SIMULATIONS OF DENTO-FACIAL MODIFICATIONS DETERMINED BY ORTHODONTIC TREATMENT VERSUS THE ACHIEVED POSTTHERAPEUTICAL RESULTS

ANCA ȘTEFANIA MESAROȘ[1], MICHAELA FLORICA MESAROȘ[2], MÎNDRA EUGENIA BADEA[3]

[1]Department of Dental Propaedeutics and Aesthetics
[2]Department of Paediatric Dentistry
[3]Department of Prevention in Dental Medicine
University of Medicine and Pharmacy „Iuliu Haţieganu", Cluj-Napoca

Abstract

Introduction. *The orthodontic treatment is capable of determining major changes in the facial appearance. Many times, before such treatment, the patient is shown an illustrated foreshadow of these desired modifications, based on the diagnosis and on the treatment plan.*

Aims. *To compare the actual post therapeutic results with the illustrated foreshadow done prior to the treatment.*

Material and methods. *10 orthodontic patients, for which the case documentation at the beginning of the treatment consisted also in photographs and lateral Cephalometric X-Ray were recruited for this study. The analysis was redone using the Dolphin Imaging Cephalometric System. With this analysis, based on the initial records and the treatment plan we simulated images to show the future treatment results. These modified photos were compared to the real photos taken of the patient at the end of treatment by 5 orthodontists, in order to obtain a more critical analysis.*

Results. *The simulated images as well as the after-treatment images presented relative significant facial modifications, in accordance with the gravity of the malocclusion and the accuracy of the simulation was bigger if the difficulty index of the case was smaller.*

Discussions and conclusions. *The technique of simulating a therapeutic result brings a big benefice in doctor-patient communication, but patients need to be warned that there is no imaging instrument that can simulate the treatment outcome with 100% accuracy.*

Keywords: facial aesthetics, orthodontics, simulation of treatment-outcome.

SIMULAREA MODIFICĂRILOR DENTO-FACIALE DETERMINATE DE TRATAMENTUL ORTODONTIC VERSUS REZULTATELE POST-TERAPEUTICE OBŢINUTE

Rezumat

Introducere. *Tratamentul ortodontic este capabil să aducă schimbări majore ale trăsăturilor faciale. De multe ori, înainte de începerea unui astfel de tratament, pacientului i se prezintă pe baza diagnosticului şi a planului de tratament o prefigurare a acestor modificări.*

Obiective. *Compararea rezultatelor obţinute postterapeutic cu prefigurarea acestora, realizată preterapeutic.*

Material şi metode. *Au fost luaţi în studiu 10 pacienţi ortodontici a căror documentaţie de început de tratament cuprindea atât fotografii, cât şi teleradiografii de profil. Analiza teleradiografică a fost refacută cu ajutorul programului de analiză cefalometrică Dolphin Imaging şi, pe baza acesteia, a documentaţiei iniţiale şi a planului terapeutic, au fost simulate imagini care să prefigureze rezultatele estetice*

sperate. Aceste fotografii modificate au fost comparate cu fotografiile realizate pacienţilor la finalul tratamentului de către un lot de 5 ortodonţi, în vederea realizării unei analize cât mai critice.

Rezultate. *Atât pe imaginile care simulau tratamentul, cât şi pe cele reale de final de tratament, modificările faciale au fost relativ importante, în funcţie şi de gravitatea anomaliei, iar acurateţea simulării a fost cu atât mai mare, cu cât gravitatea era mai mică.*

Concluzii şi discuţii. *Tehnica prefigurării rezultatelor terapeutice aduce un beneficiu mare în comunicarea cu pacienţii, însă aceştia trebuie preveniţi că nici un instrument imagistic nu poate simula cu o acurateţe de 100% rezultatele postterapeutice finale.*

Cuvinte cheie: estetică facială, ortodonţie, simularea rezultatelor post-terapeutice.

INTRODUCTION

The number of patients seeking orthodontic treatment continues to rise while Orthodontics is still an evolving discipline in Romania. Therefore, general dentists are the ones to have the first opportunity to examine patients and predict the development of the occlusion and refer orthodontic cases to the orthodontic specialist [1].

Orthodontic dento-alveolar treatment goals are often formulated on the bases of "ideal" occlusion concepts, including an Angle Class I occlusion, adequate canine guidance and an interincisal relationship judged as good : incisal inclinations, proper support, no midline deviation, good aesthetics, and adequate function [2,3,4]. But for patients, the most important treatment goal is facial aesthetics, as this is the only concept that they are likely to be able to assess themselves without benefiting of education in the field [5].

After having their primary orthodontic contact with the general dentist, or the orthodontist they become more aware of the malocclusion and therefore, the most frequent question asked in the office at the time they are presented with the treatment options is: How would I look like at the end of the treatment if I decide to have one? For this reason and due to modern technology, nowadays patients can be shown an illustrated foreshadow of the desired modifications to exemplify the possible change of their appearance. The simulations are done on the initial photos based on the diagnosis and on the treatment plan. This means that using specific analysis and software the orthodontists are capable of changing pictures of the patients taken for diagnostic purposes in order to simulate the facial aspect after the treatment [6]. It can be said that such instruments help the doctor explain the treatment objectives and the sequence of procedures, but also help patients decide in having an ortodontic treatment or choosing between different treatment options.

OBJECTIVE

Having in mind the simulation procedures and the advantages they brought to modern orthodontics testing the accuracy of such simulations was the main purpose of the present study. Therefore the study is based on a comparison between real post-treatment results and illustrated predictions done on photos from the beginning of the treatment.

MATERIAL AND METHODS

The retrospective study was initiated after receiving the informed consent from all participants and their parents. A total of 10 (7 girls and 3 boys) consecutive orthodontic patients that met the requirements for being included and presented themselves for regular follow-ups at the Orthodontic Department of the University of Medicine and Pharmacy "Iuliu-Haţieganu", Cluj-Napoca were enrolled in this pilot-study. Their mean age was 14.26±1.7 years, (range between 12-16 years). All patients were treated by the same orthodontist and the same resident and had complete orthodontic charts from the beginning of treatment until present day. Patient dental charts included casts, teleradiographic X-rays, orthopantomographies, interpretation of cephalometric measurements and a complete set of photographs according to the University's Orthodontic Department requirements: frontal perspective of the face with natural head position, lateral profile perspective with natural head position, upper arch, lower arch and 3 perspectives of the static habitual occlusion (frontal, right lateral and left lateral). None of the patients had any congenital or chronic diseases and they all benefited from an active orthodontic treatment for at least 18 months (mean of 19.6±1.5 months, range between 18 and 21 months). We considered the type of appliance and the technique used (fixed or removable appliance) for treating the patients not relevant for our study. Since the study was meant to compare the pre-treatment simulation of the facial aspect with the actual facial appearance of the patient after the treatment we used the Dolphin Imaging Software to make the changes on the "before" photos. Due to the fact that this Software featuring the Visual Treatment Objectives (VTO) option was not available at the time of the beginning of the treatment, such simulations were not presented or even tried for these patients at that time.

Adresa pentru corespondenţă: mesaros.anca@umfcluj.ro
ancames@yahoo.com

Therefore this procedure was done only with the purpose of this study. The teleradiographic X-Rays of the patients from before treatment were scanned and introduced in the software, as well as the initial photographs of the patient. They were calibrated, digitized, and the cephalometric measurements were recalculated using the Dolphin Imaging software. All initial tracings and measurements from the charts and all digitisations and recalculations with the aid of the software were done by the same person. Digitization was done using all Roth-Williams, Steiner, Tweed and Sassouni digitization points but the measurements were for the Tweed-Merrifield cephalometric analysis because this was the one initially used for diagnostic purposes. This analysis also permitted the calculation of a difficulty index, helping us to rate the difficulty of the malocclusion and therefore of the treatment.

A comparison between the cephalometric values returned by the software and the ones from the initial tracings was done as well [6]. Afterwards, the digitization was correlated to the picture of lateral profile and the VTO procedure of simulating on the initial picture the morphological changes of the face according to treatment objectives was done for each case. The software also included a growth simulation tool, so for each of the patients, before making the desired therapeutically changes we simulated the growth for the amount of time elapsed from the moment of the initial set of photos and the time of their scheduled follow-up appointment.

CEPHALO-METRICS	OBJECTIVES	
	Normal Values	Individual Values
FMIA	**67° ± 3**	67
FMA	**25° ± 3**	27
IMPA	**85° ± 3**	86
SNA	**82°**	83
SNB	**80°**	90
ANB	**2° ± 2**	-7
AoBo	**2mm ± 2**	13
Occ Plane	**10°**	22
Z	**75° ± 5**	67
Ii	**130°**	133
Upper Lip	/	13
Total Chin	/	11
HFP	**45mm**	48
HFA	**65mm**	64
HFP/HFA	**0,69**	0.75

Image 1. The VTO procedure for predicting the morphological changes of the face according to treatment objectives (Patient 8).

The initial lateral profile photo, the simulated image of their post-terapeutical aspect, together with the profile photo from the follow-up was printed and for each of the cases a portfolio was done. The portfolio presented beside the three above mentioned images a table containing the cephalometric values, as well as information regarding the treatment plan. The 10 portfolios were then presented to a number of 5 orthodontic specialists (4 women and 1 man).

Table I. Example of the Tweed-Merrifield Analysis for one of the patients (Patient 4).

	PARA-METERS	NORMAL VALUES	INDIVIDUAL VALUES	DIFFERENCE	DIFFICULTY QUOTIENT	DIFFICULTY
CRANIO-FACIAL ANALYSIS	FMA	**22° - 28°**	27	0	**5**	0
	ANB	**1° - 5°**	-7	8	**15**	120
	Z angle	**70° - 80°**	67	3	**2**	6
	Occ Plane	**8° - 12°**	22	10	**3**	30
	SNB	**78° - 82°**	90	8	**5**	40
	HFP/HFA	**0,65 – 0,75**	0.75	0	**3**	0
	TOTAL CRANIO-FACIAL DIFFICULTY					**196**
TOTAL SPACE ANALYSIS	**ANTERIOR**	Dento-alveolar discrepancy		1	**1,5**	1.5
		Cephalometric correction		0	**1**	0
		TOTAL:				**1.5**
	MID-ARCH	Dento-alveolar discrepancy		0	**1**	0
		Curve of Spee		3	**1**	3
		TOTAL:				**3**
	Occlusal horizontal discrepancy			13	2	26
	POSTERIOR	Dento-alveolar discrepancy		0	**0,5**	0
		Estimated Growth		0	**0,5**	0
		TOTAL:				**26**
	DENTAL TOTAL :				**DENTAL DIFFICULTY**	**30.5**
DIFFICULTY INDEX						**0 - 60 MILD**
						60-120 MODERATE
		TOTAL DIFFICULTY:			**226.5**	**>120 SEVERE**

All specialists were approached separately so there could be no interaction between them during the examinations of the portfolios therefore avoiding any influence upon their individual judgement in reference to the cases.

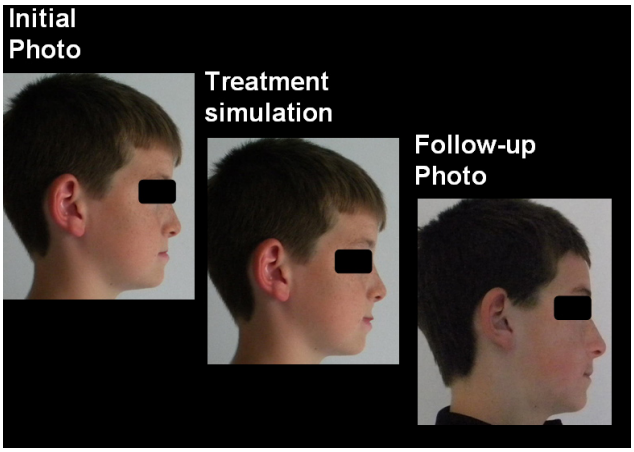

Image 2. Example of portfolio photos for one of the patients (Patient 4).

For each of the cases they were asked :

- if they agreed to the treatment objectives (and to which percent of agreement) and if so:
- to assess the facial changes that occurred due to the orthodontic treatment;
- to evaluate on a scale from 1 to 10 the aesthetic result of the treatment by assessment of changes on the lateral profile photos from the initial time point and the follow-up appointment;
- to evaluate on a scale from 1 to 10 the accuracy of the prediction on the simulated photographs in comparison to the real facial aspect of the patient at the follow-up appointment.

The results given by the 5 examiners were statistically interpreted using general descriptive statistics with the help of Microsoft Office Excell 2003 software.

RESULTS AND DISCUSSIONS

The central objective of the study was to determine the accuracy of the prediction on the simulated photographs in relation with the end-of-the-treatment real aspect photographs. But to be able to obtain an objective opinion it was important to find out if the examiners agreed to our treatment plan. It is common for orthodontists to have some differences of opinion regarding the treatment plan due to the development of so many orthodontic techniques, and that is the reason why the degree of accepting the treatment objectives was important. For all cases there was a mean agreement of the objectives of 82%±5% with a range between 77% and 87%. It has been observed that there was a direct relationship between the difficulty index of the case and the acceptance of the objectives: the more difficult the case, the acceptance of the treatment plan diminished (75%) and the easier the case, the highest acceptance rate from the fellow orthodontics (87%), with more than 10% differences. In the same manner, it was observed that among the 5 examiners, for the more difficult cases the values had significant variations, whereas for the easier cases the values were more convergent.

The assessment of the aesthetic result had more success. The improvement of the facial appearance was appreciated with a mean of 8,9 and values from 8 to 10. It is important to observe that even if the acceptance rate of the treatment plan was not as high as we presumed in the hypothesis of the study (above 90% [6,7]) the appreciation of improvement of facial aesthetics was even higher than expected (around 8,5 [8]). This time, it was observed an indirect relation between the difficulty index and the facial aspect improvement. For the severe cases the facial improvement was considered to be better than for the one with mild or moderate difficulty index.

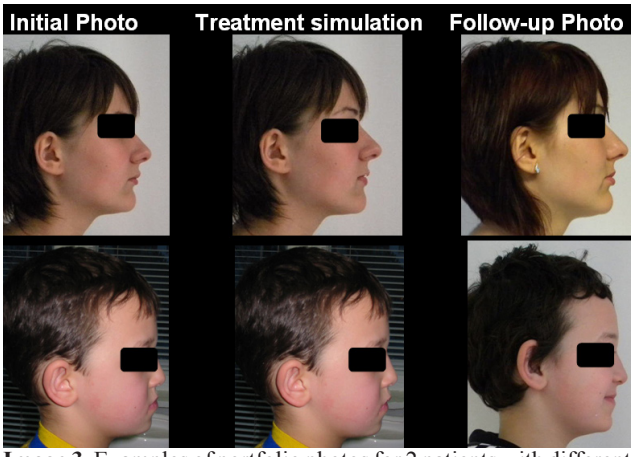

Image 3. Examples of portfolio photos for 2 patients with different difficulty indexes (Patients 8 and 1).

The assessment of the accuracy in predicting the final facial aspect of the patient using the initial diagnostic photographs was the primary objective of the study. The values given by the examiners were somehow parallel. If for the other assessments the values were approximately even distributed (in the sense that one examiner could have given an average rating for patient 3, a high rating on patient 6 and the lowest rating for case 7), for the accuracy of prediction it was observed also a ranking among evaluators. Examiner B gave all the highest rankings for the patients, examiner E the lowest assessments and examiners C, A and D gave the second lowest, middle value and respectively second highest evaluations. Again it was observed a link between the severity of the case and the accuracy of prediction. The difficult the case, the less accurate the prediction, the milder the malocclusion, the more accurate the prediction. The average for the predictions was 6,7 with ranges between 4 and 9.

A secondary objective during the study was to see if

the initial hand tracings were accurate in comparison to the software generated ones by comparing the measurements. It was observed that there were little and insignificant ($p>0.05$) differences between measurements. The initial measurements, done using the classical tracing technique, were accurate in a percentage of 92%±3% (in reference for each of the cases) with the new ones, and all discrepancies were within the limits of standard deviation from a certain typology. Significant discrepancies would have biased the study because they might have imposed a different therapeutically conduct. In order to evaluate measurement errors, the digitization was redone by the same investigator one week later. Method error was determined by using Dahlberg's formula: $ME=\Sigma d^2/2n$, where ME is method error, n is the number of subjects and d is the difference between the first and second measurements [9]. The maximum method error for linear measurements was 0,41 mm.

One of the limits of the study is the fact that the simulations of the final facial appearance were done retrospectively, after the case was treated, and the fact that the patient had already been seen by the doctor might have influenced the amount of change done on the photograph, although the predictive photos were done based on the initial treatment plan objectives.

CONCLUSIONS

The following conclusions can be drawn from this retrospective pilot study:

1. A thorough diagnosis will always give more information to the orthodontist, it will help in the establishment of a correct treatment plan that would give less opportunity to discussion around the objectives.

2. The difficult cases are always to be debated in terms of treatment plan options, but for them the facial changes occurred during orthodontic treatment are more visible and more impressive.

3. The prediction of the facial aesthetic appearance at the end of treatment by using modern imagistic methods can be a useful tool for the orthodontist: to visualize his objectives, to help convince the patient in having an orthodontic treatment by showing an improvement of facial appearance, but the accuracy of these predictions diminishes with the increase of severity of the case.

4. Even for mild and moderate cases, the accuracy of the prediction is not 100% and the patients need to be warned that this instrumental tool does not guarantee the success of any treatment and their final look might be closer to the prediction than to the initial situation, but there can be variations from these predictions.

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