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Evaluation of facial aesthetics by laypersons in patients undergoing intraoral quadrangular Le Fort II osteotomy compared with conventional Le Fort I osteotomy

J. Cede, A. Graf, J. Zeitlinger, F. Wagner, K. Willinger, C. Klug
University Department for Oral and Maxillofacial Surgery, Vienna General Hospital, Waehringer Guertel 18-20, 1090 Vienna, Austria

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Abstract. In this study we compared the aesthetic outcome of (1) Le Fort I (LFI) osteotomy and (2) intraoral quadrangular Le Fort II (IQLFII) osteotomy for surgical correction of skeletal class III dysgnathia involving midfacial deficiency. The aim was to investigate whether laypersons see differences in facial changes that occur due to variations of the osteotomy cuts. The patient collectives consisted of 23 patients in each group. Pre- and postoperative photographs were presented in a random sequence to 40 layperson raters. The rating procedure was conducted with a four-point Likert scale. Assessed characteristics were 'attractiveness' ('Attraktivität'), 'likeability' ('Sympathie'), 'intelligence' ('Intelligenz'), 'aggressiveness' ('Aggressivität') and 'dominance' ('Dominanz'). For preoperative photographs we found a significant difference for 'likeability' with lower ratings for the IQLFII group; all other criteria were rated similarly. For the IQLFII group we found a significantly larger shift from lower to higher ratings for 'attractiveness' and 'likeability' and a significantly larger shift from higher to lower ratings for 'aggressiveness' and 'dominance' than for the LF I group. Our study shows that lay raters detect significant differences between the two surgical groups. Thus, IQLFII osteotomy, when indicated, represents a favourable alternative to conventional LFI osteotomy, if patients desire the expectable change in recognition by their social circle.

Key words: maxillofacial development; malocclusion, angle class III; craniofacial abnormalities; maxillary osteotomy; osteotomy, Le Fort; esthetics.

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Dysgnathic jaw relations markedly influence patients' aesthetics and thus have an impact on their self-esteem, social perception and quality of life[1]. The appearance of dysgnathic patients is frequently associated with negative personality traits. In particular, patients with Class III malocclusion are assumed to be more dominant, aggressive and less intelligent when compared with Class I patients[2–4], which may negatively influence social integrity and professional development.

Besides conventional Le Fort I (LFI) osteotomy, which is frequently regarded as the gold standard procedure for maxillary movements in bimaxillary surgery, intraoral quadrangular Le Fort II (IQLFII) osteotomy can be conducted in cases of severe infraorbital deficits[5]. The key element of IQLFII osteotomy is the advancement of the infraorbital rim with the intention to correct suborbital flattening in cases of midfacial deficiency and increase infraorbital rim projection. Bony deficits can thus be corrected concomitantly with occlusal anomalies. Existing literature provides evidence for improved aesthetic outcomes with higher levels of osteotomy than the conventional LFI level[6]. Based on data of previous studies, it could be suggested that the projection of deficient midfaces and cheek lines becomes more obvious when the infraorbital rim is included in the advancement procedure compared with mere advancement at the LFI level[5,7].

Facial changes following corrective surgery can be quantified. However, it must be questioned whether or not improvement in profile and aesthetics can be perceived by laypersons at all. While mere benefits of computed tomography (CT)-based measurement do not justify a variation in the gold standard osteotomy line, a more positive perception by the patients' lay social circle certainly would. This is especially relevant to adolescents, who are likely to experience psychosocial discomfort when teased about their facial appearance and thus are influenced by the feedback of others[8].

The purpose of this study was to examine whether the untrained 'non-expert eye' is able to detect differences in facial changes as a result of two different procedures utilizing different osteotomy cuts in the midface.

A

		1	2	3	4	
attractiveness *(germ. "Attraktivität")*	*unattractive*	☐	☐	☐	☐	*attractive*
likeability *(germ. "Sympathie")*	*not likeable*	☐	☐	☐	☐	*likeable*
intelligence *(germ. "Intelligenz")*	*unintelligent*	☐	☐	☐	☐	*intelligent*
aggressiveness *(germ. "Aggressivität")*	*aggressive*	☐	☐	☐	☐	*not aggressive*
dominance *(germ. "Dominanz")*	*dominant*	☐	☐	☐	☐	*reserved*

Instructions: Please rate all of the above character traits according to the patient's appearance and assign checkmarks where applicable. E.g. if you perceive the person's appearance as "very unattractive", tick the box at number "1". If you checkmark the box at "2", it means you find the person your "rather unattractive", and accordingly "rather" or "very attractive" at box "3" and "4", respectively. For every slide, you have 20 seconds to assign all 5 ratings, until the next photograph will be shown.

B

Age: _____

Sex: Female ☐
Male ☐

Education degree:
Compulsory education ☐
Apprenticeship ☐
General qualification for university entrance ☐
Academic studies ☐

Fig. 1. (A) Likert scale for tested characteristics in the questionnaire. (B) Assessed background information of the raters.

Materials and Methods

Study design

This study was designed according to the Declaration of Helsinki and Good Clinical Practice guidelines and was reviewed and approved by the ethics committee of the authors' institution (1640/2018).

The patient collective comprised two groups: the LFI group and the IQLFII group. All patients but one received two jaw surgeries. Mandibular osteotomies were conducted by means of bilateral sagittal split osteotomy (BSSO), except for one patient, who received a mandibular wing osteotomy. The IQLFII group was a consecutive case series of 23 patients within the period of 2013–2019 without any exclusions. The comparison group, 23 LFI patients, was acquired as follows: (1) the clinic archive was searched for all class III dysgnathia patients, (2) preoperative photo documentation was previewed for the presence of midfacial deficiency and (3) patients who were considered in retrospect to have been eligible to receive IQLFII but received LFI osteotomy instead were selected and matched. Matching was conducted retrospectively for age (±5 years) and sex, according to the IQLFII patient data. All patients were otherwise healthy and had no syndromes or any other congenital anomalies. Further requirements were age over 18 years and a complete photo documentation pre- and up to 6 months postoperatively. All digital photographs were formatted to fit a 16:9 PowerPoint® slide (PowerPoint® 2017, Microsoft Corporation), but not otherwise modified.

Surgical procedures

IQLFII osteotomy

For IQLFII osteotomy, the detailed surgical protocol was described by the authors in a previous study[5]. A vestibular approach was conducted to carefully lift periorbital tissues with sinuslift instruments (FRIOS SinusSet, Dentsply IH GmbH, Vienna, Austria) after neurolysis of the infraorbital nerve. The osteotomy was performed with a piezotome (piezoelectric system; Synthes, West Chester, PA, USA). The course of the osteotomy line was chosen along the Wassmund II fracture line. The lateral line (parallel to the zygomaticomaxillary fissure through the infraorbital rim) and medial line (vertically and medial to the infraorbital nerve to the piriform aperture) were connected transversally along the orbital floor just behind the rim (3–4 mm). At the pterygomaxillary fissure the osteotomy was completed as performed in Le Fort I osteotomies with an Obwegeser chisel. Down-fracture and maxillary mobilization was performed using reposition forceps of Rowe and osteosynthesis was performed laterally at the zygomatic buttress with two L-shaped miniplates. Occlusion bal-

Fig. 2. Intraoral quadrangular Le Fort II osteotomy patient photograph. From left to right: frontal view relaxed lips, frontal view smiling, lateral profile view. (A–C) Preoperatively, (D–F) postoperatively.

Fig. 3. Le Fort I osteotomy patient photograph. From left to right: frontal view relaxed lips, frontal view smiling, lateral profile view. (A–C) Preoperatively, (D–F) postoperatively.

ance was achieved by splints for a period of 2–6 weeks with the guidance of elastics.

LFI osteotomy

The LFI osteotomy was performed in the typical manner. Following a vestibular approach, soft tissues including the nasal lining were elevated. The osteotomy was bilaterally conducted at LFI level using an oscillating saw and fine osteotomes for the nasal septum and lateral nasal walls. Pterygomaxillary disjunction was performed using a curved pterygoid chisel (pterygoid osteotome, curved, 11 mm, Medicon®, Germany). After down-fracture, maxillary mobilization was performed with maxillary Tessier mobilizers on both sides (Maxillary Tessier Mobilizer, Falcon Medical®, Austria).

Rater collective

The rater collective consisted of 40 laypersons, who were divided into two cohorts. Twenty people were aged between 18 and 30 years, which resembled the patients' ages. The other cohort involved 20 people aged above 50 years, thus representing the parents' generation of the patients. The rater collective was recruited from the social environment of the study staff. The raters did not have any medical backgrounds and were not informed about any details regarding the surgical techniques. Before the rating session, all raters were instructed and asked to rate a typical photograph of a patient, who was not involved in the study, in order to introduce them to the rating procedure.

Parameters

All pre- and postoperative patient photographs were assessed by means of a four-point Likert scale (see Fig. 1A). Higher values indicated more positive ratings. The assessed characteristics were: (1) attractive – unattractive, (2) likeable – not likeable, (3) intelligent – unintelligent, (4) aggressive – good natured, and (5) dominant – withdrawn.

The main objective of the investigation was the feature 'attractiveness'. The other characteristics were assessed in order to determine what kind of associations occur with face evaluation in midfacial-deficient patients and to what extent LFI or IQLFII osteotomy may succeed in changing these interconnections.

Rating procedure

The laypersons were questioned in a relaxed atmosphere in groups of two to three persons by means of a PowerPoint® presentation. Before the actual rating session, the laypersons were calibrated in order to familiarize them with the rating procedure as such. For this purpose, two patient cases, one of either surgical method, which were not included for statistical analyses, were presented. Patients were anonymized for the rating sessions using a black bar across the eyes. For each

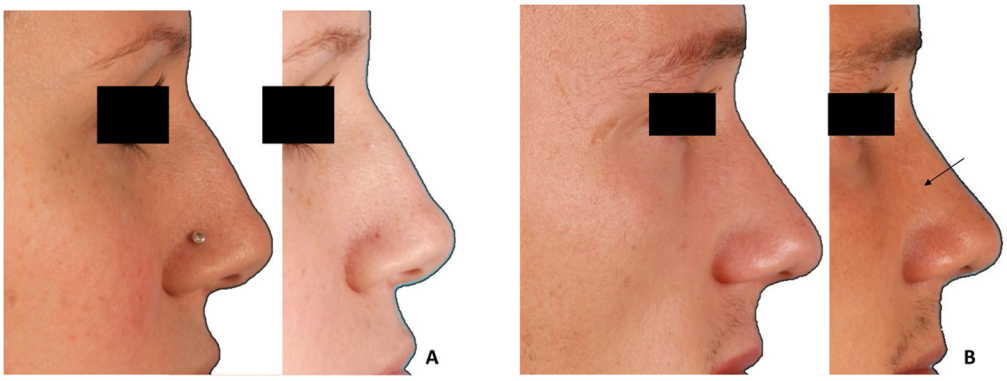

Fig. 4. Comparison of a Le Fort I (A) and intraoral quadrangular Le Fort II (B) patient case with regard to infraorbital rim projection pre- and postoperatively. The difference in outcome with regard to infraorbital rim projection is pointed out by the black arrowhead.

patient, three photographs (frontal relaxed, frontal smiling, lateral profile) were shown on one slide, as per the examples demonstrated in Fig. 2. Within the course of the rating session a pre- and postoperative photograph of each individual were shown in random sequence with those of other patients. Each photograph was shown for 20 s, in order to ensure an immediate reaction by the rater and to offer just enough time to make five marks on the paper questionnaire. Reviewing of photographs was forbidden. After the presentation, all raters were asked to indicate their gender, age and highest degree of education on the questionnaire (see Fig. 1B). Finally, the sheets were collected and numbered for anonymization.

Statistical analysis

All analyses were performed using SAS, release 9.4 and R, release 3.3.3. Descriptive statistics were calculated for all variables. For continuous measurements, means and standard deviations and for categorial data, frequencies and percentages were calculated. To compare the mean values over all raters between test groups (LFI and IQLFII), two-sample *t*-tests were calculated for all characteristics pre- and postoperatively, as well as for the difference in between time points. First ordinal logistic regression models accounting for surgery method, time and the interaction between method and time as fixed factor, as well as a random patient effect were calculated. Furthermore, an univariable ordinal logistic regression model with random patient effect was calculated (only accounting for one of the influence factors). All influence factors that were significant in the univariable models ($P < 0.05$), were included in a multivariable ordinal logistic regression model (with random patient effect). *P*-values <0.05 were considered statistically significant.

Results

Figure 2 demonstrates a male IQLFII osteotomy patient pre- (A–C) and postoperatively (D–F). Figure 3 shows a female LFI osteotomy patient pre- (A–C) and postoperatively (D–F). Figure 4 illustrates the difference in outcomes between LFI (A) and IQLFII (B) osteotomy with regard to infraorbital projection (black arrowhead).

Demographic Data

Overall, patients had a mean age of 23.83 ± 5.88 years. The average age of patients in the LF I and IQLFII group was 23.86 ± 5.65 years and 23.78 ± 6.23 years, respectively. The average age of the 20 younger raters was 25.55 ± 2.78 years and 57.55 ± 9.89 years of the older raters.

Comparison of pre- to postoperative mean ratings

Table 1 shows the mean values over all raters for each kind of osteotomy pre- and postoperatively for each character criterion. *P*-values of the *t*-tests are shown for each criterion comparing findings preoperatively, postoperatively and for the differences (pre- to postoperatively).

Figure 5 demonstrates the mean results pre- and postoperatively for each criterion and each osteotomy method graphically.

Attractiveness (*German*: 'Attraktivität')

Regarding the preoperative findings, no significant differences could be detected between the ratings of both patient groups (IQLFII, LFI) ($P = 0.140$). In the univari-

Table 1. Analysis of covariance.

	Method	Mean (pre)	± SD	*P*	Mean (post)	± SD	*P*	Difference pre–post	± SD	*P*
Attractiveness	LFI	2.04	0.41	0.140	2.51	0.34	0.002	0.48	0.35	<0.0001
	IQLFII	1.86	0.39		2.85	0.44		0.99	0.23	
Likeability	LFI	2.51	0.39	0.038	2.73	0.30	0.194	0.21	0.36	<0.0001
	IQLFII	2.27	0.42		2.85	0.43		0.59	0.34	
Intelligence	LFI	2.39	0.43	0.468	2.69	0.36	0.239	0.31	0.32	0.352
	IQLFII	2.30	0.44		2.56	0.44		0.26	0.29	
Aggressiveness	LFI	2.98	0.33	0.170	2.76	0.58	0.007	0.23	0.66	<0.0001
	IQLFII	2.83	0.45		2.29	0.57		0.55	0.74	
Dominance	LFI	2.86	0.27	0.184	2.58	0.47	0.022	0.27	0.55	<0.0001
	IQLFII	2.73	0.37		2.22	0.61		0.51	0.61	

Mean rating values, standard deviations (SDs) and *P*-values are shown separately for each kind of osteotomy and for each character criterion. IOQLFII, intraoral quadrangular Le Fort II; LFI, Le Fort I.

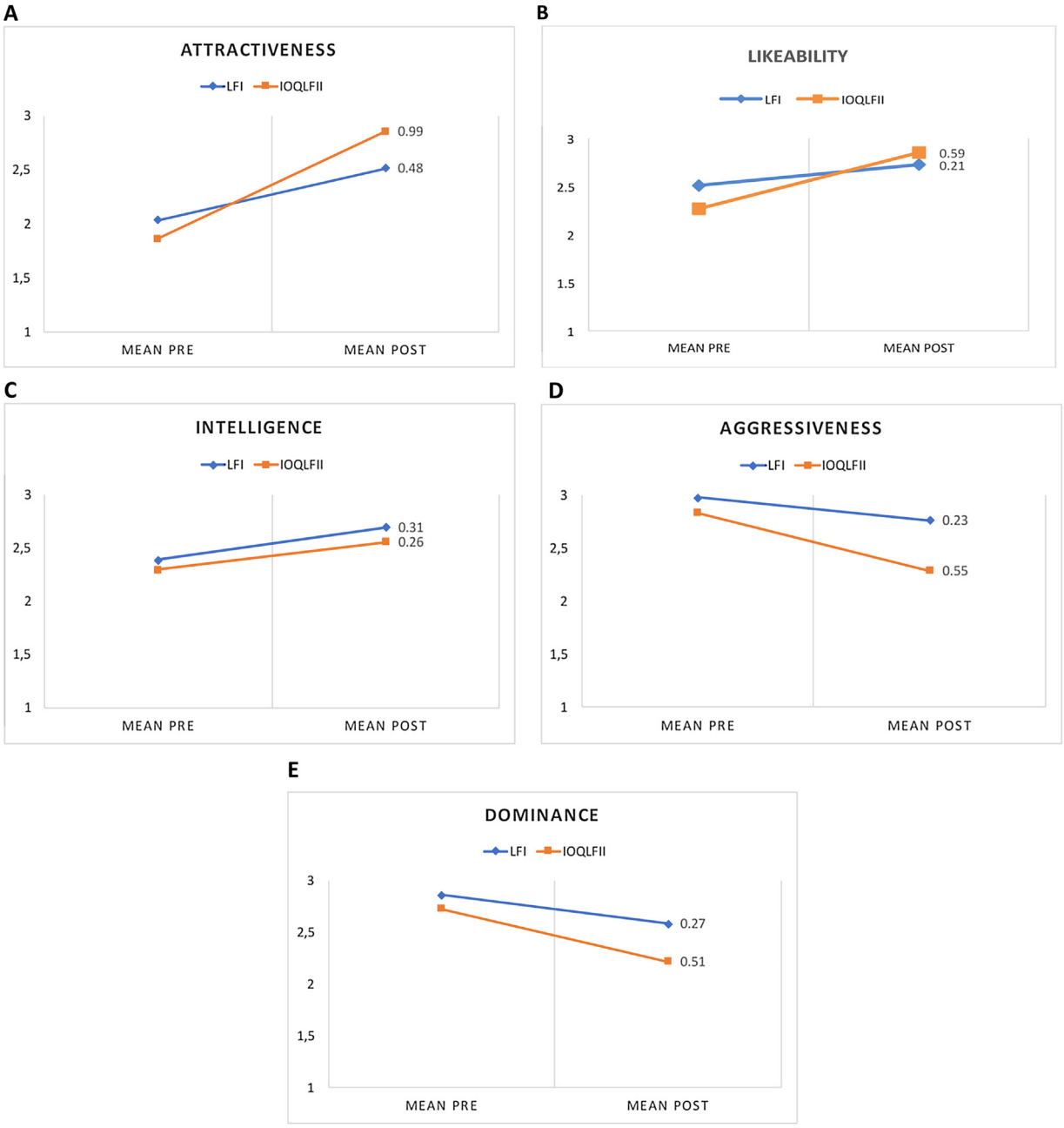

Fig. 5. Mean results over all raters pre- and postoperatively for Le Fort I (LFI) patient group (blue line) and intraoral quadrangular Le Fort II (IOQLFII) patient group (orange line). Results are depicted for each criterion separately: 'attractiveness' (A), 'likeability' (B), 'intelligence' (C), 'aggressiveness' (D) and 'dominance' (E). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

able model, a significant difference between surgical methods could be detected ($P < 0.0001$). A larger shift from lower to higher ratings in 'attractiveness' was found for IQLFII as compared to LFI osteotomy. The postoperative rating results showed higher values for the IQLFII osteotomy group ($P = 0.002$). Furthermore, a larger probability of higher ratings was found for old as compared to young raters ($P < 0.0001$). A significant influence of raters' education on ratings of attractiveness was observed ($P < 0.0001$) with stricter values of raters who had 'academic studies'. A significant larger probability of higher ratings was found for younger patients ($P = 0.0003$). In the multivariable regression model, the effects of surgery ($P < 0.0001$), patients' age ($P = 0.0005$) as well as raters' age ($P < 0.0001$) and education ($P < 0.0001$) remained significant. Figure 6 shows the predicted probabilities for all levels, separately for method, raters' gender, age group and education.

Likeability (*German*: 'Sympathie')

Initial preoperative findings showed higher ratings in likeability for the LFI patient group ($P = 0.038$). In the univariable model, a significant difference between surgery methods could be

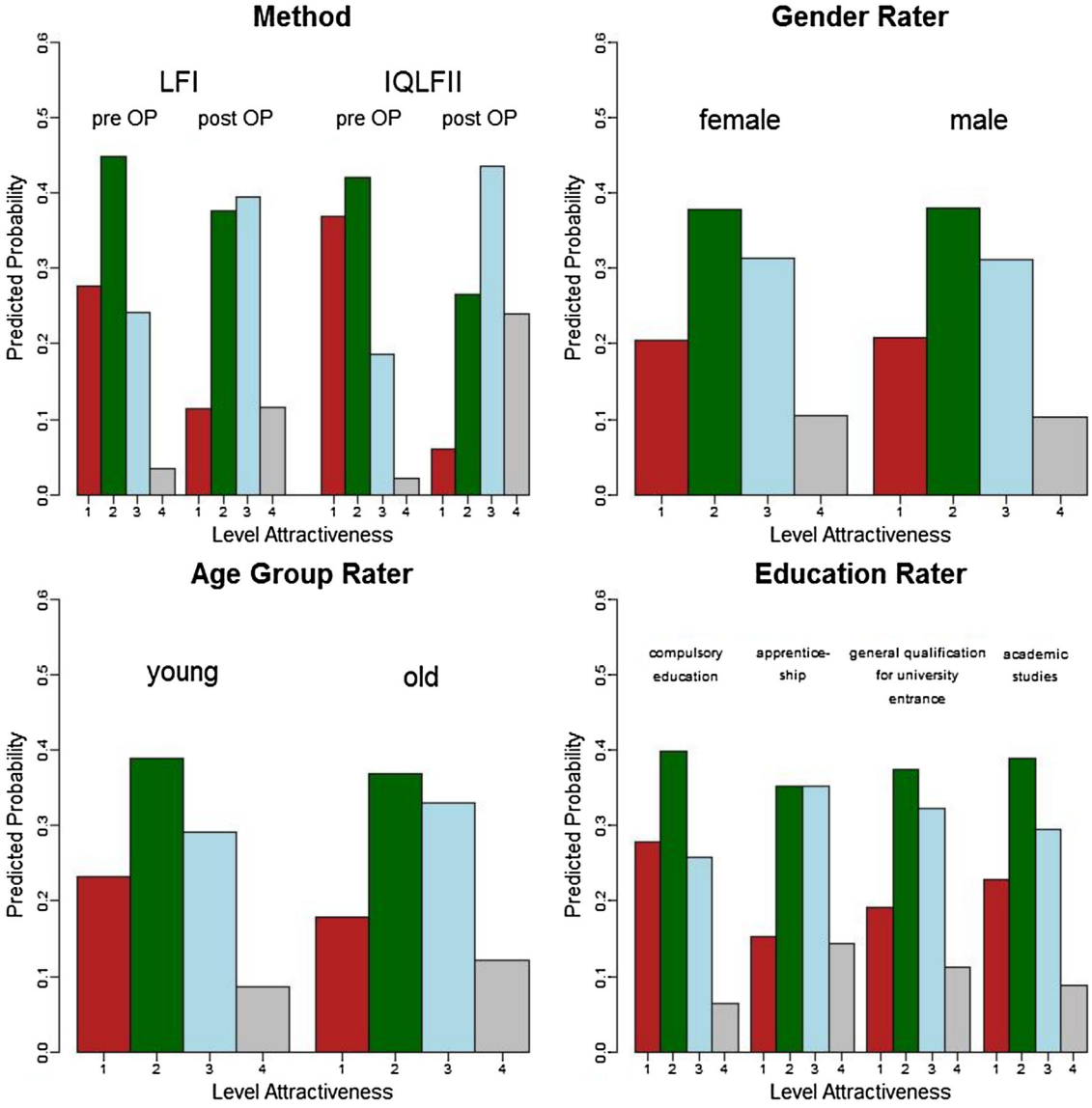

Fig. 6. Predicted probabilities for all levels, separately for method, rater's gender, age group and education, exemplary for the criterion 'attractiveness'. IOQLFII, intraoral quadrangular Le Fort II; LFI, Le Fort I.

detected ($P < 0.0001$). A larger shift from lower to higher ratings in likeability was found for IQLFII as compared to LFI osteotomy. The postoperative rating results showed higher values for the IQLFII osteotomy group, however results were not significant ($P = 0.194$). In the multivariable regression model, the effects of surgery ($P < 0.0001$), patients' age ($P = 0.002$) as well as raters' education ($P < 0.0001$) remained significant.

Intelligence (*German*: 'Intelligenz')

Preoperatively, rating results did not differ significantly for both osteotomy groups ($P = 0.468$). In the univariable model, no significant difference in the increase or decrease of ratings between surgery methods could be detected ($P = 0.352$) and the absolute rating results did not differ significantly ($P = 0.239$). In the multivariable regression model, the effects of patients' age ($P = 0.006$) and gender ($P = 0.035$) as well as raters' age ($P < 0.0001$), gender ($P < 0.0001$) and education ($P < 0.0001$) remained significant.

Aggressiveness (*German*: 'Aggressivität')

No difference in initial rating results was detected in preoperative findings ($P = 0.454$). In the univariable model, a significant difference between surgery methods could be detected ($P < 0.0001$). A larger shift from higher to lower ratings in aggressiveness was found for IQLFII as compared with LFI osteotomy. Postoperative ratings significantly changed to lower values for the IQLFII osteotomy group ($P = 0.007$). In the multivariable regression model, the effects of surgery ($P < 0.0001$), patients' gender ($P = 0.004$) as well as raters' age ($P = 0.022$) and education ($P = 0.001$) remained significant.

Dominance (*German*: 'Dominanz')

For 'dominance' the rating results did not differ significantly preoperatively ($P = 0.184$). In the univariable model, a

significant difference between surgery methods could be detected ($P < 0.0001$). A larger shift from higher to lower ratings in dominance was found for IQLFII as compared with LFI osteotomy. The postoperative rating results changed to significantly lower values for the IQLFII osteotomy group ($P = 0.022$). In the multivariable regression model, the effects of surgery ($P < 0.0001$), patients' gender ($P = 0.045$) as well as raters' age ($P = 0.002$) and education ($P < 0.0001$) remained significant.

Discussion

To our knowledge, this is the first study evaluating the aesthetic outcome of a patient collective with midfacial deficiency that was treated by IQLFII surgery. Individualized surgical treatment planning has become the gold standard in orthognathic surgery, where tools for virtual surgical planning, such as prefabricated cutting guides and customized plates facilitate and improve surgical treatment[9–12]. However, surgical planning, devoid of profile analyses, poses the risk that infraorbital deficits are underdiagnosed and neglected. Because IQLFII and LFI osteotomy cannot be regarded as interchangeable choices, we believe that class III cases, should be analysed for infraorbital bone projection and subjected to quadrangular Le Fort II osteotomy, if needed.

This study was not a randomized trial. Certainly, this study design would be optimal for the quest of our investigation. However, we believed that a randomization of patients with two quite different surgical procedures was not justifiable. In order to overcome this limitation, we screened our institution's database for a suitable collective for comparison. Due to the fact that not all surgeons at our institution perform IQLFII, and that the number of conventional bimaxillary surgery for class III cases exceeds the consecutive IQLFII group by far, we had a good chance of finding LFI patients with infraorbital deficits. Our process of finding a suitable group for comparison included the viewing of all preoperative photographs and matching of eligible patients according to age and sex.

By hypothesizing that positive feedback for patients could primarily be achieved by their social circle, we defined a group of laypersons as jury. The types of images presented for evaluation were frontal and lateral views of the patients. We refrained from a strict definition of the assessed criteria to avoid distortion of the natural subjective perception by the laypersons. We also refrained from showing detailed images or unusual perspectives (e.g., retro-inclined caudal view) to the laypersons, because such images would not represent the natural sight of a person. The photographs showed the full face of each patient (excluding the eyes), because the scientific question sought a holistic assessment of the patients' faces. Although evaluation of conventional photographs is a widespread and well-established method, it may nowadays represent a possible limitation, because more advanced technologies, such as three-dimensional photography or video analyses may yield even more reliable results.

The main aspect for evaluation was the criterion 'attractiveness', followed by subordinated and more specified character criteria. Preoperative evaluation of all criteria revealed equal ratings for both patient groups, except for the criterion 'likeability', in which IQLFII osteotomy patients scored significantly worse than LFI osteotomy patients. Postoperatively, 'attractiveness', 'aggressiveness' and 'dominance' were significantly better for the IQLFII osteotomy group. 'Attractiveness' represents a well-defined character trait[13–16]. However, people seem to evaluate faces on multiple dimensions, which also exerts an impact on social outcomes. Oosterhof et al. found that two orthogonal dimensions, namely 'valence' and 'dominance', which are called 'likeability' and 'dominance' in this study, respectively, are sufficient to describe face evaluation[17]. While the criterion 'dominance' implies a sense of power and control over someone, the criterion 'aggressiveness' represents a strongly threatening sentiment at the sight of a person's face. Thus, we additionally introduced the criterion 'aggressiveness'. Retrospectively and with regard to the results of this study, this choice may have overreached the judging capability of the layperson jury, because the results of both criteria were very similar. This fact may be regarded as a limitation of the study, because too many choices may have confused the raters.

Moreover, we introduced the criterion 'intelligence', which is, according to literature, strongly correlated with evaluation of 'attractiveness' (and vice versa) and thus may predict social outcomes. Zebrowitz et al. found that a person with higher intelligence appears to be more attractive[18], while Dion et al. found that attractive people attain more prestigious jobs than less attractive people[19]. Since then, several studies and meta-analyses have been conducted that show a positive correlation between intelligence and attractiveness ratings[20,21]. Thus, there seems to be a close interdependence between both traits. A negative perception of attractiveness and concomitant misjudgment of intelligence by the social environment may potentially lead to severe after effects in the social and professional development of an individual. However, for the criterion 'intelligence' results did not show any significant differences between the patient groups. Retrospectively, this seems to be reasonable, because the raters were aware that they evaluated surgical procedures, which clearly could not alter patients' intelligence. However, it would be interesting to examine rating values for 'intelligence' without pre- to postoperative comparison at a given instant in the future.

In some respects, facial ideals are different for men and women. For example, it is generally known that among men a prominent chin is favourable, because it implies a strong personality[14,22]. Our data support the hypothesis that the infraorbital region has an impact on social perception to a similar extent, as it significantly influences perception of 'attractiveness', 'likeability ', 'aggressiveness' and 'dominance' in men as well as women. Although ideal facial aesthetic forms vary with gender, culture and societies' interpretations, several studies show consensus with regard to cheek bone prominence. Beautiful faces are, amongst other physiognomies, characterized by high cheekbones in women as well as in men[13,23]. From a lateral point of view, this may somehow correlate with the projection of the infraorbital rim. Although indication for IQLFII osteotomy cannot exclusively be determined by infraorbital prominence, it should at least be considered in midfacial-deficient class III patients.

A possible downside of IQLFII osteotomy is the increased risk of nerve damage and fracture of the thin anterior wall of the maxilla. However, a modification of the technique as initially described by Keller and Sather[24] ensures minimization of surgical risks with respect to nerve damage, damage to orbital content, bleeding and swelling[5]. The use of an angulated piezotome enables a safe cut along the anterior orbital rim without putting the infraorbital nerve at risk. Fractures of the maxillary shield are rare events and can be fixed with miniplates without any observed postoperative complications[5].

Although choices are limited, the question for alternative treatment approaches has to be considered. Several study

groups proposed the insertion of PEEK implants to correct infraorbital rim deficits[25,26]. We believe that a mere camouflage by implants in malocclusion patients is not an adequate alternative, because occlusal and functional aspects might be neglected. However, implants may be an appropriate choice in asymmetric cases (e.g., hemifacial microsomia or unilateral cleft lip and palate patients) that preclude the possibility of conducting IQLFII osteotomy alone, but potentially in combination with augmentative procedures[25–27].

In conclusion, appropriate midfacial projection can be regarded as a prerequisite for a harmonic profile. With given indication, occlusal anomalies and infraorbital deficits can be corrected concomitantly with IQLFII as opposed to LFI osteotomy. Our analysis shows that laypersons are able to detect differences in outcome of the two compared surgical methods. It further reveals that change of the infraorbital rim projection makes a significant difference. Our analyses also show that patients treated by means of IQLFII osteotomy have greater chances for change to more 'attractiveness' and 'likeability', less 'aggressiveness' and 'dominance' than LFI patients. With these results, we hope to improve presurgical information for our patients prior to the decision for one treatment or the other. Future studies will focus on objectification of criteria regarding the indication of IQLFII osteotomy and its further validation.

Competing interests

None.

Funding

None.

Ethical approval

Ethical approval was given by the ethics committee of the Medical University of Vienna (reference number: 1640/2018).

Patient consent

Patient consent was acquired for the publication of photographs and case histories.

Statement to confirm

All authors have viewed the manuscript and agreed to submission.

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Address:
Julia Cede
University Department for Oral and Maxillofacial Surgery
Vienna General Hospital
Waehringer Guertel 18-20
1090 Vienna
Austria
Tel.: +43 664 389 82 03
E-mail: julia.cede@meduniwien.ac.at