AL-AZHAR
Dental Journal
For Girls

The Official Publication
of The Faculty of Dental
Medicine For Girls,
Al-Azhar University
Cairo, Egypt.

Print ISSN 2537-0308 • Online ISSN 2537-0316

ADJ-for Girls, Vol. 8, No. 1, January (2021) — PP. 99:104

Surgery-first Approach Using Virtual Setup for the Treatment of Dentoskeletal Deformities

Yara Qadry[1]*, Suzan A. Hassan[2], Fahmy A. Mobarak[3], Moustapha A. Abdelrahman[4]

Codex : 12/21.01

azhardentj@azhar.edu.eg

http://adjg.journals.ekb.eg

DOI: 10.21608/adjg.2021.22987.1221

Oral Medicine & Surgical Sciences
(Oral Medicine, Oral & Maxillofacial Surgery, Oral Pathology, Oral Biology)

ABSTRACT

Purpose: to evaluate the accuracy of Computer-Assisted Surgical Simulation (CASS) in the surgery-first treatment of Dentoskeletal Deformities. **Materials and methods**: Ten patients with different dentoskeletal deformities, were involved in this study. Preoperative clinical evaluation, photographs, study models, and 2D lateral cephalometry were adopted for orthodontic evaluation if the case is eligible for the surgery- first approach. MSCT (in DICOM format), and optical scanning of the study model (in STL format) were adopted and imported to MIMICS software for construction of virtual 3D composite model. The virtual surgical simulation was performed on the light of the preclinical evaluation and preoperative records, then the occlusal splints and surgical guides were designed to transfer the planned surgery to the reality. For evaluation of the virtual surgical simulation 3D cephalometric analysis for the planned and postoperative readings**.** **Result**: No significant difference between the planned and postoperative 3D cephalometric analysis. **Conclusion**: Surgery First cases needed thorough orthodontic and surgical planning. Virtual surgical planning with subsequent designed occlusal splints and cutting guides allow for accurate transfer of the virtual planning into reality.

KEYWORDS

Computer assisted surgery, surgery first approach, orthognathic surgery.

INTRODUCTION

At the very beginning, the purpose of the orthognathic surgery was to correct the skeletal deformities, without preoperative orthodontics(1). However the amount of mandibular setback was limited because of the

- Paper extracted from Doctor thesis titled "Surgery-first Approach Using Virtual Setup for the Treatment of Dentoskeletal Deformities"

1. PhD candidate, Department of Oral and Maxillofacial surgery- Faculty of Dental Medicine for Girls, Cairo, Egypt.
2. Professor of oral and maxillofacial surgery, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt.
3. Professor of Oral and maxillofacial surgery, Faculty of Dentistry, Cairo University, Cairo, Egypt.
4. Researcher of Oro-Dental Genetics, Oro-Dental Genetics Department, Division of Human Genetics and Genome Research, National Research Center, Cairo, Egypt.

* Corresponding author email: yarakadry@gmail.com

anterior dental compensation. The aim of orthodontic treatment was to arrange the malaligned teeth in the best possible position in the individual jaws prior to surgery to increase the amount of surgical setback to correct mandibular prognathism [2, 3].

The disadvantages of orthodontics- first approach prolonged preoperative preparation up to 47 months, dental caries, deterioration of the dental periodontium and root resorption. In addition to temporary worsening of facial appearance and masticatory discomfort in class III cases [4].

Surgery first approach is reintroduced in 1991 to reduce the inconveniences of presurgical orthodontics, Bypassing preoperative orthodontics shortens the treatment time up to 1–1.5 years or less, in addition to immediate correction of the facial profile[5].

The computer assisted surgical simulation (CASS) have greatly contributed to the success of the surgery first approach technique [6]. The aim of this study is to evaluate the accuracy of virtual surgery in planning for the orthognathic surgeries for dentofacial deformities that are eligible for surgery first approach.

MATERIAL AND METHODS

Ten patients with different dentofacial deformities are involved in the study. Preoperative clinical evaluation, photographs, study models, and 2D lateral cephalometry were adopted for orthodontic evaluation if the case is eligible for the surgery- first approach. MSCT (in DICOM format), and optical scanning of the study model (in STL format) were adopted and imported to MIMICS software for construction of virtual 3D composite model. The virtual surgical simulation was performed on the light of the preclinical evaluation and preoperative records, then the occlusal splints and surgical guides were designed to transfer the planned surgery to the reality.

For evaluation of the virtual surgical simulation 3D cephalometric analysis for the planned and postoperative readings, these linear and angular measurements are listed in Table (1) and fig (1).

Table (1) *Showing the linear and angular measurements of the 3D cephalometric analysis*

Linear measurement	
FH	Distance between the nasion **N** and menton **Me**
AFH	Distance between the anterior nasal spine **ANS** and **Me**
PFH	Distance between the posterior nasal spine **PNS** to the right Gonion **Go**
RHrt	Distance between Articular **Ar** and Gonion **Go** right side
RHlt	Distance between Articular **Ar** and Gonion **Go** left side
U_6-rt Zf	Distance between the mesial cusp of upper right six $\mathbf{U_6}$ to the most superior point at the zygomaticofrontal suture of the right side **Zf**
U6-lt Zf	Distance between the mesial cusp of upper left six $\mathbf{U_6}$ to the most superior point at the zygomaticofrontal suture of the left side **Zf**
Ui- (Mid-sag)	Distance between the most mesial point of the incisal edge of the right central upper incisor **Ui** to midsagittal plane ***Mid-sag***
Li- (Mid-sag)	Distance between the most mesial point of the incisal edge of the right lower central incisor **Li** to midsagittal plane ***Mid-sag***
Ui-Li	Distance between the midline of the upper and lower dental midline

Angular measurements	
Go rt	Angle between articular, gonion **Go**, and menton points at right side
Go lt	Angle between articular, gonion **Go**, and menton points at left side
SNA	Angle between sella **S**, nasion **N**, and **A** points
SNB	Angle between sella **S**, nasion **N**, and **B** points
SNPog	Angle between sella **S**, nasion **N**, and **Pog** points
ANB	Angle between **A**, **N**, and **B** points

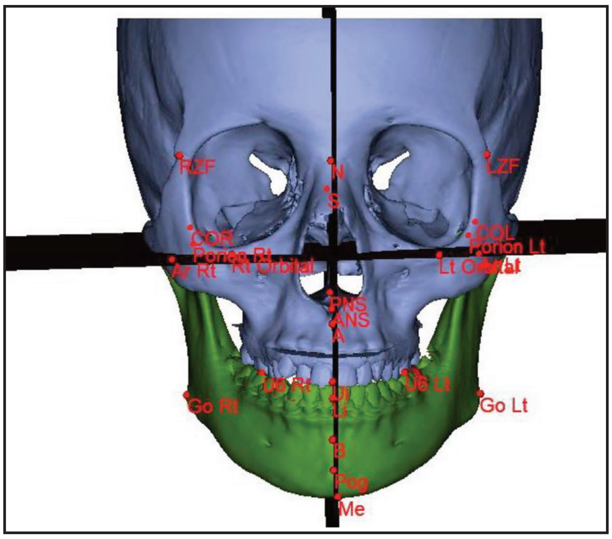

Figure (1) showing the landmarks and the planes used in 3D cephalometric analysis

Statistical analysis

All data were analyzed by using SPSS 12.0. Paired *t* test was used to calculate the difference between the planned position and the actual position of the jaws and teeth. Statistical significance was set at $P < 0.05$

RESULTS

Clinical outcomes

3D printed occlusal splints and the cutting guides helped to transfer the virtual planning into the surgery. All patients were satisfied with their postoperative profile. However, they were unsatisfied with their occlusion.

The first orthodontic consultation was immediate after the surgery to evaluate the postoperative intended malocclusion, then the orthodontic treatment began one month postoperatively.

Analysis of the accuracy of virtual surgical planning

The quantitative data was compared and paired *t* test was applied for normally distributed data and Mann-Whitney test was done for non-parametric data. Comparison among post, planned and preoperative results among studied group. The results revealed that the differences between post and planned measures are statistically non-significant ($p>0.05$), while the differences between planned and preoperative measures or between postoperative and preoperative measures were statistically significant ($p<0.05$) in AFH, FH, Li mid sag, SNA and Ui-Li measures. The measures were significantly decreased in AFH, FH, Li mid sag and Ui-Li measures and significantly increased in SNA measure. (Fig 2 and 3), Table (2)

Table (2): *Comparison among post, planned and preoperative results among studied group:*

Measurement	Post	Planned	Pre	P1	P2	P3
AFH	66.87±9.2	66.74±8.9	70.79±8.8	0.725	0.004*	0.007*
ANB	2.55±1.5	2.31±1.5	4.48±2.7	0.551	0.072	0.124
FH	118.29±9.9	117.97±9.9	122.15±11.4	0.32	0.028*	0.04*
Go angle Rt	124.89±4.6	124.36±4.9	126.27±6.7	0.075	0.103	0.255
Go angle Lt	125.03±5.0	124.62±5.1	126.31±5.5	0.068	0.05	0.143
Li mid sag	0.92±0.5	0.89±0.6	2.41±2.1	0.861	0.037*	0.04*
PFH	63.17±6.3	63.09±6.0	62.09±5.3	0.759	0.25	0.269
RH Rt	55.33±7.1	55.34±7.3	57.34±9.3	0.971	0.147	0.177
RH Lt	55.97±6.2	56.45±6.2	57.77±7.3	0.349	0.306	0.228
SNA	82.76±4.3	82.54±4.4	79.22±4.7	0.286	0.016*	0.015*
SNB	81.48±4.3	81.57±4.2	84.32±7.7	0.683	0.1	0.099
SNPog	83.6±5.4	84.08±4.1	85.19±7.8	0.477	0.429	0.116
U6 Lt LZF	77.35±5.8	77.1±5.8	77.0±5.6	0.355	0.865	0.575
U6 Rt LZF	77.45±5.4	77.65±5.8	77.74±5.1	0.477	0.888	0.599
Ui mid sag	1.1±1.1	0.97±1.2	1.46±1.2	0.338	0.216	0.332
Ui-Li	0.61±0.6	0.56±0.6	3.43±3.1	0.169	0.013*	0.013*

P1: difference between post and planned *p2: difference between planned and pre*

P3: difference between post and pre **statistically significant difference p≤0.05*

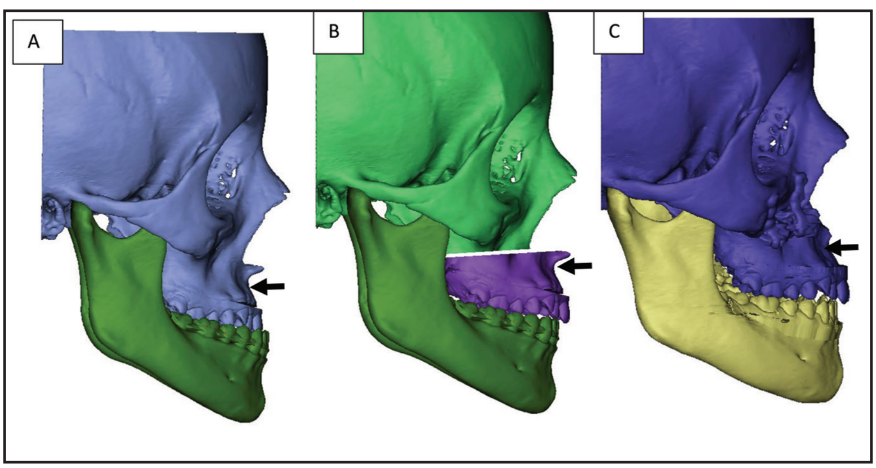

Figure (2) (A) showing preoperative 3D model with decreased anteroposterior projection of the maxilla (black arrow). (B) 3D model of the planned Lefort I osteotomy and 6 mm advancement of the maxilla to get normal skeletal class I relation (black arrow). (C) The postoperative 3D model that is similar to the planned position of the maxilla (black arrow).

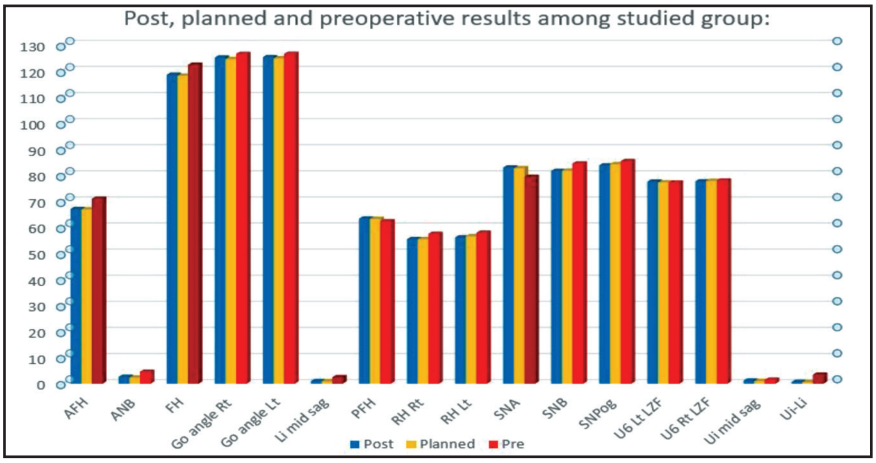

Figure (3) showing that the differences between post and planned measures are statistically non-significant (p>0.05), while the differences between planned and preoperative measures or between postoperative and preoperative measures were statistically significant (p≤0.05) in AFH, FH, Li mid sag, SNA and Ui-Li measures.

DISCUSSION

Numerous studies have been published on virtual surgical planning in orthognathic surgery[7–10], Zinser et al[11] compared the accuracy of CAD-CAM surgical splints, intraoperative navigation, and conventional occlusal splints for the transfer of virtual orthognathic planning between three groups of patients, they found that the CAD/ CAM occlusal splints gave the highest precision for maxillary planning transfer. This study was conducted to evaluate the accuracy of virtual planning in orthognathic surgery via quantitative comparison of preoperative planned and postoperative custom made cephalometric analysis

First, there were significant difference between the preoperative readings in comparison with the planned and postoperative measurements at the total facial height (FH) preoperative (122.15±11.4), the planned (117.97±9.9- P_2 0.028*) and the postoperative(118.29±9.9- P_3 0.04*) and anterior facial height (AFH) preoperative (70.79±8.8) , the planned (66.74±8.9) (P_2 0.004*), the postoperative (66.87±9.2) (P_3 0.007*) (the planned (which were decreased postoperatively as most of the patient suffering from prognathic mandible with increased facial height.

The other significant difference was the linear measurements between the mandibular dental mid line to the midsagittal plane (Li- midsag) the preoperative (2.41±2.1) the planned (0.89±0.6- $P_2$0.037*) and the postoperative (0.92±0.5- P_3 0.04*) that is because of presence of five cases of mandibular asymmetry involved in this study. Also there was a significant difference between the upper and lower dental midline (Ui-Li) the preoperative (3.43±3.1), the planned (0.56±0.6 P_2 0.013*) and the postoperative (3.43±3.1- P_3 0.014) for the same reason.

The angular measurement (SNA) was significantly different in preoperative when compared to the postoperative and planned measurements. The preoperative (79.22±4.7), the planned (82.54±4.4- P_2 0.016*) and the postoperative (82.76±4.3- $P_3$0.015*). It was increased in the planned and postoperative reading, this is because six out of ten patients were suffering from maxillary anteroposterior deficiency.

When comparing the planned and the postoperative readings we found that there was no statistical difference between these measurements. Our results are in concordance with the results of Zinser et al[11], and Zhang et al [12] who should no statistical difference between the planned and the postoperative linear and angular measurements.

CONCLUSIONS

- Surgery-first technique needs careful orthodontic and surgical planning. Hence , 3D planning is crucial in such a technique
- 3D planning facilitates the preoperative diagnosis, facial analysis and the decisions made by the surgeon, but each step of the planning must be precise, because the accuracy of each step is built on the accuracy of the previous one.
- Virtual surgical planning with subsequent designed occlusal splints and cutting guides allow for accurate transfer of the virtual planning into reality.

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