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3-D VIRTUAL SURGICAL PLANNING IN MANAGEMENT OF FACIAL ASYMMETRY SECONDARY TO TRAUMA – A CASE REPORT

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ABSTRACT

Three-dimensional (3D) virtual surgical planning (VSP) has proved to be far more precise as compared to traditional two-dimensional (2D) planning in orthognathic surgery.

Facial asymmetries are a challenge to treat as the defect is multidimensional. Hence, a 3D VSP is much more suited for accurate planning and surgical execution with precise and predictable results of complex orthognathic procedures.

In, this article, we have devised a simple 3D VSP protocol which can be utilised for surgical planning for facial asymmetry.

KEYWORDS

Facial asymmetry, three-dimensional virtual surgical planning, orthognathic surgery

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INTRODUCTION

Facial asymmetry is common in the general population and often presents sub clinically. Nevertheless, on occasion, significant facial asymmetry results not only in functional, but also aesthetic issues which may lead to psychosocial problems.[1]

Approximately 4% of the population has a dental facial deformity that requires orthodontic-surgical treatment for its correction.[2] The most common indications for surgical treatment are severe skeletal class two and three cases as well as vertical skeletal discrepancies in patients who are no longer in an active growth stage. Proffit et al reported that 20% of surgical patients have mandibular excess, 17% have maxillary retrusion and 10% have both.[2]

This article aims to derive a seamless 3D workflow using a multi-disciplinary approach to achieve predictable aesthetic and functionally stable results in patients with facial asymmetry to further improve their quality of life and social acceptance.

Mandible forms the skeletal support for soft tissues of the lower face and has a longer period of growth. In addition to having a shorter period of growth, the maxilla is also rigidly attached to the stable region of synchondroses at the cranial base. Therefore, facial asymmetries more commonly manifest in mandible and chin as compared to maxilla.

Over a period of time, orthognathic surgery has undergone significant refinement and development in relation to technique modifications, rigid fixation modalities and recent technological advancements in presurgical planning and splint fabrication. Any discussion surrounding orthognathic surgery in present-day medicine now includes the argument of traditional model surgery versus VSP.[3]. However, VSP has a definite edge in patient acceptance and accurate clinical results.

Facial asymmetry being a 3D problem requires a 3D solution. Cephalometrics being one dimensional do not provide us with accurate problem lists and prediction. 3D cephalometry, which has been facilitated by the introduction of cone-beam computed tomography, can solve these problems.

Computer-aided surgical simulation has greatly enhanced the efficiency and accuracy of orthognathic surgery for correction of dentofacial deformities. VSP improves the efficiency of the presurgical work-up and provides an opportunity to illustrate the multidimensional correction at the dental and skeletal level to the patient.[4]

In this article, we have devised a concise workflow which can be utilized for VSP for facial asymmetry.

CASE REPORT

A 24-year-old male with facial asymmetry secondary to trauma sustained during childhood reported to the Department of Maxillofacial Surgery for correction. He was reluctant to undergo surgery, however, even after prolonged orthodontic treatment for approximately three years, the patient was not happy with his facial appearance. VSP was done and it played a vital role in convincing the patient to correct his facial appearance by orthognathic surgery.

3D-VSP PROTOCOL FOLLOWED FOR ORTHOGNATHIC SURGERY

PHYSICAL EXAMINATION AND CLINICAL PHOTOGRAPHY

Physical examination was done and noted followed by colour photographs taken with the patient in the natural head position (NHP) (Lundstrom et al).5, 7 The extraoral photographic series included complete lateral profile and 45°lateral profile photos from the left and right and two frontal photographs of the patient at rest and smiling. Midline shift with marking, chin deviation with marking, occlusal cant photographs were also taken in repose with a suitable background. Figure 1-Figure 5

Photographic series also included intraoral- occlusion and arch photos. Figure 6-Figure 8

Figure 1 (FRONT PROFILE)

Figure 2 (FRONT PROFILE WITH SMILE)

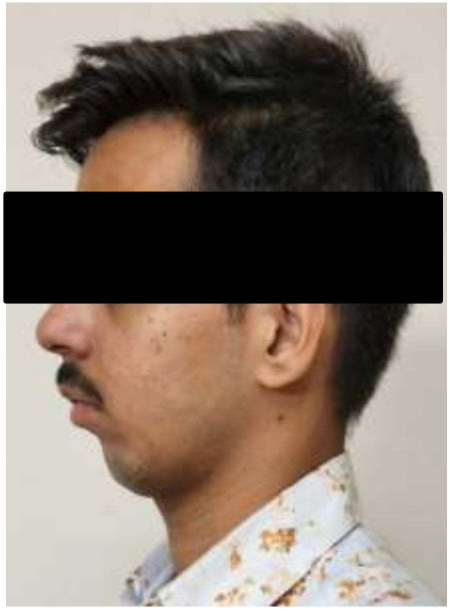

Figure 3 (LATERAL PROFILE)

Figure 4 (LATERAL PROFILE)

Figure 5 (CANT WITH CHIN DEVIATION)

Figure 6

Figure 7

Figure 8

PRE-OPERATIVE PLANNING USING 3 DIMENTIONAL VIRTUAL PLANNING

In general, the planning process involves the following steps. The first step is to compile data from different sources. These sources include physical examination, medical photographs, and medical imaging studies that include plain radiographs, cephalometric radiographs, CT, and other studies. The surgeons will then compile all the data to create a complete comprehensive picture of the patient's condition. This task is often challenging, especially in patients with complex 3D problems. The second step in the planning process is to simulate the surgery. In craniomaxillofacial surgery, this step may begin with prediction tracings. The surgical simulation is completed by moving the bone tracings to the desired position. A drawback of prediction tracing is that it is two-dimensional. 9 3D reconstruction data in DICOM was obtained with cone beam computed tomography for the upper and lower arch using the CS9600(Carestream) system. Intraoral scanning was done for both the arches and the occlusion, and the data was obtained as STL files.

This data was used, and treatment planning was done using the PROPLAN CMF software. Three treatment plans were designed using 3D visualization of patient's dentofacial anatomy and were constructed virtually to predict the outcome which were as follows:

TREATMENT PLAN A – WITHOUT GENIOPLASTY

Was proposed with impaction of right maxilla by 2 mm for cant correction with midline correction of 2mm and down fracture of left maxilla by 2mm for cant correction. Mandible was planned to be advanced by 4mm with dental midline correction and bodily shift towards the right by 4mm along with differential impaction of the mandible to set into occlusion.

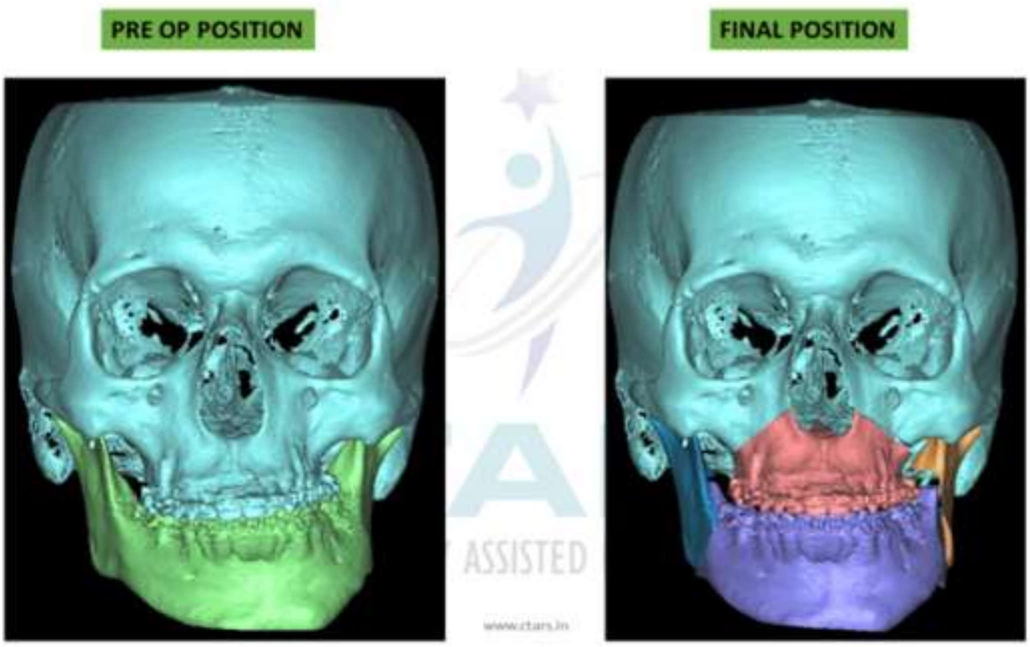

Figure 1 (hard tissue simulation of plan A – front view)

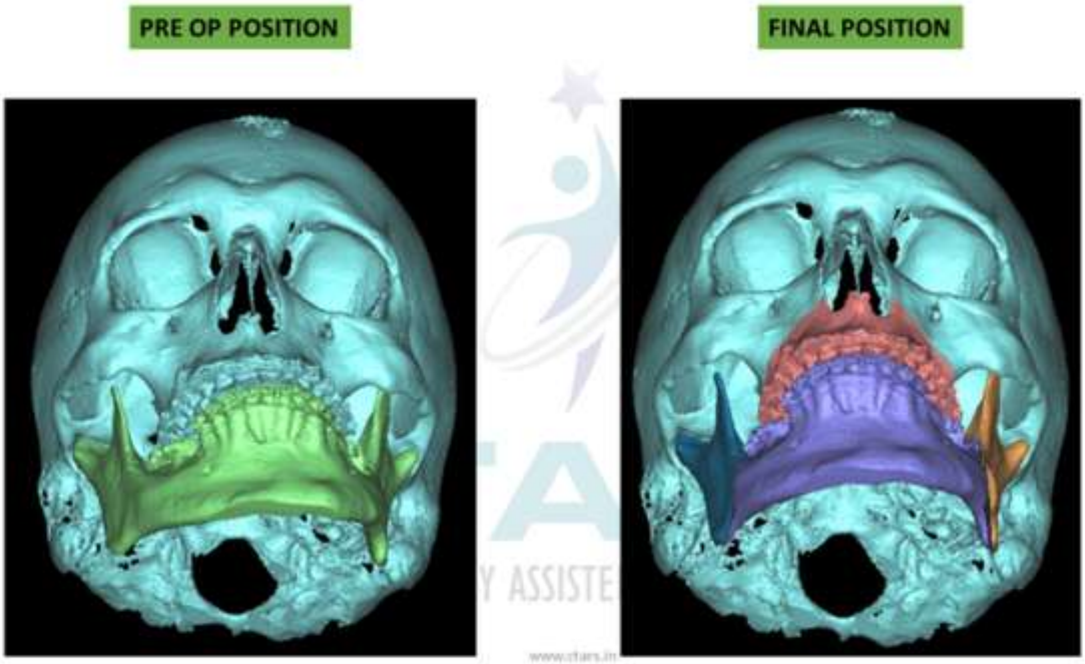

Figure 2(hard tissue simulation of plan A)

Figure 3(soft tissue simulation of plan A)

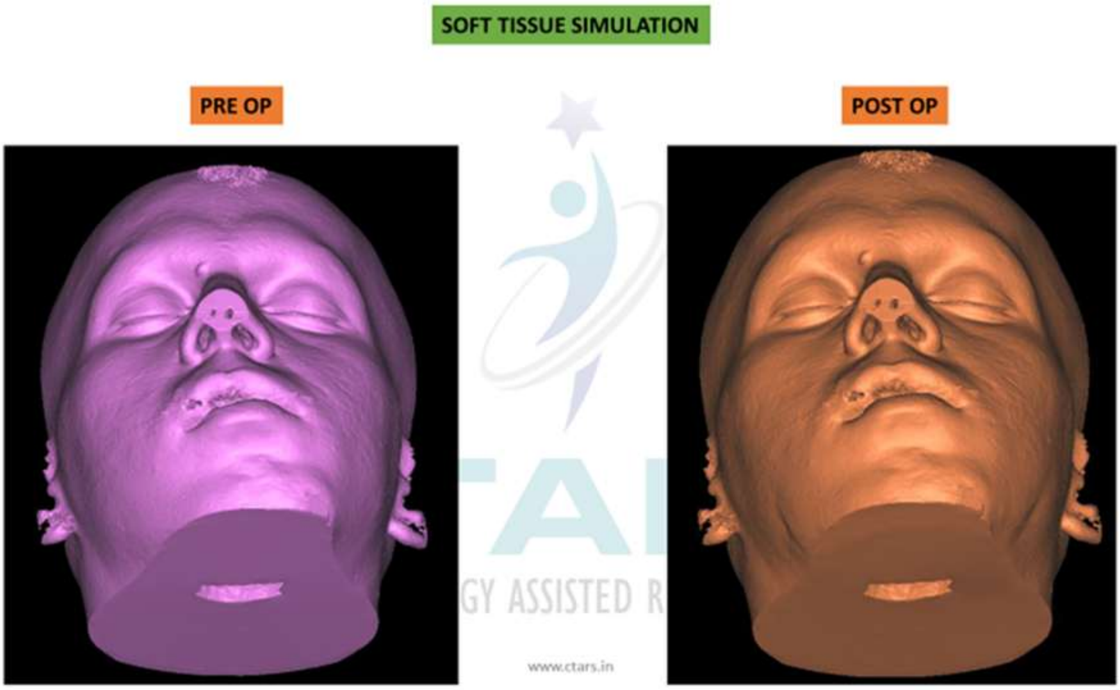

Figure 4(soft tissue simulation of plan A)

TREATMENT PLAN B-

Was proposed for correction of midline in maxilla by 2mm, impaction of right side of the maxilla by 2mm along with downward movement of the left maxilla by 2 mm for cant correction. In the mandible advancement of 4mm was proposed with dental midline correction obtained by bodily shift towards the right by 4mm. Reduction genioplasty was proposed by 3mm in height along with setback of 4mm and rotated towards the right by 2mm.

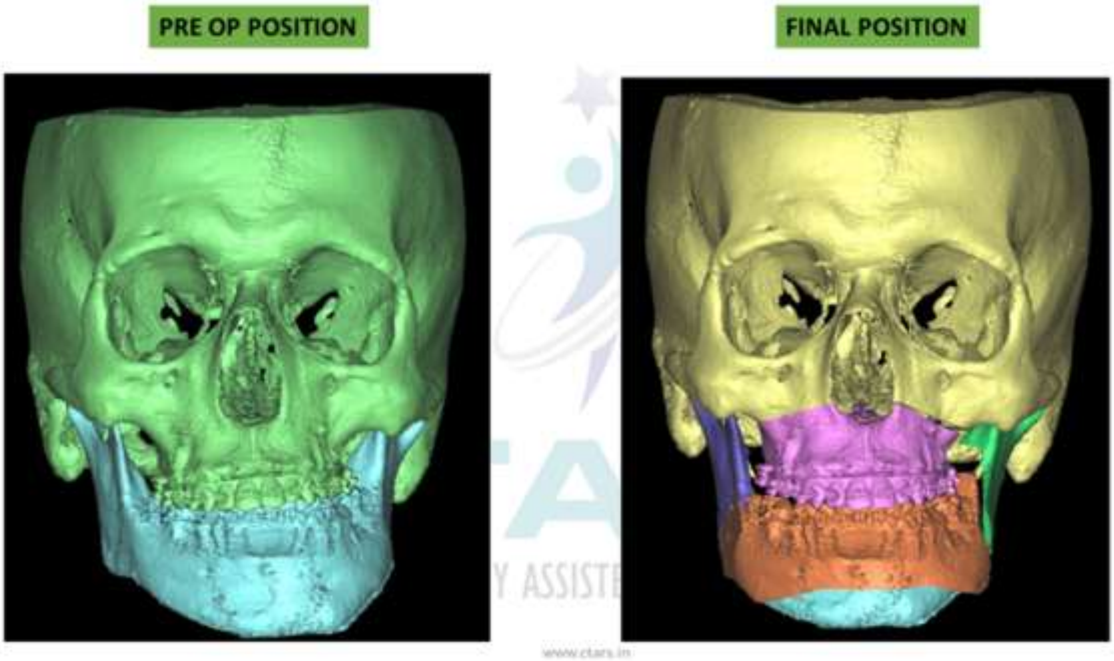

Figure 5 (hard tissue simulation of plan B)

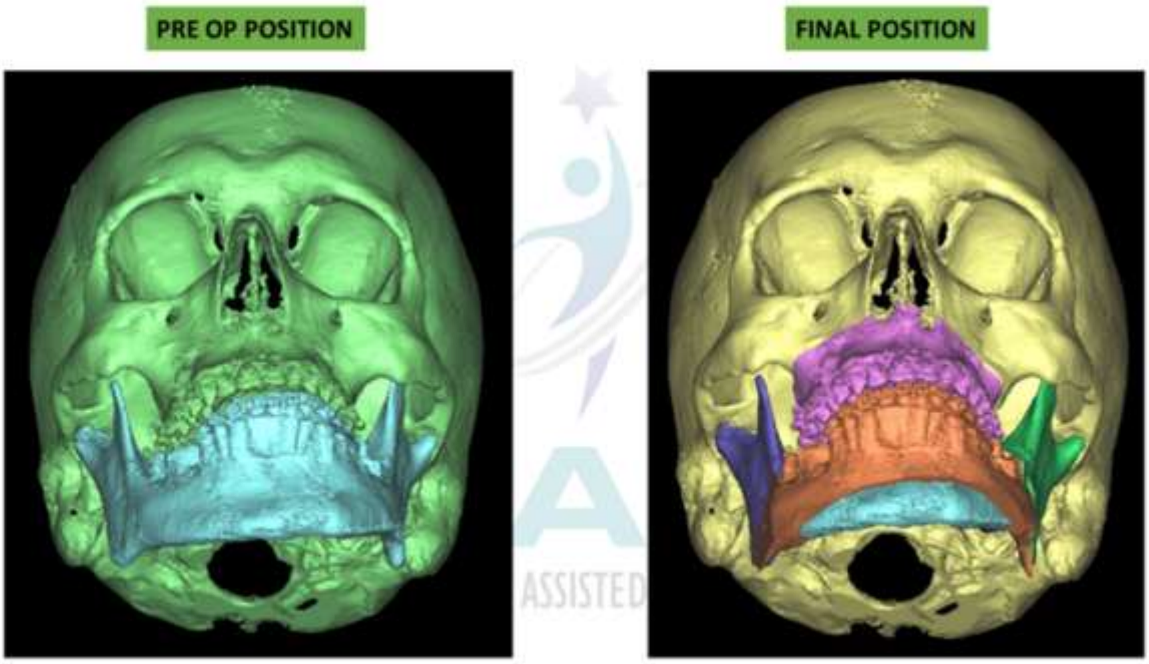

Figure 6 (hard tissue simulation of plan B)

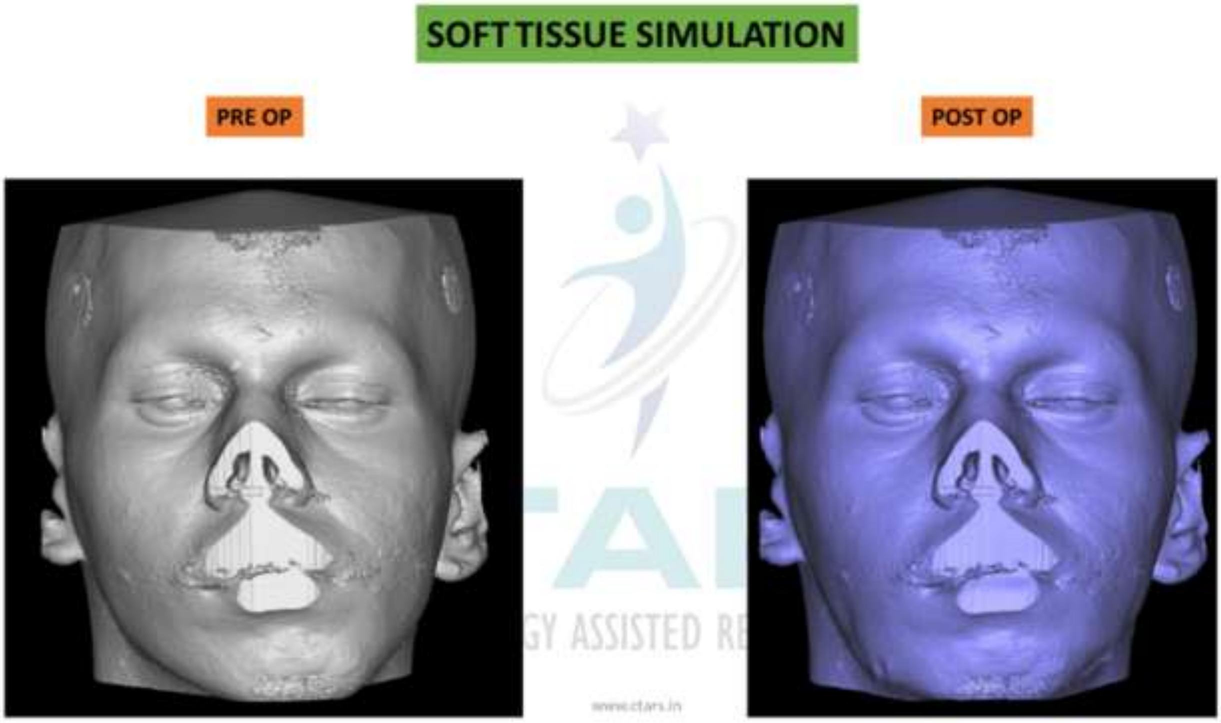

Figure 7(soft tissue simulation of plan B)

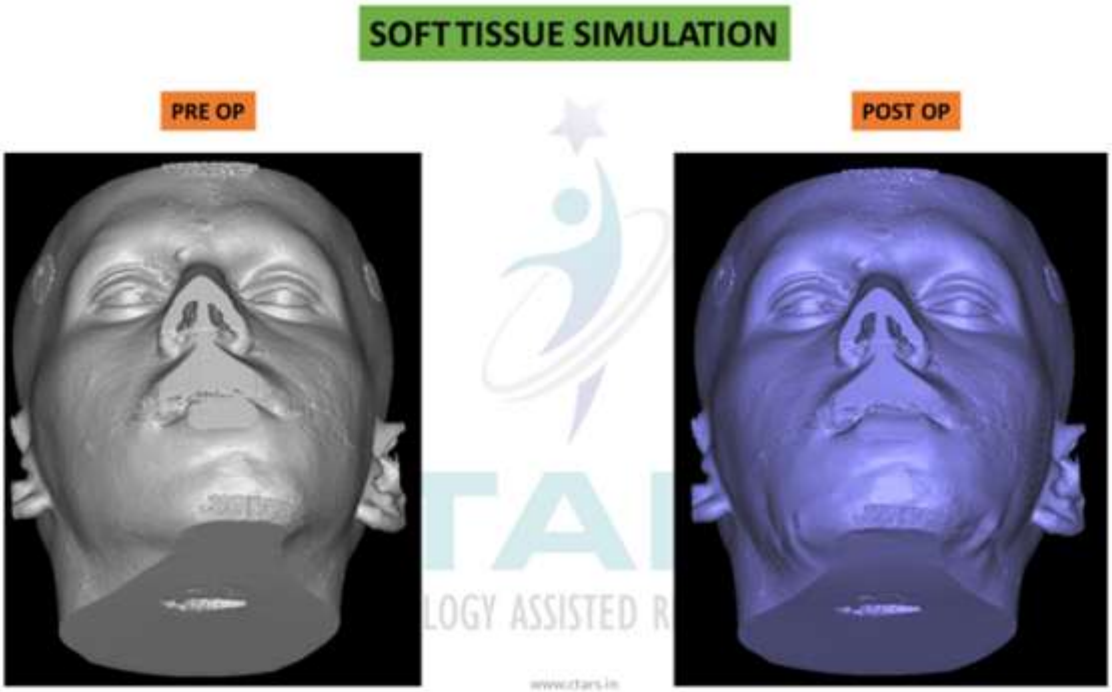

Figure 8(soft tissue simulation of plan B)

TREATMENT PLAN C

Was proposed with midline correction of 2mm in the maxilla along with right side impaction of 2mm for cant correction and downward movement of left maxilla by 2mm for cant correction. Mandible was proposed to be advanced by 4mm with dental midline correction and a bodily shift towards the right by 4mm along with differential impaction on the mandible to set into occlusion and temporomandibular joint replacement. Genioplasty was proposed with 3mm of reduction and setback of 4mm and shift towards the right by 2mm.

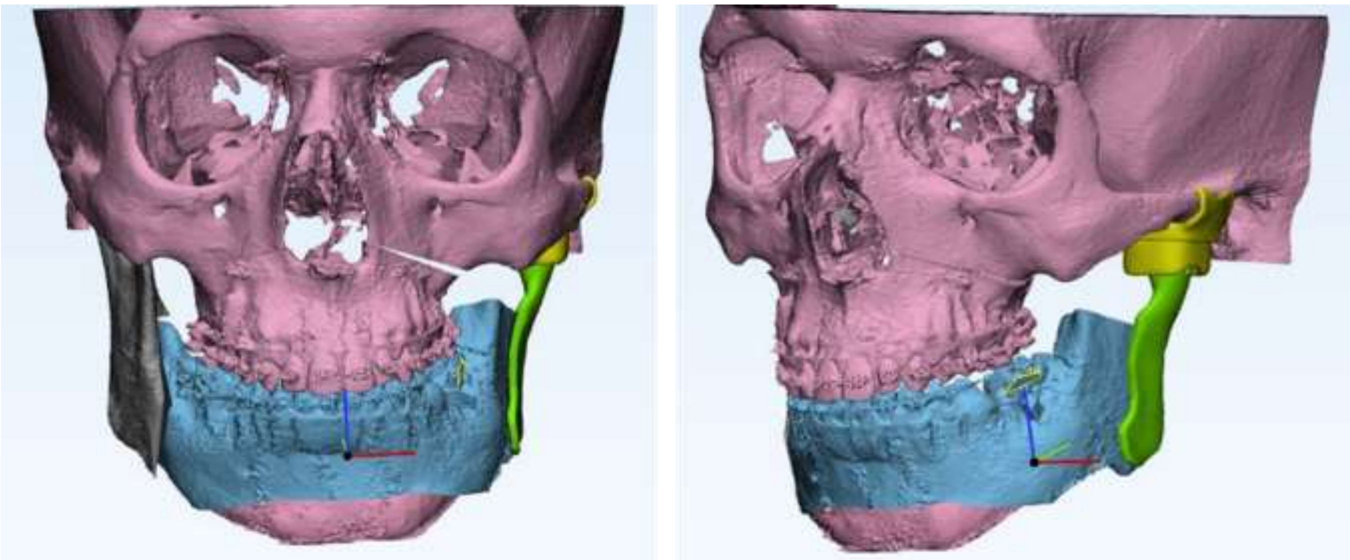

Figure 9(hard tissue simulation of plan C)

After due deliberations with the patient and patient's relatives, plan B was finalized as the most effective treatment plan.

WORKFLOW:

Compilation of data (patient's concern, medical records, clinical examination and photographs)

⬇

Radiographic data (2D cephalometry, orthopantomogram, CBCT, 2D and 3D CT face-dicom files)

⬇

Intra-oral scan (STL file)

⬇

Alignment and fusion of scanned data

⬇

Data analysis using software (PROPLAN CMF)

⬇

Derivation of treatment plans

⬇

Finalise the treatment plan after discussion with operating team and the patient

⬇

3D printing of models, bone cutting guides, surgical templates, patient specific implants

⬇

Provisional and final splints

FINAL SURGICAL APPROACH-

After discussion with patient, patients relative and the operating surgeons the final treatment plan was finalised.

A pre-anaesthetic check up was done for the patient. Pre-antibiotic coverage was given. Patient was taken into the operation theatre and intubated via naso-endotracheal route. All routine aseptic procedures were done. Injection 2% lignocaine hydrochloride with adrenaline (1:200000) was injected intraorally with respect to upper and lower arch in the form of nerve blocks and local infiltrations. Vestibular degloving incision was taken in the lower labial vestibule to approach the symphysis region. Bilateral mental nerves were identified. Reduction genioplasty was done by 3mm along with setback of 4mm and shifted towards the right side by 2mm. The segment was then secured with 3D genioplasty miniplate and titanium screws. Bilaterally the ramus of the mandible was exposed, and bilateral sagittal split osteotomy cuts were given with a piezoelectric device. Bilateral third molar extraction was done in the upper arch. A degloving incision was taken in the maxillary arch. Blunt dissection was done to expose the bone. Modified le-fort 1 osteotomy cuts were given followed by superior impaction of right maxilla by 2mm and downward movement of left maxilla by 2mm for correction of the yaw. Intermediate splint was then secured using intermaxillary fixation. Fixation of maxillary segment was done using titanium miniplates and screws. The midline correction was done. Intermediate splint was removed, and final splint was secured. Fixation was done using titanium miniplates and screws after final mandible position was achieved. Final splint was then removed. Satisfactory occlusion was achieved, and alar cinch was taken to aid in soft tissue contouring. Closure was done in layers using 3-0 vicryl. Patient was extubated uneventfully.

POST OPERATIVE PHOTOS -

Figure 10 (FRONT PROFILE)

Figure 11 (FRONT PROFILE WITH SMILE)

Figure 12 (LATERAL PROFILE)

Figure 13 (LATERAL PROFILE)

Figure 14 (CANT CORRECTION AND

CHIN DEVIATION CORRECTION)

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Figure 15

Figure 16

Figure 17

DISCUSSION

As surgeons, our goal is to create a surgical plan that will result in an ideal surgical outcome.4, 9 For the treatment to be successful, the patients must have a thorough awareness of the expected outcomes. Precise treatment planning is essential for the best possible occlusal and aesthetic outcomes while undertaking orthognathic surgery. A number of methods have been used in the past to achieve this goal including manual surgical simulation based on tracing of cephalometric radiographs, acetate overlays, and cut-and-paste profile tracings followed by manual repositioning of the patient photograph. Lately, computer software programs have been developed and used to analyze and predict the outcome of orthognathic surgery. These programs are designed so that they allow surgical manipulation of both the skeletal and overlying soft tissue response10

In orthognathic surgery, due to the inherent limitations of visualising, planning and predicting 3D structures and procedures in 2D, over the last decade there has been a progressive movement towards working virtually in 3D (Popat and Richmond, 2010).5,6 The drawback with using these software programs is that they require time, practice, and precision to use the different tools available for predictable results, and the novice user would find this challenging.10 Conventional model surgery planning produces one or more acrylic occlusal splints to aid maxillary or mandibular segment fixation intraoperatively. Errors, however, can be introduced during this process, for example, in identifying the condylar hinge axis or transferring the facebow record to the articulator (Zizelmann et al., 2012). It is also felt that the complex rotational and translational movements of the condylar hinge axis are oversimplified by traditional articulators. The degree to which this affects surgical planning is unknown as no high-quality studies verifying accuracy have been published.5

Use of the 3D modeling system has increased our effectiveness during the surgery. It has saved us tremendous amount of time in the preparation of surgical cases. The average surgical workup takes about 1 hour to collect the clinical data and scans, another 5 to 10 minutes to set and mark models after they are dry and determine the postoperative occlusion, and anywhere from 10 to 20 minutes to finalize the surgical treatment plan on the computer depending on the difficulty of the bony movements.8 Because the 3D nature of the planned surgery is visualized, it allows the surgical team to anticipate potential complications and pitfalls before undertaking surgery. This may not be readily apparent during conventional model surgery. In addition, because the cross-sectional anatomy can be visualized, important anatomic features can be visualized and appreciated before surgery. The reliability of this type of planning and splint fabrication is excellent.8

Treatment for facial and dental asymmetries can be challenging, necessitating a thorough diagnosis based on accurate and comprehensive information. If we follow the right evaluation methods for craniofacial and dental conditions and make the appropriate use of the various diagnostic aids that are available, diagnosing face asymmetries will be easier.

Starting with the diagnosis, the orthodontic-surgical treatments must be planned in an interdisciplinary manner. The patient's cooperation is necessary. Regardless of the type of dentofacial deformity, patients should follow a protocol of individualised attention that prioritises their needs and addresses them in the necessary order in a timely manner.

Protocols for 3D virtual surgical planning (3D-VSP) have been developed in a number of surgical disciplines, including complex facial trauma reconstruction, head and neck oncology, dental implantology, neurosurgery and orthopaedics (Berrone et al., 2016; Franz et al., 2019; Kärkkäinen et al., 2018; Rinaldi and Ganz, 2019; Tetsworth et al., 2017).5

VSP has challenged the current state of presurgical orthognathic preparation and workups. What has yet to be determined is whether the application and feasibility of virtual model surgery is at a point where it will eliminate the need for traditional model surgery in both the private and academic setting. Certainly, VSP and medical modeling are significant time-saving tools that are proving to be highly accurate in terms of imaging, quantitative analysis, and predictability of aesthetic outcomes from the planned surgical movements on key components of the maxillofacial and mandibular skeleton and their overlying soft-tissue components. Although there are many obvious advantages to VSP, there are still significant limitations such as the VSP planning is expensive, the requirement of having to use an intermediary technician to facilitate VSP, a splint fabrication time lag from completion of VSP to splint delivery, splint production by an outside laboratory as opposed to an in-house 3D printer or milling device. 3

3D-VSP is a significant development in the planning of orthognathic cases and once staff have been trained and gain experience, this can lead to a reduction in time planning cases. There are limitations with 3D-VSP, as have been discussed, but it is our experience that the advantages far outweigh the disadvantages. The future of orthognathic treatment planning is moving with ease into the next dimension.

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