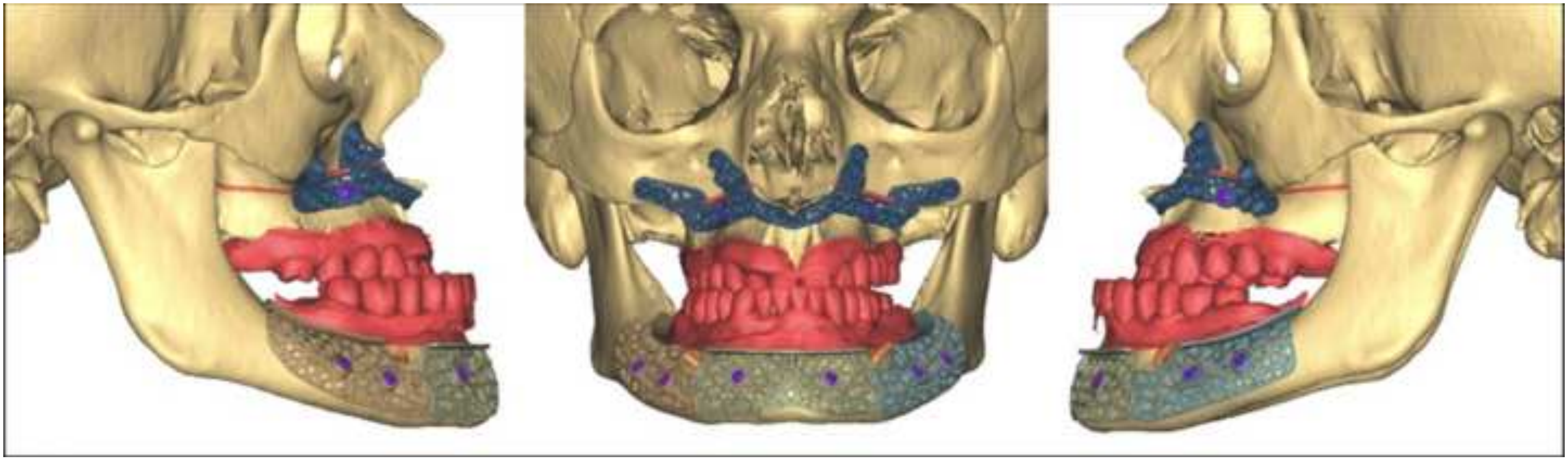
Figure





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