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Professionals' and laypersons' appreciation of various options for Class III surgical correction

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SUMMARY The objectives of this study were to evaluate the assessments of maxillofacial surgeons, orthodontists, and laypersons on the predicted aesthetic outcome of various surgical options in Class III correction and the associations between certain initial cephalometric values and the judges' preferred option.

Pre-surgical lateral headfilms and coloured profile photographs of 18 skeletal Class III Caucasian adult patients (10 males and 8 females) with a mean age of 24.5 years were used. The headfilms were hand traced and digitized. Conventional cephalometric analysis was performed. Computerized predictions of three surgical options, mandibular setback, Le Fort I advancement, and bimaxillary surgery, were made. For each case, the pre-surgical profile photograph with the three predictions was presented on a printed page. The questionnaire was sent to 51 maxillofacial surgeons (response rate 45.1 per cent), 78 orthodontists (response rate 71.8 per cent), and 61 laypersons (response rate 100 per cent) to aesthetically evaluate the pre-surgical photographs and the surgical predictions by placing a mark along a 10-graded visual analogue scale (VAS) using a standard profile for calibration. Confidence interval was calculated for each patient. An independent samples *t*-test was used to detect initial cephalometric values associated with the judges' preferred option and analysis of variance/Tukey's honestly significant differences to evaluate differences between judges. Intra-observer reliability was assessed with a paired *t*-test.

All treatment predictions led to improved scoring of facial aesthetics with the exception of the setback option for three patients. For 14 patients, general agreement for the preferred option existed between the three groups of judges. Laypersons tended to give lower improvement scores than professionals. Overjet, nasofacial, and nasomental angles were important in decision making between the mandibular setback and Le Fort I options (the more negative the overjet, the larger the nasofacial angle, the smaller the nasomental angle, the greater the preference for the Le Fort I option). Wits appraisal seemed to be important in decision making between the mandibular setback and bimaxillary options (the more negative the Wits appraisal, the greater the preference for the latter option).

Introduction

Class III malformations are the consequence of insufficient forward growth of the maxilla, excessive forward mandibular growth, or a combination of both. It is often combined with excessive vertical growth and less frequently with insufficient vertical development.

Nowadays, a combined orthodontic–surgical approach is widely accepted as the preferred method to correct moderate to severe skeletal deformity in adults. This approach resolves the problems for which orthodontic treatment alone would do little to improve facial aesthetics.

In the past, a mandibular bilateral sagittal split osteotomy (BSSO), as described by Trauner and Obwegeser (1957), modified by Dal Pont (1961) and later by Epker (1977), was the only surgical alternative. This operative technique appeared very unstable (Kobayashi *et al.*, 1986; Bailey *et al.*, 1995; Schatz and Tsimas, 1995) and the results were unpredictable. They depended greatly on the ability of the surgeon to position correctly the two proximal fragments during intervention under general anaesthesia (Fish and Epker, 1986). Moreover, with a large mandibular setback, the risk of inducing obstructive sleep apnoea (Riley *et al.*, 1987) was high. Long-term evaluation of facial profiles also revealed more premature signs of ageing in patients with retrusive compared with protrusive profiles.

Maxillary advancement with Le Fort I osteotomies became popular in the early 1980s to correct moderate Class III malocclusions. It was found to be a more stable technique (Wardrop and Wolford, 1989) that resulted in a more stable occlusion and a more pleasing profile (Bailey *et al.*, 1995; Proffit and Phillips, 2003) and was also indicated in Class III patients with vertical excess.

In subjects with severe malformations and in those with mandibular asymmetry, combined mandibular and maxillary osteotomies were, however, indicated.

Based on studies that show excellent profile improvement and good long-term stability (Proffit *et al.*, 1991), the tendency of the last decade has been to undertake bimaxillary surgery on most Class III patients (Bailey *et al.*, 1995). However, the differences between single- and double-jaw surgery concerning surgical risks and costs, time of recovery, and patient inconvenience during this period should also be considered.

The recognition of aesthetic factors and the ability to predict the final facial profile play an increasingly important role in orthognathic treatment planning since aesthetics remains the principal motive for the majority of patients seeking orthognathic surgery (Laufer *et al.*, 1976; Kiyak *et al.*, 1981; Jacobson, 1984). However, a number of studies have confirmed that the general public and professionals view facial aesthetics differently (Lines *et al.*, 1978; Prahl-Andersen *et al.*, 1979), with the general public demonstrating the greatest variation in what they consider attractive (Cochrane *et al.*, 1999).

The purpose of this study was to evaluate the assessments of maxillofacial surgeons, orthodontists, and laypersons on the predicted aesthetic outcome of the various surgical options in Class III correction in order to establish guidelines that derive not only from the professionals' but also from patient peer opinion. The choice of a certain orthognathic option depends on many factors, one of which is the initial facial morphology. Therefore, the aim was to identify certain cephalometric variables which could be related to the preferred option.

It was hypothesized that a difference between professionals and laypersons exists in the evaluation of Class III surgical predictions and that laypersons do not perceive the differences between the various options as clearly as professionals.

Subjects and methods

Subjects

Eighteen Caucasian skeletal Class III adult patients seeking treatment during the period 1984–2001 and treated with combined orthodontics and orthognathic surgery were selected. They had to meet the following inclusion criteria: a Class III malocclusion in centric relation, with a negative or zero overjet and an ANB angle of 1 or less degree before treatment. Patients with a cleft lip/palate, recognized syndromes, or facial trauma were excluded.

The selected patients (10 males and 8 females) with a mean age of 24.5 years, range 17.5–38.4 years presented a mean pre-surgical overjet and ANB angle of −5.4 mm (range −10.5 to −0.4 mm) and −2.6 degrees (range −6.4 to 0.8 degrees), respectively.

Methods

Lateral headfilms, taken in the natural head position (NHP) with the lips in the rest position, and coloured facial profile photographs taken prior to surgery were obtained from the patients' records.

The lateral cephalograms were hand traced and the tracings were digitized by the same examiner (MF). Angular and linear cephalometric variables, as shown in Table 1 and Figure 1, were calculated by computer using the OTP software (OTP for Windows, Version 8.5.4, Pacific Coast Software, Smith Micro Software, Inc., Aliso Viejo, California, USA).

Table 1 Cephalometric variables studied.

Cephalometric variables
Angles (°)
ANB (point A–nasion–point B)
SN–MEGO (sella turcica–nasion/menton–gonion)
Nasolabial angle*
(ac–pc–sl: anterior columella–posterior columella–labrale superius)
Nasofacial angle**
(g–pg: soft tissue glabella–soft tissue pogonion/line tangent to dorsum of nose)
Nasomental angle**
(n–nt/nt–pg: soft tissue nasion–nasal tip/nasal tip–soft tissue pogonion)
Facial contour angle***
(g–pc/pc–pg: soft tissue glabella–posterior columella/posterior columella–soft tissue pogonion)
Distances (mm)
Overjet
Wits appraisal
Upper lip protrusion****
(sl to nt–pg: distance labrale superius to nasal tip–soft tissue pogonion line)
Lower lip protrusion****
(ll to nt–pg: distance labrale inferius to nasal tip–soft tissue pogonion line)
Upper face height***
(E–pc: eye–posterior columella)
Lower face height***
(pc–me: posterior columella–soft tissue menton)
Upper lip length***
(pc–s: posterior columella–stomion)
Lower lip length***
(s–me: stomion–soft tissue menton)
Ratios
MEGO/ANS–PNS
(menton–gonion/anterior nasal spine–posterior nasal spine)
Upper lip length/lower face height

*Arnett and Bergman (1993), **Powell and Humphreys (1984), ***Worms *et al.* (1976), ****Ricketts (1960).

The profile photographs were checked for adequate quality: each photograph had to show the profile in the NHP with the lips in the rest position and without the subjects wearing spectacles.

From the headfilms and profile photographs, predictions of the three surgical options (mandibular setback, Le Fort I advancement, and bimaxillary surgery) were made using the OTP software. Colour and blending of the predictions were adjusted with Image Magician (Version 2.0.10, Pacific Coast Software, Inc.) to provide an appearance as natural as possible, eliminating distracting discontinuities between discrete distortions. This was obtained without changing the profile outline.

For each subject, the pre-surgical profile photograph and the three predictions, in random order, were presented on one printed page with a modified visual analogue scale (VAS) from 0 to 10 cm underneath each profile (Figure 2). A total of 72 photographs were presented on 18 pages, accompanied by a standard calibration profile.

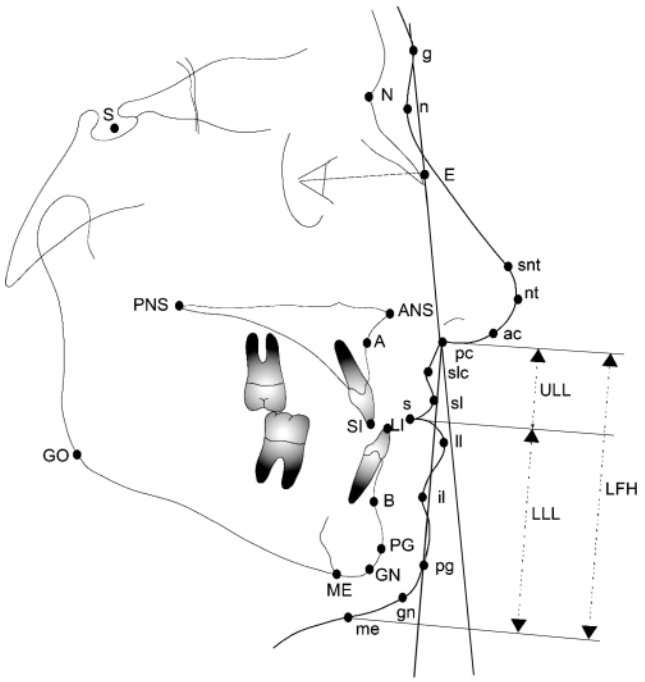

Figure 1 Reference points and lines used in the cephalometric analysis. Hard tissue points: S, sella turcica; N, nasion; ANS, anterior nasal spine; PNS, posterior nasal spine; A, point A; B, point B; PG, pogonion; GN, gnathion; ME, menton; SI, incision superius; LI, incision inferius; GO, gonion. Soft tissue points: g, soft tissue glabella; n, soft tissue nasion; snt, superior nasal tip; nt, nasal tip; ac, anterior columella; pc, posterior columella; slc, superior labial sulcus; sl, labrale superius; s, stomion; ll, labrale inferius; il, infralabiale; pg, soft tissue pogonion; gn, soft tissue gnathion; me, soft tissue menton. Constructed points: E, eye, the intersection of soft tissue glabella–posterior columella plane by a perpendicular line bisecting the eye (Worms *et al.*, 1976). LFH, lower face height; LLL, lower lip length; ULL, upper lip length.

Judges

The questionnaire was sent to 51 maxillofacial surgeons (48 males and 3 females), 78 orthodontists (48 males and 30 females), and 61 laypersons (20 males and 41 females).

The judges represented a wide age range but all were adults. The professionals had various levels of experience. The laypersons consisted of participants recruited from incidental contacts and had a mixed socio-economic background, but none of them was trained in dentistry or facial surgery.

The assessors were given a written explanation of the study. They were asked to aesthetically evaluate the pre-surgical photographs and the surgical predictions of all 18 patients by placing a mark along the VAS from 0 to 10 underneath each photograph, 0 being described as 'a very unattractive profile' and 10 being described as 'a very attractive profile' [profile assessment score (PAS)] in the most objective way, without being influenced by factors such as make-up, colour of the eyes, and hair style.

To standardize the assessments of the judges, the photographs were to be rated in relation to a standard calibration profile, with a mean PAS of 6.0 on the VAS, which had been previously validated (Fabré *et al.*, 2009).

'Improvement' of facial aesthetics was considered when there was a positive difference in PAS of at least 0.5 units on the VAS between the pre-surgical and predicted post-surgical profile.

Statistical analysis

Based on the mean scores for the pre-surgical photograph and the mean improvement units for each prediction of the 18 patients, when all 140 judges were taken together, confidence interval (CI) was calculated for each patient individually. A positive/negative CI of at least 0.5 units was considered as an improvement/worsening of facial aesthetics, respectively.

For every option for each Class III patient, the percentage of surgeons, orthodontists, and laypersons who preferred that option was calculated. This differentiated three groups of patients with consensus of preferred surgical option by all judges.

Independent samples *t*-tests were used to investigate differences in the pre-surgical cephalometric variables (Table 1, Figure 1) between the three groups of patients, to detect why, for a certain group of patients, a certain surgical option was preferred.

To compare the improvement units (with standard deviation) for the preferred option by the three groups of judges, repeated measures analysis of variance was used to determine if there was a difference in judgement between the maxillofacial surgeons, the orthodontists, and the laypersons. A repeated measures design was employed because each patient was evaluated three times, once by the surgeons, once by the orthodontists, and once by the laypersons. Tukey's honestly significant differences test was used to ensure that any differences found were not due to chance. This was undertaken for the patients for whom there was a general agreement of preferred surgical option between the three groups of judges.

Method error

To test intra-observer reliability, the questionnaire was submitted for re-evaluation with a minimum interval of 6 months to five maxillofacial surgeons, five orthodontists, and five laypersons. All the pre-surgical values and one prediction per patient taken at random were submitted to statistical analysis. A paired *t*-test was used to assess systematic error between the two occasions.

The error of the method (SE) was calculated using the formula of Dahlberg

$$SE = \sqrt{\frac{\sum d^2}{2N}},$$

where Σd^2 is the sum of the squared differences between the first and the second occasion and N is the number of subjects evaluated twice (Houston, 1983).

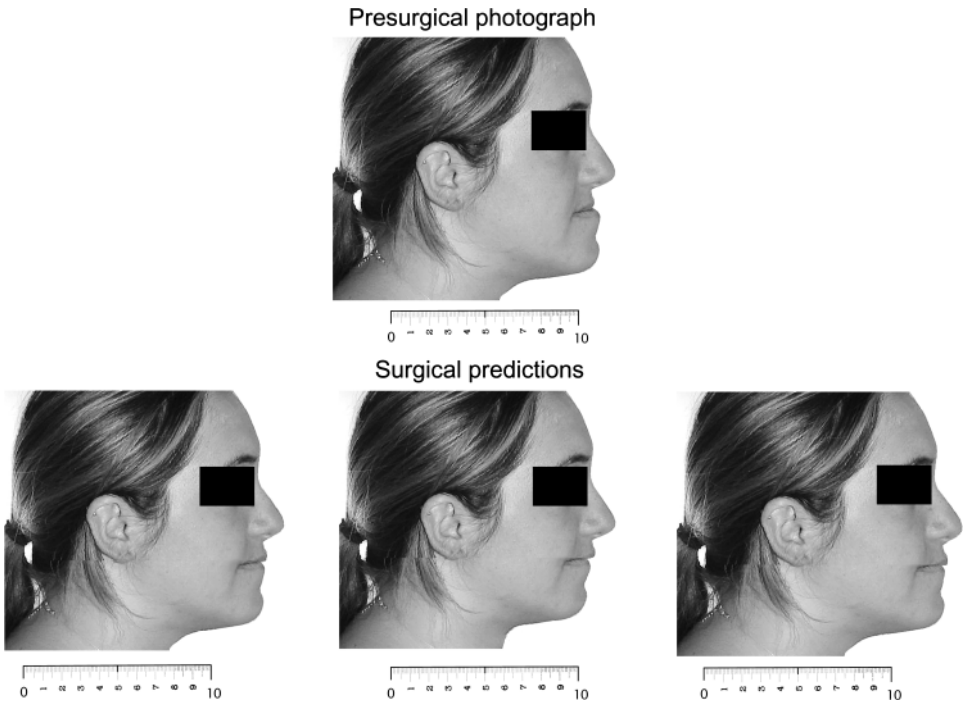

Figure 2 The mark sheet with the pre-surgical profile photograph on the top of the page with the three surgical predictions below in random order. The judges were asked to aesthetically score each photograph by placing a mark on the visual analogue scale (0 = a very unattractive profile; 10 = a very attractive profile).

When assessing the pre-surgical photographs, a difference between the two occasions of 0.25/0.09/0.18 units on the VAS was found for the surgeons, orthodontists, and laypersons, respectively.

When assessing the predictions, the laypersons were the most consistent (0.42), followed by the orthodontists (0.63) and then the surgeons (0.65).

Tracing and point identification error between duplicate measurements had been previously assessed (Fabré *et al.*, 2009). The systematic error between the two sets of measurements was low.

Results

Response rate

The response rate for maxillofacial surgeons, orthodontists, and laypersons was 45.1, 71.8, and 100 per cent, respectively. The orthodontists and laypersons represented both genders, while there was an over-representation of males among the surgeons.

Evaluation of the improvement scores

CI showed that most of the results were reliable and were not an accidental finding. Depending on the pre-surgical photograph, a specific surgical option was preferred, and it could be any of the three proposed alternatives. For all the subjects, each option was an improvement, except for the setback option where three subjects did not meet the standards (Figure 3).

For 14 of the 18 patients, there was a general agreement on the preferred surgical option between maxillofacial surgeons, orthodontists, and laypersons (Figure 4): the setback option was preferred for four patients, the Le Fort I option for seven, and the bimaxillary option for three patients by the three groups of judges.

Comparison between the judges showed that for the setback option (four patients), the surgeons and the orthodontists found an aesthetic improvement of 3.2 and 3.3 units, respectively, and thus were both more satisfied with the predicted outcome as compared with the laypersons (1.8 units, $P = 0.004$ and $P = 0.003$, respectively). No difference was found between orthodontists and surgeons. For the Le Fort I option (seven patients), the surgeons and orthodontists gave a higher improvement rate (3.1 and 3.6 units, respectively) as compared with the laypersons (1.9 units, $P = 0.041$ and $P = 0.005$, respectively), while no difference was found between orthodontists and surgeons. No significant difference between the three groups of judges was found in the improvement score for the three patients where the bimaxillary option was preferred (surgeons: 3.3, orthodontists: 3.7, and laypersons: 2.2).

For the remaining four patients, there was not total consensus. Two of the three groups of assessors agreed on the option while the third group had this option as the second choice (Figure 4). For these four patients, the preferred option

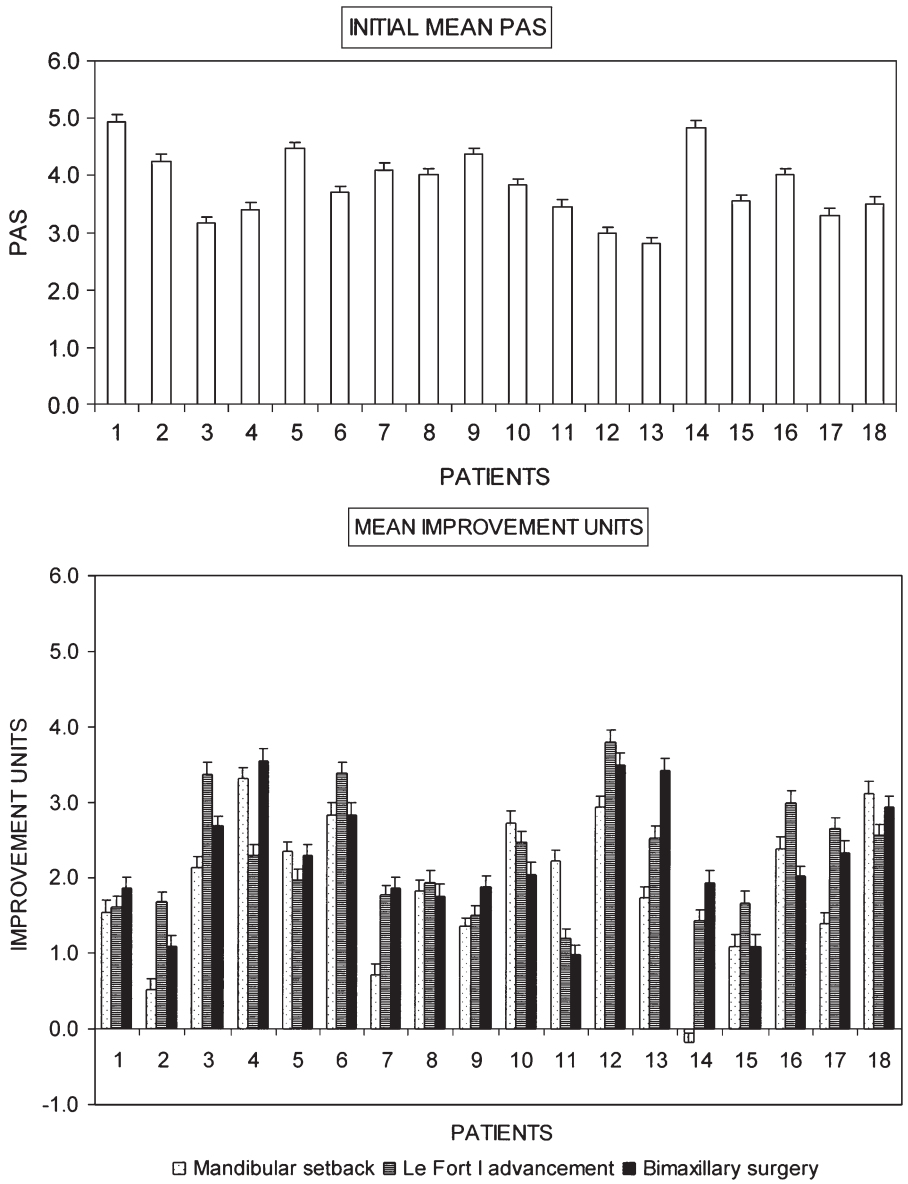

Figure 3 Mean profile assessment scores (PAS) (with SEM = SD/$\sqrt{n}$) for the pre-surgical photograph and mean improvement units (with SEM) for each surgical prediction for each of the 18 patients, based on all assessments (n = 140 assessors).

fluctuated between Le Fort I and bimaxillary surgery. None of the three groups of judges preferred the setback option.

Correlation between preferred prediction and initial craniofacial disharmony

When comparing the four patients selected for setback with respect to the seven patients selected for the Le Fort I option, independent samples *t*-tests showed that overjet, nasofacial, and nasomental angles were important in the decision-making process. The more negative the overjet before surgery, the more probable the judges would choose the Le Fort I option (compared with the setback option; $P = 0.013$). The larger the nasofacial angle, the more the judges preferred the Le Fort I option ($P = 0.01$) and the larger the nasomental angle, the more the judges preferred the setback option ($P = 0.024$).

When comparing the four patients selected for setback with the three patients selected for the bimaxillary option, only the Wits appraisal seemed to be important. The more negative the Wits appraisal, the greater the probability that the judge would choose bimaxillary surgery ($P = 0.01$).

No significant differences in initial craniofacial characteristics were found between the patients selected for the Le Fort I advancement and those selected for bimaxillary surgery.

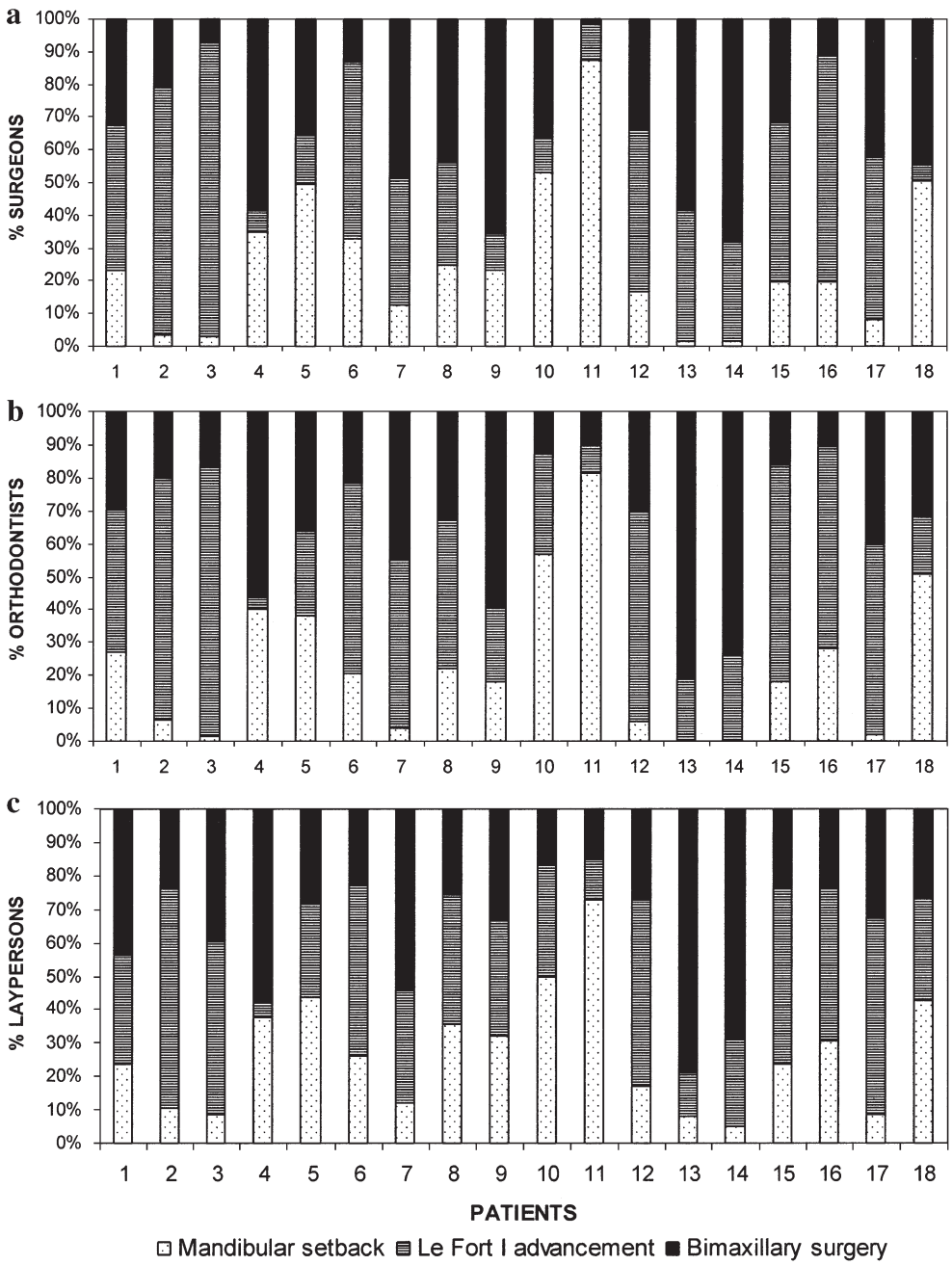

Figure 4 Percentage of maxillofacial surgeons (**a**), orthodontists (**b**), and laypersons (**c**) who preferred mandibular setback/Le Fort I advancement/bimaxillary surgery for each of the 18 patients.

Discussion

It has been shown that both laypersons and orthodontists consider subjects with Class I profiles as more attractive than those with Class III profiles, and, when assessing the aesthetics of Class III profiles, laypersons are less critical (Fabré *et al.*, 2009).

In the present investigation, three surgical options for skeletal Class III correction were proposed to maxillofacial surgeons, orthodontists, and laypersons in order to evaluate their assessments on the eventual final aesthetic outcome.

While the orthodontist and the layperson groups were representative of their professional population, the surgeon group, with the lowest response rate, consisted almost exclusively of males. It can be assumed that this selection corresponded to a specific European area and thus may not be comparable with other countries. However, since De Smit and Dermaut (1984) found no significant difference between male and female participants in aesthetic preference for the gender of a profile, it can be assumed that the results were not biased by the selection of the judges.

Overall, all types of predicted interventions led to an improved scoring of facial aesthetics and, depending on the pre-surgical photograph, a different type of surgery was preferred.

For 14 of the 18 patients evaluated, there was general agreement for the preferred surgical option. For the remaining four patients, there was always an agreement for a certain option between two of the three groups of judges, while the third group chose the same option as the second best. The hypothesis that laypersons do not perceive differences between the different options as clearly as professionals was not totally verified.

Surgeons and orthodontists tended to differentiate pre- and post-surgical profile better than laypersons since most of the time the former gave higher improvement scores. Only for the bimaxillary surgical option, was there no difference between the judges. In Class II surgical correction using either mandibular advancement alone or combined maxillary impaction and mandibular advancement, Dunlevy *et al.* (1987) demonstrated that professionals systematically ranked the surgical outcomes higher than laypersons. Professionals frequently perceive facial aspects that may appear unimportant to laymen. Orthodontists tend to focus on facial profile and different portions of the face, whereas laymen tend to view facial aesthetics as a whole (Cochrane *et al.*, 1999).

Only few initial cephalometric characteristics could be identified as influencing the choice for a certain surgical option, possibly due to the limited number of cases studied. Enacar *et al.* (1999) evaluated the soft tissue profile changes resulting from double-jaw surgery and mandibular setback alone in Class III patients and found that the soft tissue ratios seen in double-jaw surgery were similar to those in mandibular setback surgery, with the exception of the changes in nasal tip projection and upper lip area. Altug-Atac *et al.* (2008) concluded that because maxillary advancement does not significantly improve nose/upper lip tissues, it should be avoided in borderline Class III patients who may benefit from a mandibular setback. Increasing the number of subjects studied with a larger spectrum of severity of Class III malocclusion may have permitted the identification of more cephalometric variables important in decision making.

The present investigation was also undertaken to determine if bimaxillary surgery was systematically ranked as the best alternative to correct Class III skeletal malformations. It was clearly not the case, and for that reason, when planning surgery, all three options must be considered and factors other than aesthetics, such as surgical risks, pain, discomfort, and costs, should be carefully evaluated.

Girod *et al.* (2001) found that major adverse outcome from maxillary osteotomy is infrequent but serious, whereas adverse outcomes in mandibular surgery are more common but less problematic. Furthermore, Lenzen *et al.* (1999) found that operation mode (maxillary or bimaxillary) and the duration of surgery were the most significant factors for intra-operative blood loss; analysis of the rate of autologous blood transfusion showed a significant correlation with blood loss in bimaxillary surgery.

Another important complication to consider is relapse. Forward movement of the maxilla is reasonably stable but not so mandibular setback. After combined mandibular setback and maxillary advancement, the post-surgical changes appear to be similar to, and no greater than, the changes seen in each jaw after maxillary advancement or mandibular setback alone (Proffit *et al.*, 1996). In a systematic review of the literature on stability after double-jaw surgery in skeletal Class III malocclusion subjects, Mucedero *et al.* (2008) found good stability for pre-surgical sagittal intermaxillary discrepancies smaller than 7 mm.

A study by Panula *et al.* (2002) found that a BSSO alone was the most cost-effective procedure and bimaxillary osteotomies the most expensive. They suggested that this fact should be considered in pre-treatment planning, especially in borderline cases where several treatment alternatives exist.

In severe cases, however, the bimaxillary approach is still indicated or is even preferable to single-jaw surgery, as mentioned by Kahnberg and Ridell (1988). Also in patients who require a change in the occlusal plane (Enacar *et al.*, 2001), a change in facial vertical dimension, or in patients who present a severe mandibular asymmetry, bimaxillary surgery remains the only available option.

The present study demonstrated that, even if a consensus was found between the three groups of judges for a surgical option in Class III correction, differences in aesthetic perception exist between professionals and patients. Communication with the patient concerning aesthetic expectations, surgical risks, discomfort, and cost is thus important. Computer imaging can be helpful in demonstrating to the patients the eventual outcome of surgery. Three-dimensional prediction images are already available and are a more realistic tool for this purpose in the future.

Conclusions

1. Overall, all types of predicted interventions for skeletal Class III correction led to an improved scoring of facial aesthetics.
2. For the majority of patients evaluated, there was a general agreement on the preferred surgical option between maxillofacial surgeons, orthodontists, and laypersons.
3. Orthodontists and surgeons tended to rank surgical outcomes higher than laypersons.
4. Overjet, nasofacial, and nasomental angles were important in decision making between mandibular setback and Le Fort I option. Wits appraisal seemed to be important in decision making between the mandibular setback and bimaxillary option.

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