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Computer planned implant-orthognathic rehabilitation: a case of one step surgical procedure with implants insertion, Le Fort I advancement, grafting and immediate loading

ABSTRACT

Aim In the last decade several systems for computer-planned implantology have been reported. Among them is a system that uses a software and a three-dimensional parallelometer able to transfer the implant position from the virtual project to the master model. To verify the potentiality of this system, a single step oral rehabilitation was planned in a patient with edentulous maxilla.

Materials and methods A 52 year old male patient was referred to the Department of Maxillofacial Surgery, Orthopedic Institute Galeazzi, Milan (Italy), in January 2008. He was almost completely edentulous in the maxilla. A CT scan and a computer planning were performed. The one step oral rehabilitation consisted of a single operation composed by a Le Fort I osteotomy, flapless implant insertion, provisional full arch screwing, maxillary advancement and fixation, gaps grafting.

Results After 8 months follow-up no implant was lost and clinical and radiological controls demonstrated the stability of the surgical procedure.

Conclusion Computer-planned and cast model transferred implantology is a helpful technology not only for planning prosthodontic rehabilitation but also for implant-orthognathic surgery.

Keywords Computer, fixture, tomography, graft, pre-prosthetic surgery, orthognathic surgery.

INTRODUCTION

The planning of implant position and its transfer to the operation site is one of the most critical factors for the long-term success of implant supported prosthetic restorations (1). In many clinical studies conventional implant surgery performed by an experienced surgeon has proved to achieve high levels, provided that a proper preoperative planning is carried out (2, 3). However, new technologies should be evaluated in view of their potential advantages. During the last decade, image-guidance systems have become a valuable tool in several surgical disciplines (4). Basic research and routine clinical application of computer-aided navigation conducted over the past 10 years have proved that the application of this technology offers essential improvement in the outcome and intra-operative safety in a wide range of craniomaxillofacial procedures (5), including oral implant surgery (6-8).
Similar to the application of drilling

templates, image guidance system is intended to improve the precision of implant placement and thereby to broaden the indications to difficult anatomical situations. Additionally, both methods are thought to enhance the safety of patients by reducing the risk of damage to adjacent anatomical structures (8, 9). In contrast to drilling templates, image guidance provides the surgeon with multi-dimensional real-time information of the anatomy thus allowing modifications during surgery without loss of guidance (10).

The identification of critical anatomical structures, at the position of the probe, such as the lower alveolar nerve, the maxillary sinus and the roots of adjacent teeth improve surgical performance and safety (11).

A potentially important application of image-guided systems is the exact placement of dental implants in partially or completely edentulous patients with highly atrophic alveolar ridges; as, in fact, the long-term prognosis of implant-supported oral restorations, concerning functionality and implant stability, depends to a large extent on implant anchorage in the jawbone (11). By using three dimensions (3D) images the practitioner virtually places implants in the bone in precise relation to their position in the final prosthesis. Then, the dental laboratory can construct the provisional restoration before surgery, allowing the restoration to be inserted immediately after implants placement (12).

Computer-assisted surgery is known to enhance safety in oral implantology (13), while being compatible with all aspects of implant surgery, including flapless technique (14-18).

Recently, a system to combine computer-planned data to a working cast has been reported (19). The procedure allows the

Fig. 1 Frontal pre-surgical endoral photo.

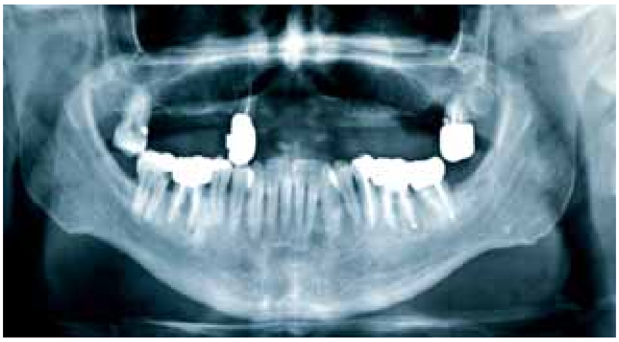

Fig. 2 Pre-surgical ortopantomograph.

Fig. 3 Pre-surgical teleradiograph.

clinician to obtain, on a master cast, the correct implant position based on the one previously planned. This cast is used to build an individual surgical stent that perfectly matches the teeth and soft tissues as well as a provisional or definitive implant-supported prosthesis for partially or completely edentulous patients. To verify the potentiality of this system, a single step oral rehabilitation was planned in a patient with edentulous maxillae.

CASE REPORT

A 52 year old male was referred to the Department of Maxillofacial Surgery, Orthopedic Institute Galeazzi, Milan (Italy), in May 2008. He was almost edentulous in the maxilla. The patient was a smoker (5 cigarettes per day) but not a drinker. He worked in a factory. He had undergone no operation in the head and neck region. No physical problem was referred.

Examination of the oral cavity showed the presence one canine and two third molars in the upper jaw (Fig. 1). In addition a skeletal III Class was evident. No mucosal lesion was detected.

Imaging investigations were performed (Fig. 2, 3) which confirmed the clinical diagnosis and revealed an atrophy of the upper jaw.

Laboratory investigations and chest X-rays were normal.

A CT and a computer planning for implant insertion were performed (Fig. 4). The software elaboration was then transferred to a parallelometer (Fig. 5), and a provisional full arch as well as surgical guide (Fig. 6) were prepared.

The computer planning was analogue to the one previously reported (19). Shortly, the method is based on the transfer of geometric and mathematical values relative to implants three-dimensional

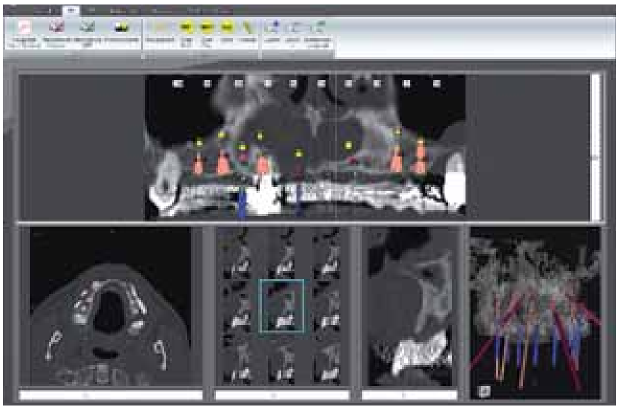

Fig. 4 The computer plan of implant insertion.

Fig. 5 The three-dimensional parallelometer for the transfer of implant position from the virtual project to the master model.

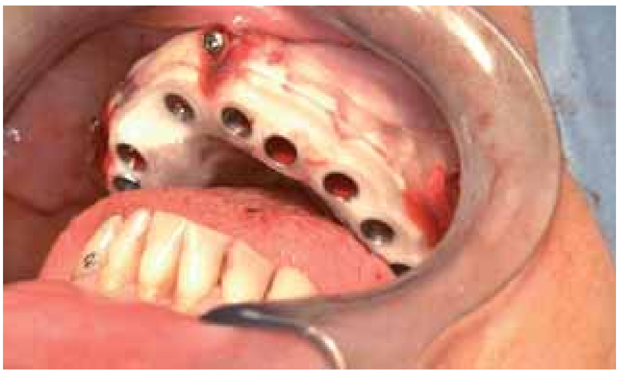

Fig. 6 The surgical guide used during the operation.

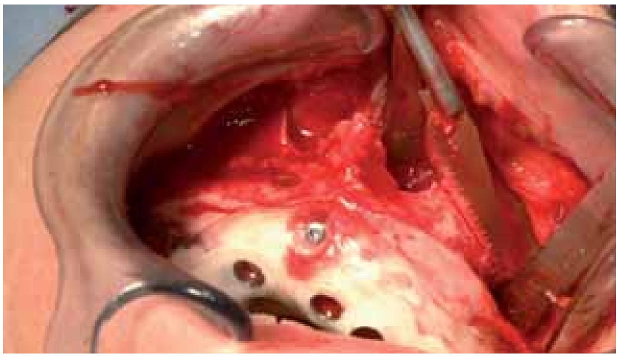

Fig. 7 Le Fort I osteotomy.

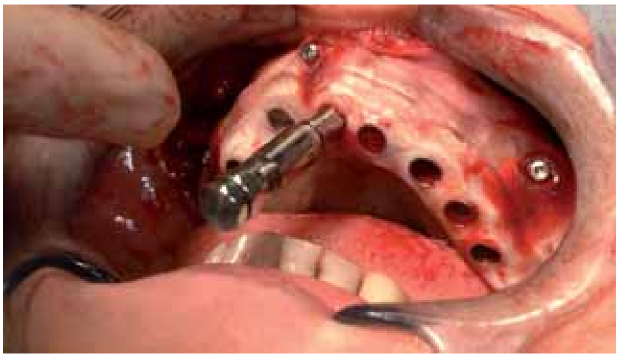

Fig. 8 Implant insertion.

Fig. 9 The provisional full arch is screwed on inserted implants.

Fig. 10 Temporary intermaxillary fixation to maintain the occlusion during the upper jaw fixation.

position obtained by CT and elaborated with a computer program (Implant 3D Software Media - Lab co. La Spezia, Italy). Thanks to the values in the radiographic template, the data elaboration program allows the definition of the implants position with respect to the anatomical paraxial planes prosthetically involved. The faithful reproduction of each implant position on the master model, by means of the implant analog insertion and the treatment simulation, represents the goal of the prosthetic rehabilitation plan and creates the assumption for the temporary and immediate prosthetic construction. Moreover the construction of surgical template of highest precision is done on the basis of the same virtual data. Ray-Set apparatus (Biaggini Medical Devices, La Spezia, Italy) has been planned for the data transfer from the virtual one to the real one. It is a three-dimensional parallelometer able to define the axes relative to the implants positions, their inclinations on the bi-dimensional plans (linguo-vestibular and mesio-distal) and the vertical heights.

Informed written consent approved by the local Ethics Committee was obtained from the patient to perform the surgical procedure and to use his data for research purposes.

Pre-operatively the patients underwent professional oral hygiene and agreed to participate in a post-operative check-up program.

The patient was operated in October 2008. An antimicrobial prophylaxis was administered with 1 g Amoxycillin twice daily for 5 days starting one hour before surgery. In addition to general anesthesia, local anesthesia was induced by infiltration with articaine/epinephrine and post-surgical analgesic treatment was administerd (Nimesulid 100 mg twice daily for 3 days). Oral hygiene instructions were

provided.
After placing the surgical guide (Fig. 6), Le Fort I osteotomy (Fig. 7) and mucotomy were performed, bone drilled and implants were inserted (Fig. 8) as previously planned in the CT-guided protocol. A total of 6 spiral implants (3D Alpha-Biomedical s.r.l., Pescara, Italy) were inserted. The provisional full arch was screwed onto implants (Fig. 9) and a temporary intermaxillary fixation was done to maintain the occlusion during the upper jaw fixation (fig. 10). Homologue femur bone (Fig. 11) was grafted into the gaps (Fig. 12). The femur homografts obtained from the bone bank of living donors (Bone Bank of Orthopedic Institute Gaetano Pini, Milan - Italy) - is a mineralized, non-irradiated, only disinfected (with specific antibiotics) and frozen homologous bone. The bone harvesting is obtained from the head of femur immediately after removal from patients treated for hip substitution and several tests to detect potential infective diseases are performed, such as those done for bone derived from cadaver (37-39). Finally the incision was sutured with separate stitches (Fig. 13)
After 8 weeks the final restoration was delivered and at the last check-up (June 2009) clinical (Fig. 14) and radiological controls (Fig. 15, 16) demonstrated the stability of the surgical procedure. No implant was lost.


Fig. 11 The head of femur, an example of homograft from living donor.


Fig. 12 Internal rigid fixation and bone grafts.


Fig. 13 The occlusion at the end of the operation.


Fig. 14 Frontal endoral view after 8 months.

DISCUSSION

Diagnostic imaging is an essential component of implant treatment planning. Until 1980, conventional radiographic techniques have been the accepted standard. Since then, developments in cross-sectional imaging techniques have become increasingly popular in the preoperative assessment and planning of


Fig. 15 Post-surgical ortopantomography.


Fig. 16 Post-surgical teleradiography.

implant patients (20). Recently, computer software programs and 3D radiographic techniques have become available to allow clinicians to manipulate digital images on PC computer software programs and to provide the practitioner with precise implant placement planning (17, 20). However, the exact positioning of the implant with respect to location and angulation is often difficult 25 and to reduce alignment problems, numerous types of radiological, surgical and combined templates and techniques have been proposed (21-27). Therefore, the precise positioning of implants is an essential goal and it may be improved by guidance during the drilling process. Image guidance can reduce the inherent invasiveness of surgery and improve targeting by pre- and intra-operative imaging (11). Currently, a clear trend in the use of computer-guided navigation in dental implantology can be observed (28).

A reliable computer-guided intra-operative navigation system allows accurate transfer of the pre-operative plan to the patient and enables the surgeon to minimize surgical exposure, with the possibility to use a smaller mucosal flap, which results in improved vascularization of the implant site, in less morbidity and bone resorption (29). By using this sophisticated method of computer-guided implantology, anatomic limitations and bone quantity and quality for implant insertion can be evaluated precisely (17). Therefore, intra-operative safety is enhanced because risks such as inadequate bone support or compromise and infringing upon important anatomic structures are avoided (29). Furthermore, postoperative pain and swelling are reduced and postoperative soft tissue dehiscence is eliminated (30). To verify the potentiality of this system, a single step oral rehabilitation was planned in a patient with edentulous maxilla.

The procedure was successful both in immediate and late follow-up .

In addition to the verification of the effectiveness of the surgical planning by means of CT planning and cast model coordination, femur homograft from living donors was tested.

Generally, loss of bone substance reduces the volume of bone available for the placement of implants, and diminished bone quality increases the risk of implant failure. As this occurs, vertically directed resorption increases the inter-arch space. As the projection of the maxilla diminishes in the sagittal plane, the intermaxillary relationships change thereby creating a pseudoprognathism (31, 32). This discrepancy between the jaws leads to

problems with both fixed and removable prosthetic reconstructions of the jaws with teeth.
The jaws are often resorbed to the point where adequate implants cannot be placed (33). The combination of loss of projection of the maxilla and diminished vertical bone height results in collapse of the soft tissues of the midface and an aged appearance while simultaneously creating an oral environment unsuitable for denture retention (31, 32).
Various procedures have been developed to augment the alveolar ridges to allow for adequate reconstruction of the dentition. Orthognathic surgical procedures have been developed to reposition the jaws and have been traditionally used in the dentate patient to correct a skeletal malocclusion. These procedures are usually carried out with orthodontic control of the dentition to produce the best results. These same procedures, like a maxillary Le Fort I osteotomy, can be used on the edentulous patient to correct the discrepancies between the jaws, in order to reconstruct the dentition with implants (33, 34). Bone grafting procedures are often required in these cases so that the alveolar crest can be augmented at the same time and allow for dental implants to be placed (33).
Different approaches have been proposed based on different procedures (35, 36). The use of an interpositional bone graft and a Le Fort I osteotomy as a pre-prosthetic procedure in atrophic edentulous maxilla has been well accepted since 1976 (37-39). This reconstructive method has the advantage over other commonly used techniques of allowing the placement of osseointegrated implants into a highly atrophic maxilla while correcting the unfavorable intermaxillary sagittal, transverse and vertical relationship and improving facial esthetics (40).
Evidence-based data from refereed journals indicate that the two accepted methods for reconstructing severely atrophic maxilla are simultaneous Le Fort I osteotomy with interpositional bone grafting or iliac crest onlay bone grafting (36, 41, 42). In our case femur homograft was derived from living donors: it has relatively low costs, is available in programmed amounts, and avoids a second operation field. Moreover, it is safer than the homograft derived from cadaver as it allows repeating the serological test after several months providing additional security for the receiving patient.

CONCLUSION

In conclusion, one step oral rehabilitation by means computer-planned and cast model coordination can be used in selected patients. It significantly shortened the time of rehabilitation without adverse effect. In addition, femur homograft derived from living donors is a valuable material for grafting jaw: it is not costly, available in programmed amounts, avoids a second operation field, and it is safer then the homograft derived from cadaver.

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