Guided sinus lift: virtual planning of surgical templates for lateral access

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The sinus lift with lateral approach is a regenerative technique nowadays considered predictable to increase the height of bone in the atrophic posterior maxilla. Knowledge of sinus anatomy and evaluation of risk factors are the basis of regenerative and rehabilitative surgical success. The positioning and size of the lateral antrostomy represent critical factors in the execution of regenerative surgery, due to the difficulty in transferring radiological information to the lateral wall of the maxillary sinus even for skilled surgeons. The knowhow of guided implant surgery in recent years is also finding use in planning and precisely delineating the lateral access to the maxillary sinus using CBCT imaging and dimensional reconstruction software, through the realization of surgical guides with 3D printing, as shown in the presented case.

The Maxillary sinus lift, with lateral access, is a surgical technique first described in literature in 1980 by Boyne and James. The lateral approach differs from the crestal approach due to the creation of a bone window on the external wall of the maxillary sinus; after the Schneiderian membrane has been detached, the bone window is tilted inside the sinus with simultaneous lifting of the membrane itself; the space between the bone floor and Schneider's membrane is filled with regenerative material. In this way, the bone height required for contextual or delayed implant placement in the edentulous maxilla can be increased in a predictable manner (1-5).

Many reviews attest to the predictability in terms of survival rate of the implants inserted in the augmented sinuses. Crucial factors for regenerative success and implant rehabilitation are evolution of radiological imaging and the piezosurgical approach as well as proper regenerative techniques (6-13).

Despite technical and technological progress, are also frequent reviews of complications and accidents associated with this procedure. The most frequent complications are perforation of the Schneider membrane and excessive bleeding. Both have or may have bad consequences for the success of regeneration and rehabilitation, with the lengthening of surgical time and an increase in the difficulty of the operation (14-23).

The design of lateral anthrostomy must consider both rehabilitation needs and the anatomical conditions of the sinus, characterised by the possible presence of a number of factors: Underwood bone septa, maxillary arterial branches, roots of adjacent teeth, sinus recesses, abnormal thickness of the vestibular bone wall, reduced sinus width, pathological thickening of the sinus membrane.

Correct tri-dimensional radiological knowledge and visualization is now essential and allows a reduction of perforation risk of Schneider's membrane if are properly transferred to the surgical table (14-31).

The positioning of the anthrostomy, size and

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extension must be defined on the TCCB and precisely positioned on the lateral wall, avoiding what Mandelaris and Rosenfield have called Mental Navigation. The authors in 2008 described the use of digital surgical templates for lateral access to the maxillary sinus. Their protocol included the acquisition of DICOM data via conventional CT or TCCB and on the basis of these, the required implant rehabilitation was outlined using 3D surgical planning software. With a different software, the osteotomic margins of the anthrostomy were designed. The project thus obtained was sent to a milling centre where the surgical template was made (32-40).

MATERIALS AND METHODS

In September 2019 we observed a 60-year-old male, non-smoker patient in good general health, with sufficient oral hygiene control, wearing a partial mobile prosthesis and presenting bilateral maxillary edentulousness following the loss of numerous dental elements; already treated 10 months earlier for maxillary sinus elevation with lateral approach in quadrant 1, he presents distal edentulousness in quadrant 2 at 2.3.

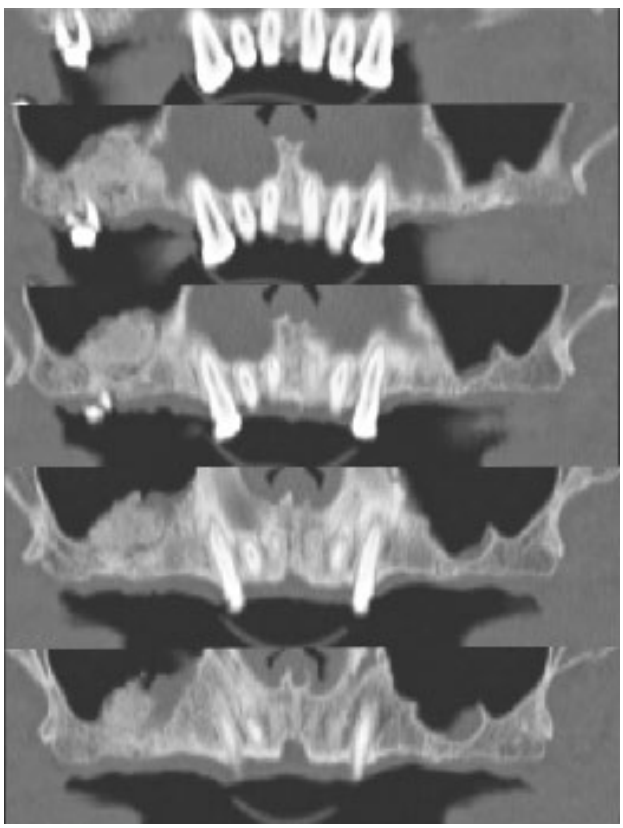

Fig. 1. *TCCB - Panorex view, bone height (3.5 mm) in zone 2.6 and the presence of septum of Underwood in zone 2.7.*

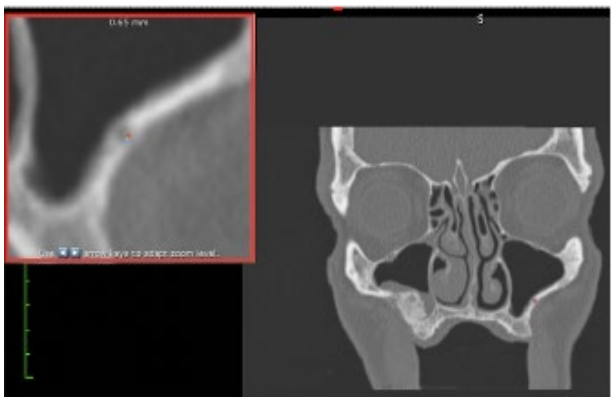

Fig. 2. *The intraosseous course of the antral artery in zone 2.6. about 10 mm from the residual ridge.*

The residual left maxillary ridge on clinical examination was of adequate width and the interarchate relation (vertical and horizontal) was acceptable. The prosthetic implant rehabilitation proposed was an Implant supported bridge, on 2 implant fixtures 2.4 and 2.6, after radiographic evaluation of sufficient bone volume for standard implant (4.1 mm x 10 mm).

The CBCT examination of the upper jaw (NewTom VGi; NewTom Inc) showed that there was insufficient bone height (3.5 mm) in zone 2.6 for the planned implant length (10 mm). In addition, there was a septum of Underwood in zone 2.7 and the intraosseous course of the antral artery in zone 2.6. about 10 mm from the residual ridge (Fig. 1, 2).

The treatment proposed in this case involves the Sinus Augmentation with a lateral approach and delayed insertion of implants. The digital workflow for planning the surgical stent to perform the maxillary sinus augmentation was described in 2018 by B.J. Goodacre:

1. The DICOM file of CBCT is transformed into a 3D bone model using the reconstruction software (InVesalius).
2. The bone model is exported as STL file; this is superimposed on the CBCT data using the surgical planning software (Blue Sky Bio). (Fig. 3).
3. In relation to the planned position of the implant, a surgical guide is designed to cover the lateral wall of the sinus with particular attention to the septum and

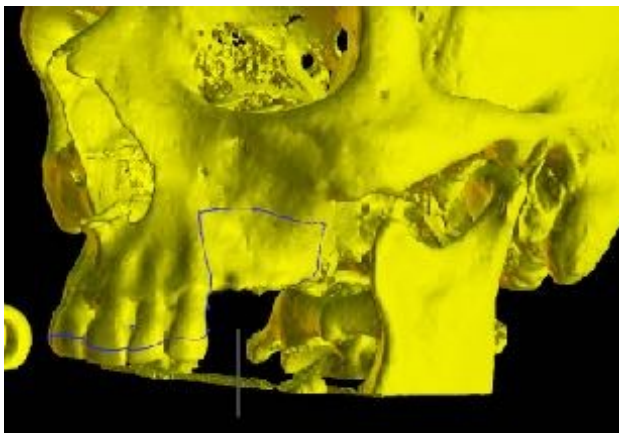

Fig. 3. *Planning the layout of the template, with support and extension on the lateral wall using Blue Sky Bio software.*

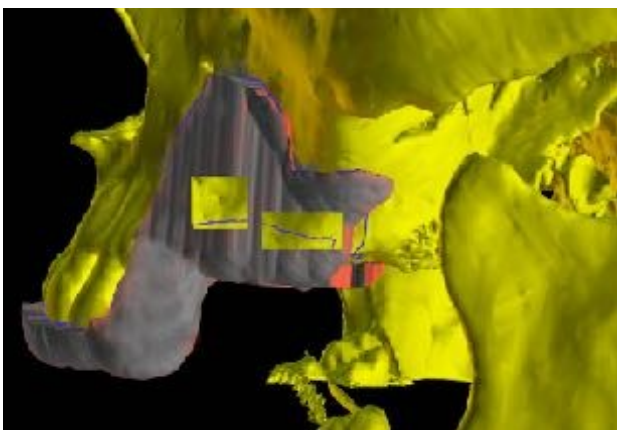

Fig. 4. *Evaluate the support of the template and view the finalized stent.*

the intraosseous course of the vessel.

4. The lateral window is designed with the appropriate extension and localization.
5. The surgical guide is exported as an STL file, its contours are defined using the Meshmixer software.
6. In conclusion, the STL file of the surgical guide is imported into the printing software. (Fig. 4).

RESULTS

The digital workflow for the realization of a surgical template to support sinus augmentation surgery with lateral approach and implant insertion is shown in Fig. 5. The DICOM data from CBCT together with the intraoral digital scan of the mouth are processed to obtain an STL bone/dental model. On this model, through the surgical programming software, the type of support of the template and the implant positioning (number, position, length, inclination) are planned; on the basis of 3D sinus anatomy, the anthrostomy is drawn, outlining the margins and their extensions. The STL file of the surgical template thus designed, can be printed through 3D printer or sent to milling centers. (41-46).

DISCUSSION

The maxillary sinus lift by a lateral approach has several critical issues; the localization and the realization of a lateral antrostomy that allows an effective and secure detachment of the schneiderian membrane, avoiding surgical complications related to the sinus anatomy. The regeneration of the maxillary sinus must also be of sufficient volume and size to allow the insertion of the planned implants, without the need for further intrasinus regenerative surgical procedures (47-54).

Therefore, the use of surgical supports that allow to prevent mental navigation, i.e., to prevent the

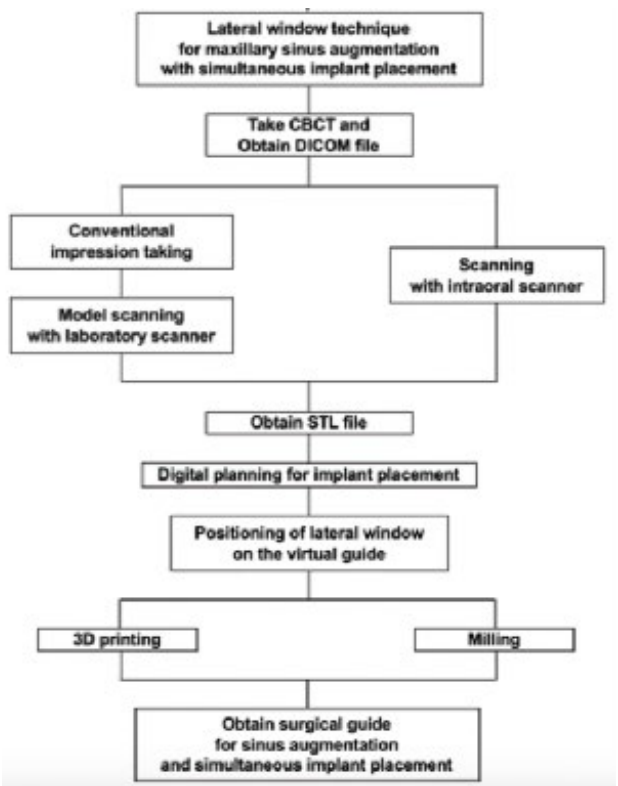

Fig. 5. *Digital workflow diagram for the realization of a surgical template for the Sinus lift augmentation.*

realization of the anthrostomy in an uncontrolled way, seems desirable. This can facilitate the surgical procedure, in terms of reducing the rate of intraoperative accidents (copious bleeding and/or extensive perforations of the membrane), also helping to reduce the surgical stress of the patient and helping the surgeon allowing the execution of more procedures in less time (55-63).

There is no doubt that these devices have advantages and disadvantages, and it is up to the clinician from time to time to identify the application criteria and the cost/benefit ratio. The possibility that with the same template it is possible to carry out the anthrostomy and guided implant insertion, is recommended especially for reducing the surgical time. The surgical template should be seen as a support aid to reduce the incidence rate of events during this procedure with a significant saving of time at the surgical table, better working ergonomics, less operator stress and greater predictability of the regenerative procedure, especially in "difficult" cases. These supports require a learning curve of the software functionality, as well as economic investments (64-69).

However, further studies are needed to evaluate on a large scale the results of the use of computer guided guides in the ability to reduce the number of complications and thus demonstrate the increase in the success rate in sinus Augmentation procedures with lateral approach.

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