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Outcome of photographic evaluation of facial appearance in orthognathic surgery: how does it correlate with planning of treatment and patient-reported outcome?

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Abstract

The outcome of treatment in orthognathic surgery is dependent on preoperative surgical planning. The main purpose of the present study was to evaluate from photographs the improvement in facial appearance after orthognathic surgery. In addition, the outcomes of two different planning techniques, 2-dimensional and 3-dimensional, were compared and the correlation between the outcome and health-related quality of life (HRQoL) assessed.

The study was a randomised controlled trial with the intervention being either 2-dimensional or 3-dimensional treatment planning. An evaluation panel compared photographs taken before and after operation on patients with severe class III malocclusion. The change in facial appearance was rated, the two planning techniques compared, and the result correlated with previously published findings on cephalometric accuracy and HRQoL in the same group.

Completed 12-month follow-up resulted in the inclusion of 57 subjects aged between 18 and 28 years at the time of operation (mean 21 years). We found significant differences between the two evaluations ($p = 4.4E\text{-}9$) but no significant difference in facial improvement between the planning techniques ($p = 0.54$). However, there was a correlation between cephalometric measurement of accuracy in the anterior maxilla and evaluation of improvement of facial appearance ($p = 0.024$, $r = 0.30$), but we found no correlation +between HRQoL and the evaluation of facial appearance ($p = 0.31$, $r = -0.14$). We conclude that there was an improvement in facial aesthetics after orthognathic surgery that was independent of the planning technique used.

Keywords: Orthognathic Surgery; Randomized Controlled Trial; Patient Reported Outcome Measures; Imaging; Three-Dimensional; Photography

Introduction

The outcome of treatment with orthognathic surgery is, as with other types of operation, dependent on preoperative surgical planning, and the purpose of treating severe malocclusions is to normalise the occlusion and oral function and improve the facial appearance.

Planning the treatment and predicting the outcome are possible today with both 2-dimensional and 3-dimensional techniques,[1,2] and multiperspective evaluations of such techniques have been made by cephalometric evaluations of accuracy,[3–6] health-related quality of life, (HRQoL),[7,8] and cost-effectiveness.[9,10]

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Patients' wish for treatment is often based on a combination of poor function and a need for improved facial and dental appearances,[11,12] and previous studies have confirmed that improvements in facial aesthetics are related to the patients' HRQoL.[8,13,14] Preoperative prediction of the facial appearance aids the success of the treatment goals.

Facial aesthetics can be evaluated from the patient's perspective through interviews, or questionnaires, or both. However, this type of evaluation could be affected by the patient's subjective impression of a poor baseline standard of facial aesthetics, which might indicate a degree of satisfaction that did not correspond to the environmental opinion.

Facial appearance and the need for treatment have also been evaluated through both lay and professional judgement of photographs.[15,16] However, the results are ambiguous and show both conformity and differences between the assessments of professionals and patients. Evaluation of the improvement in facial aesthetics from a wider environmental perspective is therefore important.

As a primary objective, we evaluated photographic changes in facial appearance after orthognathic surgery and compared two different planning techniques. Our secondary objective was to compare the outcome of these evaluations with those of previous findings in cephalometric accuracy and changes in HRQoL in the same group of patients.

Patients and methods

Trial design

The study was conducted as a prospective, randomised, 2-arm parallel, double-blind, controlled clinical trial with a 1:1 allocation ratio. No changes to the study design were made after it had started.

Participants, inclusion and exclusion criteria, and setting

Sixty-two consecutive subjects aged between 18 and 30 years who were referred to the department of Oral and Maxillofacial Surgery, University Hospital of Skåne, Lund, Sweden with Angle class III occlusion and a minimum of 5 mm negative overjet were included. Subjects with systemic musculoskeletal diseases, drug abuse, poor mental health, or disease of the temporomandibular joint were excluded. The subjects were randomised after completion of preoperative orthodontic treatment and before operation. The planning technique was used for cephalometric diagnosis, choice of treatment, and definitive planning of movements.

The 2-dimensional software used was Facad® (Ilexis AB)[17] and the 3-dimensional software was Simplant® (Materialise Corp).[18]

All subjects were planned with both a 2-dimensional and a 3-dimensional computer-assisted planning technique in the order mentioned, and were randomised before operation into

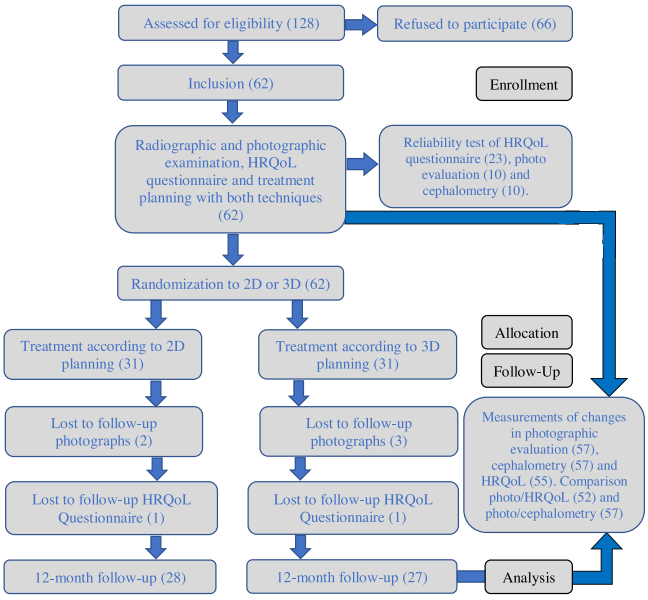

Fig. 1. CONSORT chart of subject flow during the trial (numbers of subjects in parentheses).

control and test groups (Fig. 1). In the control group, the operation was done according to the 2-dimensional, and in the test group according to the 3-dimensional, technique. Except for the difference in planning technique, both groups were handled equally during treatment. The surgical options involved Le Fort 1 maxillary osteotomy, segmented Le Fort 1 maxillary osteotomy, bilateral sagittal split mandibular osteotomy, vertical ramus mandibular osteotomy, and genioplasty. The endpoint was 12 months' follow-up and included clinical examination, photographs, orthopantomogram (profile and anteroposterior view), and computed tomography (CT).[3,4]

Throughout the period (Fig. 1) the subjects, orthodontists, and surgeons evaluated their progress while unaware of the randomisation. At follow-up, the evaluations were made by the orthodontists and the subjects.

Camera settings

Photographs were recorded with the patient's head in a neutral position from four different views: relaxed mimic muscles in the frontal, left lateral, right lateral, and smiling frontal views. All photographs were recorded by the same photographer at preoperative clinical examination and at the 12-month follow-up. Standardised camera and flash settings were used. Spectacles, jewellery, and any other interfering objects were removed. The recorded field of view was the entire head with an inferior limit of at least the anterior neck-submental angle. Long hair was pulled away from the face to expose the ears and forehead.

The photographs were coded and presented to the evaluators in a similar manner (Fig. 2a and b). A protocol for evaluation was provided as described in previous publications.[16,19]

Fig. 2. a) Example of photographic set presented to the evaluation panel: preoperative photographs. Published with the patient's consent. b) Example of photograph set presented to the evaluation panel, 1-year postoperative photographs. Published with the patient's consent.

A visual analogue scale (VAS) from 0-10, in which 0 = the minimum facial attraction and 10 the maximum facial attraction to rate the "overall" facial appearance. A 5-level Likert scale was used to record the evaluator's opinion of the "mid-face" and "lower face", respectively. The Likert scale was graded as: very unattractive, unattractive, neutral, attractive, and very attractive.

The lateral and frontal photographs were presented together. One set presented the patient's facial appearance before treatment (Fig. 2a), and one at 12-months' follow-up (Fig. 2b). The protocol instructed the evaluators to look for a maximum of 30 seconds at each set, and never to return to previous photographs. To test intra-observer reliability, photographs of 10 subjects, randomly selected, were re-evaluated by all evaluators after at least two weeks.

Six evaluators were enrolled: an orthodontist, a plastic surgeon, a maxillofacial surgeon, a prosthodontist, a professional photographer, and a layperson. The layperson was age-matched with the subjects included. The evaluators were weighted according to sex. Evaluators were not involved in the treatment, nor aware of the purpose of the evaluation or the group to which the patient had been randomised.

The cephalometric accuracy[3,4] and the HRQoL scores, of the two methods of treatment planning had previously been compared.[8] HRQoL was measured using the Oral Health Impact Profile, Swedish version (OHIP-S).[8,20]

Calculation of sample size

The study was designed for 60 subjects, which was based on previous publications.[3,5,6] No specific calculation was made for the present group because we lacked preliminary results and those from previous studies concerning cephalometric accuracy, HRQoL, and photographic evaluation at the time of data collection. Blind randomisation ensured a 1:1 allocation into the groups (Fig. 1).

Statistical analysis

The software used for statistical analysis was programmed in-house by the consulting statistician.

Fisher's test for paired comparisons was used to find out if there was a significant difference in facial appearance after operation compared with before. Fisher's permutation test was used to compare the test and the control groups.

To see if there was a correlation between the difference in cephalometric accuracy (between 2-dimensional and 3-dimensional), HRQoL and changes in facial appearance seen in the photographs, we used Pitman's test. Mean (SD) values were calculated. Two-tailed probabilities of <0.05 were accepted as significant. Pearson's correlation coefficient was calculated between test and retest. Pitman's test is a permutation for Pearson's correlation coefficient. We used non-parametric tests when the data were

Table 1
Total improvements in facialappearance. A mean value was calculated for each patient (from six values/patient because there were six evaluators).

Variable	No	Mean (SD)	Range	Two-sided p value
Photo evaluation preoperatively:				
Overall	57	4.94 (1.10)	2.8 – 7.5	-
Midface	57	1.50(0.44)	0.7 – 2.7	-
Lower face	57	1.42 (0.61)	0.3 – 2.8	-
Photo evaluation postoperatively:				
Overall	57	6.39 (1.09)	4.0 – 8.3	-
Midface	57	2.30 (0.53)	1.2 – 3.3	-
Lower face	57	2.25 (0.65)	1.0 – 3.5	-
Reliability preoperatively:				
Overall	10	4.75 (0.91)	3.0 – 6.0	-
Midface	10	1.40 (0.42)	0.8 – 2.2	-
Lower face	10	1.45 (0.53)	0.5 - 2.0	-
Reliability postoperatively:				
Overall	10	6.32 (0.88)	5.2 – 8.0	-
Midface	10	2.22 (0.54)	1.5 – 3.2	-
Lower face	10	2.07 (0.67)	1.0 - 3.3	-
Totals:				
Overall: postoperative minus preoperative	57	1.46 (1.09)	−0.8 – 4.7	4.4E-9
Midface: postoperative minus preoperative	57	0.80 (0.52)	−0.5 – 2.2	7.8E-10
Lower face: postoperative minus preoperative	57	0.83 (0.79)	−1.0 – 3.0	1.1E-7
Overall reliability: postoperative minus preoperative	10	1.57 (0.59)	0.2 – 2.2	-
Midface reliability:postoperative minus preoperative	10	0.82 (0.46)	0.2 – 1.5	-
Lower face reliability: postoperative minus preoperative	10	0.62 (0.68)	−0.8 – 1.3	-

Fisher's exact test was used for paired comparisons, to show if there was a significant difference in totals between before operation and afterwards.

not normally distributed, and parametric tests when they were.

Results

Completed 12-month follow-up resulted in inclusion of 57 patients (mean (range) age 21 (18-28) years) at the time of operation. After randomisation, the 3-dimensional planning group included 13 male and 15 female patients, mean age 21 years, and the control group 17 male and 12 female patients, mean age 21 years. We did a reliability test in 10 subjects. Fifty-two patients were eligible for comparison of outcome from photographic evaluation with HRQoL, and 57 with cephalometric accuracy.

Evaluation of facial appearance

Table 1 shows overall improvement of facial appearance, and Table 2 shows a comparison of improvement of facial appearance in the test and control groups. In total, the differences between evaluations made before and after operation were significant (p = 4.4E-9). The score increased by 1.5 for overall evaluation, 0.80 for evaluation of the midface, and 0.83 for evaluation of the lower face. The reliability test showed no difference between any regions or times of measurement (Table 1). In all aspects studied, there was no significant difference found between the test and the control group postoperatively (p = 0.54) (Table 2).

Comparison between facial appearance and cephalometric accuracy

We compared the cephalometric variables that had previously been shown to differ significantly with the present photographic evaluation of the overall facial appearance.[3]

There was a correlation between cephalometric measurement of accuracy in the anterior maxilla (A-A2) and evaluation of facial appearance "Postoperative minus preoperative, overall" (p = 0.024, r = 0.30), but no correlation between cephalometric measurement of accuracy of the inclination of upper incisors (11/NSL-112/NSL) and the evaluation of facial appearance at the same time (p = 0.30, r = -0.13) (Table 3).

Comparison between facial appearance and HRQoL

We compared HRQoL variables (OHIP-S total)[8] and the present photographic evaluation of the overall facial appearance, and found no correlation between OHIP-S total and evaluation of facial appearance at the same time (p = 0.31, r = -0.14) (Table 3).

Discussion

The observers' ratings of photographs were analysed as a group. Individually, they had different backgrounds, all of which were related to the present patients. To analyse them individually would have run the risk of their individual variations confounding the results. To analyse them as being

Table 2
Improvement in facial appearance between preoperative and postoperative – comparison between 2D and 3D.

Variable	Two-dimensional			Three-dimensional			Two-sided p value
	No.	Mean (SD)	Range	No.	Mean (SD)	Range	
Photo evaluation before operation:							
Overall	29	5.10 (0.98)	3.0 - 6.8	28	4.77 (1.21)	2.8 - 7.5	
Midface	29	1.59 (0.40)	0.7 - 2.5	28	1.40 (0.45)	0.8 - 2.7	
Lower face	29	1.41 (0.57)	0.7 - 2.5	28	1.43 (0.65)	0.3 - 2.8	
Photo evaluation after operation:							
Overall	29	6.47 (1.07)	4.3 - 8.2	28	6.32 (1.13)	4.0 - 8.3	
Midface	29	2.36 (0.51)	1.5 - 3.3	28	2.24 (0.55)	1.2 - 3.3	
Lower face	29	2.30 (0.63)	1.2 - 3.5	28	2.19 (0.67)	1.0 - 3.5	
Reliability before operation:							
Overall	4	4.96 (0.70)	4.0 - 5.7	6	4.61(1.06)	3.0 - 6.0	
Midface	4	1.46 (0.16)	1.3 - 1.7	6	1.36 (0.55)	0.8 - 2.2	
Lower face	4	1.37 (0.53)	0.8 - 1.8	6	1.50 (0.58)	0.5 - 2.0	
Reliability after operation:							
Overall	4	6.46 (0.53)	5.7 - 6.8	6	6.22 (1.10)	5.2 - 8.0	
Midface	4	2.13 (0.55)	1.5 - 2.7	6	2.28 (0.58)	1.5 - 3.2	
Lower face	4	2.13 (0.32)	1.7 - 2.3	6	2.03 (0.86)	1.0 - 3.3	
Postoperative minus preoperative:							
Overall	29	1.37 (1.00)	−0.3 - 3.5	28	1.55 (1.18)	−0.8 - 4.7	0.54
Midface	29	0.77 (0.50)	0.0 - 2.0	28	0.83 (0.54)	−0.5 - 2.2	0.65
Lower face	29	0.89 (0.77)	−0.5 - 2.7	28	0.76 (0.82)	−1.0 - 3.0	0.54
Reliability postoperative minus preoperative:							
Overall	4	1.50 (0.24)	1.2 -1.7	6	1.61 (0.77)	0.2 - 2.2	
Midface	4	0.67 (0.53)	0.2 -1.3	6	0.92 (0.43)	0.3 - 1.5	
Lower face	4	0.75 (0.44)	0.3 -1.3	6	0.53 (0.83)	−0.8 - 1.3	

Fisher's permutation test, tests if there is a difference between 2D and 3D regarding changes between pre and postop.

Table 3
Comparison of outcome from photographic evaluation with cephalometric accuracy (Corr Ceph-Photo) (n=57) and HRQoL (Corr HRQoL-Photo) (n=52).

Variable	No	Mean (SD)	Range	Pearson's correlation coefficient (95% CI)	P value (Pitman's test)
Corr Ceph-Photo:					
Photo: Postoperative minus preoperative	57	1.46 (1.09)	−0.8 – 4.7		
Overall					
Ceph A-A2	57	2.30 (1.63)	0.3 -7.6		
Ceph 11/NSL-112 NSL	57	−0.29 (3.51)	−12.1 – 10.5		
Postoperative minus preoperative, overall and A-A2	57			−0.30 (0.04 to 0.52)[1]	0.024
Postoperative minus preoperative, overall and 11/NSL-112/NSL	57			−0.13 (-0.13 to 0.39)[1]	0.30
Corr HRQoL-Photo:					
Photo: postoperative minus preoperative	52	1.42 (1.09)	−0.8 – 4.7		
Overall					
Total postoperative minus preoperative OHIP-S	52	−24.94 (29.44)	−98.4 – 55.3		
Overall and postoperative minus preoperative OHIP-S	52			−0.14 (-0.40 to 0.13)[2]	0.31

A-A2= cephalometric accuracy of the measurement of the anterior maxilla.
11NSL-112NSL=accuracy of the inclination of the upper incisors.
[1] Pitman's test was used to see if there was a relation between the difference in cephalometric accuracy (between 2- and 3-dimensional planning technique) and changes in the facial appearance on photographic evaluation.
[2] Pitman's test was used to see if there was a relation between difference in HRQoL (OHIP-S total between 2- and 3-dimensional planning technique) and changes in facial appearance in the photographic evaluation.

representative of different aspects was not intended, and is an objective for future studies.

Most of the patients who had orthognathic corrections were treated just after their growth had matured, which was why the trial was designed for subjects aged between 18-30 years. The result was independent of the planning technique used. This is also in accordance with the findings of the measurements of HRQoL.[8] However, findings about the cephalometric accuracy in the same group[3,4] showed that the 3-dimensional technique had a greater degree of accuracy in the anterior maxilla. The reason for this discrepancy in outcome between evaluation of photographs, HRQoL, and cephalometry, might be explained by a difference in techniques of measurement. The relatively small findings on

cephalometric accuracy are based on high-definition scales. When studying the effect of differences in cephalometric accuracy on HRQoL and facial appearance, the impact could be blurred and erased by the rougher measurements used in patient recorded outcome measures (PROM) and photographic evaluation. Despite this, and from a patient's perspective even more important than cephalometric findings, the present findings indicate a clear improvement in facial aesthetics and HRQoL for both planning techniques. In accordance with previous findings about PROM on HRQoL,[8] the photographic evaluation of facial appearance showed improved facial aesthetics after orthognathic surgery, which supports the hypothesis that there is conformity between different techniques of evaluation.

Despite limitations, a simple and sometimes clinically useful alternative to a computerised prediction technique for planning surgical and orthodontic corrections of malocclusion, is a patient's own physical simulation. For example, this could predict mandibular advancement in a single correction of the jaw. So that we did not have the risk of impaction from this type of prediction on treatment planning, we included only class III malocclusions, with or without asymmetry.

As the present group applies only to severe class III malocclusion, they all have a deformity that often improves significantly after orthognathic surgery. As a consequence, the present findings of improvement of facial appearance might be better compared with results after other deformities. However, this does not affect the result of the comparison of the two planning techniques.

For ethical reasons (not having two preoperative CT examinations), subjects were included at the final phase of treatment planning - after preoperative orthodontics. Being in the most severe phase of malocclusion might affect the judgement of baseline aesthetics, and consequently exaggerate the results. However, a discrepancy of less than 5 mm from normal at the point of total decompensation is probably not a dentofacial deformity. As a result of this, the limitation of diagnoses and treatment phases included is not likely to relevantly skew the results. Likewise, being equally distributed between the groups, the result of the comparison is probably not affected.

The way the photographs were taken was similar to those described in other studies of photographic evaluation of facial appearance.[16,19,21–24] Some studies have added other angulations or views, which might lead to a more detailed evaluation of the facial appearance.[25] However, the present study aimed for an overall impression of the face, through a limited number of photographs, instead of detailed evaluation. The reason for this and the limitation of the evaluation sequence (30 seconds) is conformity with facial impressions in a societal environmental setting. The composition of the evaluation panel aimed for some diversity. However, it consisted mainly of professional evaluators but, despite under-representing evaluators from the patients' environment, the photographic evaluation conformed with other evaluation methods.

The randomisation of the patients was completed after treatment had been planned, which reduced the risk of the knowledge affecting the planning of treatment and thereby favouring the planning technique used for operation.

Clinical implications

The improvement in facial appearance and HRQoL shown for both groups indicates that treatment of dentofacial deformities and malocclusions with orthognathic surgery can be recommended, regardless of whether the planning technique is 2- or 3-dimensional.

Despite there being a significant advantage in accuracy for the 3-dimensional technique in the anterior maxilla, both techniques were comparable in accuracy to other studies.[26] The results showed a degree of conformity between professional (cephalometric), patient's (HRQoL), and environmental (photographic) perspectives of outcome. This indicates that the methods used in decisions about treatment achieved an outcome that fulfilled the goals from all these perspectives. Conformity between different methods of evaluation indicates that photographic evaluation of facial aesthetics is one of several methods that shows comparable reliability when the outcome of treatment in orthognathic surgery is being evaluated.

Conclusions

Independent of which planning technique (2- or 3-dimensional) that was used, the present study shows that an improvement of facial aesthetics, judged by a jury from photographs, after treatment of dentofacial deformities and malocclusions with orthognathic surgery, is obvious.

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Conflict of interest

We have no conflicts of interest.

Ethics statement/confirmation of patients' permission

The study was approved by the regional ethics committee (registration number 011-11). Informed written consent was

obtained from all subjects. All participants signed written informed consent. The study followed the principles of the Declaration of Helsinki.

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