Reliability of Computerized Cephalometric Outcome Predictions of Mandibular Set-back Surgery

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SUMMARY

Introduction A successful treatment outcome in dentofacial deformity patients commonly requires combined orthodontic-surgical therapy. This enables us to overcome functional, aesthetic and psychological problems. Since most patients state aesthetics as the primary motive for seeking therapy, cephalometric predictions of treatment outcome have become the essential part of treatment planning, especially in combined orthodontic-surgical cases.

Objective The aim of this study was to evaluate the validity and reliability of computerized orthognathic surgery outcome predictions generated using the Nemotec Dental Studio NX 2005 software.

Methods The sample of the study consisted of 31 patients diagnosed with mandibular prognathism who were surgically treated at the Hospital for Maxillofacial Surgery in Belgrade. Investigation was done on lateral cephalograms made before and after surgical treatment. Cephalograms were digitized and analyzed using computer software. According to measurements made on superimposed pre- and postsurgical cephalograms, the patients were retreated within the software and the predictions were assessed by measuring seven angular and three linear parameters. Prediction measurements were then compared with the actual outcome.

Results Results showed statistically significant changes between posttreatment and predicted values for parameters referring to lower lip and mentolabial sulcus position.

Conclusion Computerized cephalometric predictions for hard-tissue structures in the sagittal and vertical planes, as well as the VTO parameters, generated using the Nemotec Dental Studio NX 2005 software are reliable, while lower lip and mentolabial sulcus position predictions are not reliable enough.

Keywords: dentofacial deformity; computerized predictions; manidbular prognathism

INTRODUCTION

The term dentofacial deformity refers to deviations from normal facial proportions and dental relationships that are severe enough to be handicapping [1]. In treating these patients, orthodontics may sometimes bring teeth successfully into proper occlusion, but this may not correct underlying skeletal problems well enough to overcome aesthetic and consequential psychological handicaps [2]. For patients whose orthodontic problems are so severe that neither growth modification nor camouflage offers a solution, surgical realignment of the jaws or repositioning of dentoalveolar segments is the only possible treatment. Orthognathic surgery is not a substitute for orthodontics in these patients. Instead, it must be properly coordinated with orthodontics and other dental treatment to achieve good overall results [1].

There is no single and simple classification of dentofacial deformities, as it is the case with malocclusions. The deviations from normal proportions are likely to be both severe and complex, and a patient's reaction to his/her individual situation plays a major role in determining the severity of the associated problems [2]. As most orthodontic patients state aesthetics as the primary motive for therapy, cephalometric predictions of treatment outcome have become the essential part of treatment planning, especially in combined ortho-

dontic-surgical cases. Computerized interactive treatment planning allows orthodontists and surgeons to evaluate treatment goal feasibility, and also enables better education of patients regarding their treatment plan as a part of the informed consent. Therefore, it is becoming an imperative in contemporary practice.

There is a variety of treatment planning techniques currently available; from simple cutting of cephalometric drawings and their manual repositioning, through 2D computerized predictions all the way to 3D predictions that are now being developed owing to the CBCT technology (Cone Beam Computerized Tomography) [3, 4, 5].

OBJECTIVE

The aim of this study was to evaluate the validity and reliability of computerized orthognathic surgery outcome predictions generated using the Nemotec Dental Studio NX 2005 software.

METHODS

Patients

The sample of the study consisted of 31 patients selected from a larger group of 115 patients diagnosed with mandibular prognathism who

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were surgically treated at the Hospital for Maxillofacial Surgery of the Faculty of Stomatology, University of Belgrade, between 1970 and 1991. Investigation was done on lateral cephalograms made before and after surgical treatment. Post-surgical cephalograms were made at least 3 months post surgery. The exclusion criterion was bad quality of lateral cephalograms.

Sagittal osteotomy according to Obwegeser-Dal Pont was preformed on all patients, and bony fragments were immobilized using wire. Rigid inter-maxillary fixation was used for the period of 6 weeks, after which elastic fixation was used for another 6 weeks.

Cephalometric analysis

All lateral cephalograms were digitized using the dSLR camera Cannon EOS 20D with macro lens EF 100 mm f-2.8 USM with 1:1 magnification. Photographs were made from the distance of 110 cm using a tripod and a nega-toscope. All recordings were done by one person in one day. Digitized cephalograms were imported into the computer software Nemotec Dental Studio NX 2005 (Figure 1). Calibration was done according to the SN plane in order to ensure same proportions for the pre- and post-surgical cephalograms. Hard and soft tissue reference points (Figure 2) were identified, which enabled the software to perform the analysis. A custom analysis was defined in which the following parameters were used:

- Hard tissues angular parameters: SNB (antero-posterior position of the lower jaw in relation to the cranial base), ANB (antero-posterior inter-jaw relation), SN/MP (position of the lower jaw in relation to the cranial base in the vertical plane) and SpP/MP (inter-jaw relation in the vertical plane)
- VTO: FA (facial axis, the angle between N-Ba and Ptm-Gn), Convexity (skeletal profile convexity; measured as a distance from point A to Na-Pg; in direct relation to the harmonious lip position) and LI/UI (interincisal angle)

- Soft tissues: A angle (soft tissue facial angle; angle between the Frankfort horizontal and the N'-Pg' line; defines the sagittal position of the chin), ll (lower lip) to H-line (H-line connects point Ls and Pg'; defines the sagittal position of the lower lip) and ils (inferior labial sulcus – mentolabial sulcus) to H-line (defines the sagittal position of the lower lip sulcus).

Computerized cephalometric predictions

Pre- and post-surgical cephalograms were then superimposed according to the SN line (Figure 3). The direction and amount of the surgical repositioning was measured in the sagittal plane – the distance between point upper incisor crown (UIc) and the point where lower central incisor crown ends and the alveolar ridge begins; and the
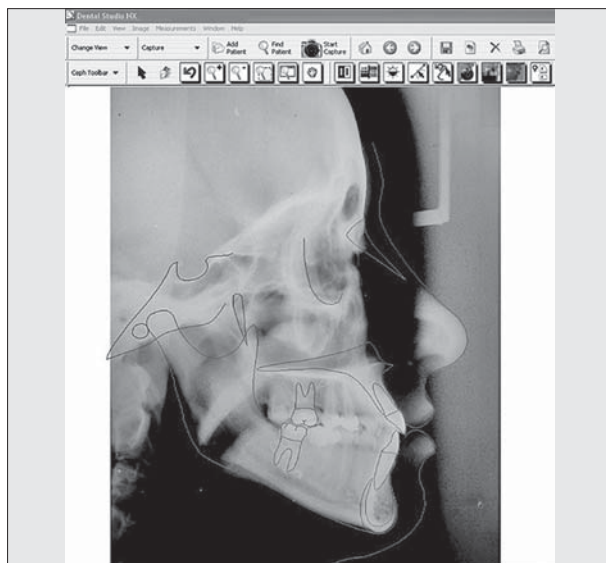

Figure 2. Hard-tissue and soft-tissue cephalometric landmarks

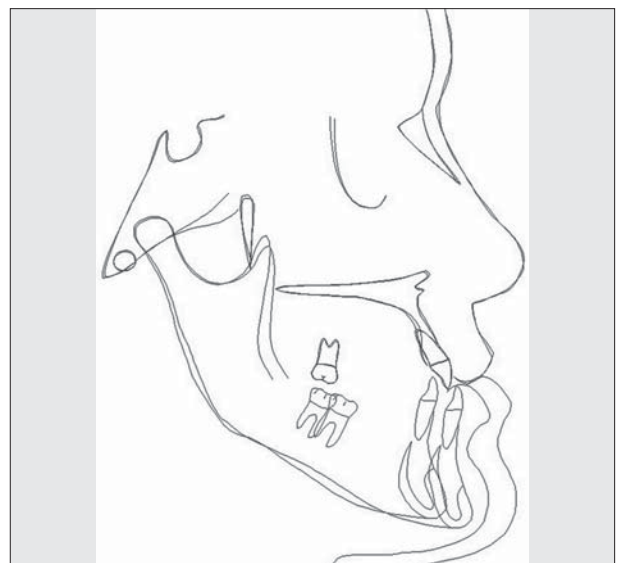**Figure 1.** Lateral cephalogram in the computer software Nemotec Dental Studio NX 2005

Figure 3. Superimposed cephalometric tracings

overjet (Figure 4), and in the vertical plane – the distance between UIc to lower incisor crown (LIc) (Figure 5).

According to the data obtained, pre-surgical cephalograms were retreated, and all post-surgical parameter values were compared to the values obtained through computerized predictions.

Statistical analysis

The data obtained was analyzed using measures of central tendency (mean and median), measures of variability (standard deviation, variance and coefficient of variation), and confidence intervals (minimal and maximal values). Statistical hypothesis was tested using the 2-tailed paired Student's t test for samples with similar variances (for controlling the results obtained within 2 groups – predicted and actual values).
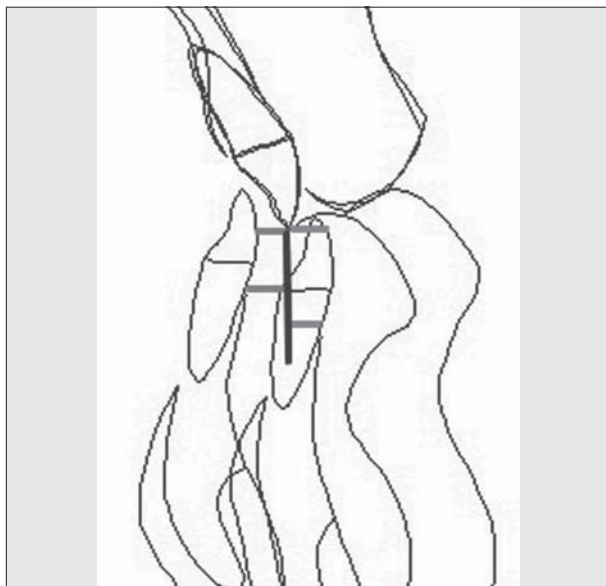

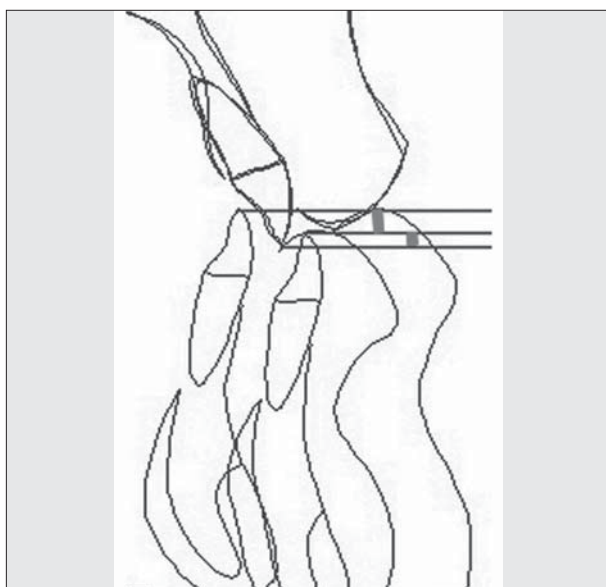**Figure 4.** Measuring surgical movement in the horizontal plane

Figure 5. Measuring surgical movement in the vertical plane

RESULTS

Minimal, maximal and average values, as well as the standard deviation and deviation coefficient are shown in Table 1 for post-surgical and Table 2 for predicted measurements.

Average pre- and postoperative value differences for parameters SNB, ANB, SN/MP, SpP/MP, FA, Convexity, LI/UI and A angle are minimal, as can be observed in Graph 1. On the other hand, in Graph 2, greater differences appear for average values of parameters ll to H line and ils to H line.

Testing of the statistical hypothesis was done using the 2-tailed paired Student's t test for samples with similar variances (Table 3). Results indicate statistically significant

Table 1. Postoperative values of angular (SNB, ANB, SN/MP, SpP/MP, FA, LI/UI, A angle) and linear parameters (convexity, ll to H line, ils to H line) in 31 patients

| Parameter	Min	Max	$\overline{X}$	SD	CV
SNB (°)	78.4	88.0	82.7	2.4	2.9
ANB (°)	-4.3	2.0	-1.1	1.8	173.3
SN/MP (°)	22.8	41.1	32.3	5.3	16.5
SpP/MP (°)	13.8	35.9	23.6	5.4	22.6
FA (°)	86.1	102.8	93.0	3.9	4.2
Convexity (mm)	-9.2	0.2	-3.6	2.7	74.3
LI/UI (°)	-10.1	165.9	147.6	10.8	7.3
A angle (°)	85.0	98.0	90.8	3.1	3.5
ll to H line (mm)	-4.0	3.5	0.1	1.7	2106.1
ils to H line (mm)	1.0	10.0	5.5	2.2	39.4

Min – minimal values; Max – maximal values; $\overline{X}$ – mean values; SD – standard deviation; CV – coefficient of variation

Table 2. Pedicted values of angular and linear parameters in 31 patients

Parameter	Min	Max	$\overline{X}$	SD	CV
SNB (°)	78.4	88.0	82.7	2.4	2.9
ANB (°)	-4.0	2.0	-1.0	1.8	180.5
SN/MP (°)	25.0	43.0	33.3	5.0	15.0
SpP/MP (°)	16.0	34.9	24.6	4.7	18.9
FA (°)	85.9	101.5	92.9	3.8	4.1
Convexity (mm)	-10.1	0.8	-3.6	2.8	79.5
LI/UI (°)	128.1	13.0	146.9	9.7	6.6
A angle (°)	85.0	98.5	91.4	3.3	3.6
ll to H line (mm)	-3.5	6.0	2.0	2.5	123.7
ils to H line (mm)	1.0	8.0	4.3	1.9	45.2
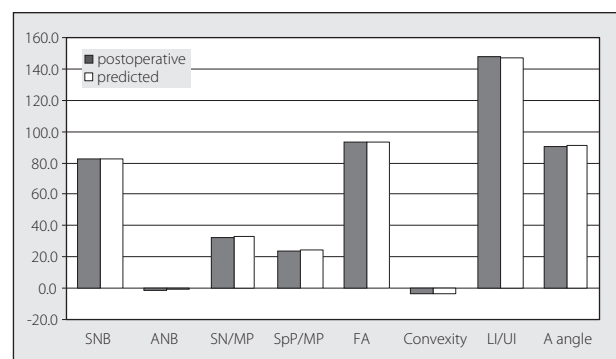
Graph 1. Pre- and postoperative mean values of examined parameters. Angular parameter values are expressed in degrees. Linear parameter Convexity values are expressed in millimeters.
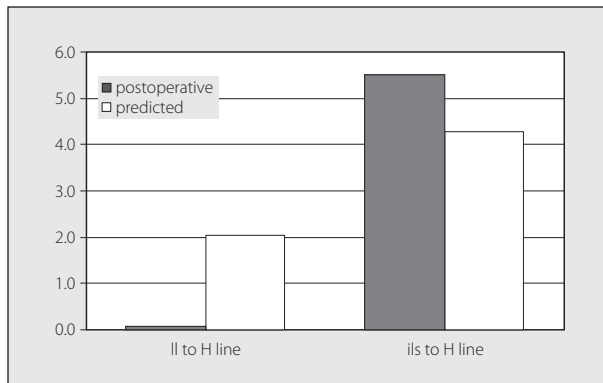
Graph 2. Pre- and postoperative mean values of parameters ll to H line and ils to H line. Values are expressed in millimeters.

Table 3. Results of statistical hypothesis testing done using paired Student's t test for samples with similar variances. Statistically significant differences for parameters ll to H line and ils to H line are presented.

Parameter	ll to H line		ils to H line	
	0.05	0.01	0.05	0.01
df	30		30	
t	3.5823**		2.3152*	
Critical t value	2.04	2.75	2.04	2.75
p	0.0007***		0.0240*	

* p<0.05, ** p<0.01, *** p<0.001; df – degree of freedom

differences between postoperative and predicted values for the parameters that show the lower lip and inferior labial sulcus position in the sagittal plane. No statistically significant differences were noted for other parameters.

DISCUSSION

Hard tissue parameters

Results of this study show that there were no statistically significant differences between the postoperative and predicted hard tissue sagittal and vertical parameter values. This indicates the reliability of the computerized predictions for these parameters, generated within the Nemotec Dental Studio NX 2005 software. Cousley and Grant [6], Donatsky et al. [7], Gosset et al. [8], Hillerup et al. [9], Kolokitha et al. [10] and Loh et al. [11] also state that no statistically significant differences have been noted between postoperative and predicted values for most hard tissue parameters. On the other hand Power et al. [12] came to the conclusion that there were statistically significant differences between the postoperative and predicted values of sagittal and linear parameters (SNA, SNB, ANB, SN/SpP, SN/MP, SpP/MP). Their general conclusion was that the Dolphin Imaging Software (2005 edition) was not as reliable as the traditional planning techniques.

Soft tissue parameters

Statistically significant differences were found between the postoperative and predicted values of parameters showing the lower lip and mentolabial sulcus position in the sagittal plane, which means that computerized predictions of lower lip and mentolabial sulcus positions, generated within the Nemotec Dental Studio NX 2005 software, were not reliable enough. Eales et al. [13], Konstiantos et al. [14], Kolokitha et al. [10] and others have concluded that the prediction of nose and chin position were generally (not absolutely) precise, but they have noted greater variability in the lower lip position prediction, what is also reported by Curtis et al. [15], Sinclair et al. [16] and Syliangco et al. [17]. Schultes et al. [18] note that besides the lower lip position, predicting was also problematic in the submental region, which coincides with the findings of Csaszar et al. [19]. In their research Hing [20] and Lew [21] concluded that the soft tissue predictions were generally precise, but the lower lip and chin position posed a difficulty. This is all in line with the findings of Aharon et al. [22] and Upton et al. [23].

Henderson [24] explained that the lower lip does not follow either the lower jaw or the lower incisors in any predictable fashion. The amount of vermilion of the lower lip which is displayed is reduced as the lower jaw is set back and increased as it comes forward. However, the amount of change does not depend only on the amount of lower jaw and lower incisor movement. It is also affected by the relative lengths of the lip in relation to the upper and lower incisors, and is therefore not predictable with accuracy. Besides relative lengths, soft tissue thickness and the morphology of the lower lip and mentolabial sulcus area is very variable, which also negatively affects prediction accuracy.

CONCLUSION

According to the results of this study, it can be concluded that hard tissue sagittal and vertical position predictions, as well as VTO parameter predictions are reliable, while lower lip and mentolabial sulcus position predictions are not reliable enough.

It is necessary to mention that there are considerable variations in the soft tissue changes that follow certain bone and teeth movements. Therefore, the most that can be claimed is that an average prediction is possible. Nevertheless, even these average predictions are most valuable in establishing in general terms the changes the face will undergo [24]. However, it is very important for the patient to understand that the simulation might be similar, but it is in no way identical to the final result of the surgical procedure [16, 25]. Predictions also do not take stability into consideration [24].

NOTE

This paper is a part of the first author's Master thesis entitled "Reliability of Computerized Cephalometric Outcome Predictions of Mandibular Set-back Surgery", which was defended in 2007.

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Поузданост компјутеризованих кефалометријских предвиђања резултата хируршке корекције мандибуларног прогнатизма

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КРАТАК САДРЖАЈ

Увод Ради постизања што бољих крајњих резултата, особе са дентофацијалним деформитетима најчешће се лече комбинованом ортодонтско-хируршком терапијом. На тај начин решавају се функционални, естетски и психолошки проблеми. Како највећи број пацијената наводи естетску промену као примарни мотив лечења, кефалометријско предвиђање исхода је важан део планирања терапије, посебно код сложених случајева.

Циљ рада Циљ рада је био да се процени прецизност и поузданост предвиђања исхода хируршке корекције мандибуларног прогнатизма развијених у оквиру компјутерског софтвера *Nemotec Dental Studio NX 2005*.

Методе рада Испитан је 31 пацијент с мандибуларним прогнатизмом који је оперисан на Клиници за максилофацијалну хирургију Стоматолошког факултета Универзитета у Београду. Истраживање је изведено на профилним телерадиограмима снимљеним пре и после хируршке интервенције. Након дигитализације снимака извршена је компјутеризо-вана кефалометријска анализа. На основу мерења одређених хоризонталних и вертикалних растојања на преоперационим и постоперационим радиограмима, урађена је симулација хируршких корекција и на њима измерена вредност седам ангуларних параметара и три линеарна параметра, чија је вредност упоређена с вредностима на постоперационим радиограмима.

Резултати Установљене су статистички значајне разлике између постоперационих и предвиђених вредности за параметре који говоре о положају доње усне и ментолабијалног сулкуса.

Закључак Компјутеризована кефалометријска предвиђања положаја чврсткивних структура у сагиталној и вертикалној равни, као и ВТО параметара, добијена у оквиру коришћеног програма су поуздана, док су предвиђања положаја доње усне и ментолабијалног сулкуса недовољно поуздана.

Кључне речи: дентофацијални деформитети; компјутеризована предвиђања; мандибуларни прогнатизам