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Assessed facial normality after Twin Block therapy

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SUMMARY The first aim of this study was to identify any difference in the perception of facial normality between orthodontists and lay people of patients with the initial presentation of a Class II division 1 malocclusion, the second is to investigate whether there was an identifiable facial change following Twin Block (TB) therapy, and lastly, the relationship between identifiable facial change and clinical measurements was explored. Animated laser scans of 16 randomly selected adolescent patients, nine males aged 12–14 years and seven females aged 11–13 years with Class II division 1 malocclusions before and after TB therapy, were assessed on a visual analogue scale (VAS) by 34 orthodontists and 35 lay people. The 'Mark and Measure' and 'Orientated' techniques were used to determine soft tissue dimensions. Overjet was also recorded. Non-parametric statistical analyses were employed, including Mann–Whitney, Wilcoxon signed value, and Spearman's rank-order correlation tests.

There was no statistically significant difference in facial normality scores of adolescents before TB therapy when assessed by orthodontists (46.2 mm) and lay people (50.9 mm; $P = 0.120$). However, TB therapy significantly improved the assessment score of the orthodontists (54.8 mm) and lay people (57.8 mm; $P = 0.000$). Using a 5 per cent threshold in categorization of change in VAS scores, the majority of assessors perceived an overall 'improvement' (87.0 per cent). An increase in soft tissue lower face height (ST LFH) and overjet reduction was strongly correlated with the higher assessments of lay people ($r = 0.515$) and orthodontists ($r = -0.505$), respectively.

Although orthodontists and lay people assess facial normality of patients with Class II division 1 malocclusions similarly, following TB therapy an increase in ST LFH with lay people and overjet reduction with orthodontists were most closely related to improved facial normality.

Introduction

Facial appearance has an important influence on social well-being and others perception of one's personal attributions (Albino *et al.*, 1990). There is national as well as international agreement on faces deemed most attractive (Ilife, 1960; Udry, 1965). The more a particular facial type is observed, the more likely we are to perceive it as being correct (Peck and Peck, 1970), and attractive faces tend to be those of the average of that population (Alley and Cunningham, 1990; Langlois and Roggman, 1990).

Studies show that Skeletal I profiles (Cochrane *et al.*, 1990; Kerr and O'Donnell, 1990; Johnson *et al.*, 2005) and those with average vertical proportions are perceived as most attractive (De Smit and Dermaut, 1984; Johnston *et al.*, 2005). Skeletal II profiles are the least attractive and are poorly tolerated in males (Cochrane *et al.*, 1990; Knight and Keith, 1990). Extremely convex profiles or recessive chins and those with increased vertical proportions (De Smit and Dermaut, 1984; Czarnecki *et al.*, 1993) are deemed least attractive.

The Twin Block (TB) is a functional appliance extensively used to treat Class II malocclusions during adolescence. Overjet reduction is mainly through dentoalveolar change (Illing *et al.*, 1998; Lund and Sandler, 1998; Mills and McCulloch, 1998). Soft tissue changes following TB therapy include retraction of the upper lip, an increase in lower lip length, opening of the labiomental fold, and anterior positioning of soft tissue pogonion (Morris *et al.*, 1998; Singh and Clark, 2005; Quintão *et al.*, 2006).

The use of manipulated images has shown that horizontal mandibular changes are more accurately identified by professionals, while vertical changes are more readily recognized by lay people (Burcel *et al.*, 1987; Romani *et al.*, 1993).

There is conflicting evidence as to whether changes in facial appearance are identifiable following functional appliance therapy. The facial appearance of patients represented in photographs has been considered more attractive after treatment in some studies (Kerr and O'Donnell, 1990; Shell and Woods, 2003). O'Neill *et al.* (2000); however, using profile silhouettes, reported no change in facial attractiveness following functional appliance therapy.

Facial laser scans have been used to report dimensional changes following TB therapy (Sharma and Lee, 2005; Lee *et al.*, 2007). They are obtained in a non-invasive manner with a precision greater than 0.5 mm (Moss *et al.*, 1989).

Figure 1 Frames from an animated laser scan of an adolescent patient (**a**) before and (**b**) after treatment with the Twin Block appliance.

Table 1 Definition of points used in the Mark and Measure method.

Point	Definition
A: Right chelion	Most lateral part of the right labial commissure
B: Left chelion	Most lateral part of the left labial commisure
C: Subnasale	Maximum depth of concavity occurring at the junction of columellar base and the upper lip
D: Labrale superioris	Most prominent point of the mucocutaneous border of the upper lip in the mid-sagittal plane
E: Labrale inferioris	Most prominent point of the mucocutaneous border of the lower lip in the mid-sagittal plane
F: Right tragion	Most superior and posterior tip of the right tragus
G: Left tragion	Most superior and posterior tip of the left tragus
H: Soft tissue pogonion	Most prominent mid-sagittal point of the soft tissue chin
I: Soft tissue menton	Most inferior mid-sagittal point of soft tissue chin

Table 2 Each soft tissue dimensions obtained using the Mark and Measure method involves digitizing two points.

Dimension	Points used
Unit mandibular length (on left and right)	F and H (on the right), G and H (on the left)
Upper lip length	C and D
Lower lip length	E and I
Commissural width	A and B

These three-dimensional (3D) images may be animated, providing more information on facial shape than profile silhouettes which lack texture and colour.

Laser scans demonstrate facial shape exclusively and the present study adopted the term facial normality instead of attractiveness, which is influenced by colour, age, and texture. The aims of this study were to:

1. Investigate whether there is a difference in the perception of facial normality between orthodontists and lay people of patients with Class II division 1 malocclusions.
2. Investigate whether there is identifiable change in facial normality following TB therapy.
3. Explore the relationship between identifiable facial normality change and change in clinical measurements.

Subjects and methods

Ethical approval (East London and The City, REC Ref. 06/Q0604/108) and signed informed consent from all participants were obtained. Data collection for both sections of the study was performed by one author (APS). This study had two elements, a facial normality exercise in which animated facial laser scans were assessed by groups of orthodontists and lay people, and a clinical measurements evaluation in which soft tissue dimensions were obtained from facial laser scans and the overjet was also recorded.

Facial normality exercise

This was a cross-sectional study located at the Orthodontic Department of the Royal London Hospital. A minimum

overall sample size of 64 assessors, 32 in each group, was proposed to offer 80 per cent power at the 95 per cent confidence interval to demonstrate a one standardized difference in assessments between the two groups, with an alpha of $P < 0.05$. Significance was set at the 5 per cent level. To reduce the effect of age and experience, the inclusion criteria for the group of orthodontists comprised dentists in the third to the fifth year of extended orthodontic training. The lay group consisted of adults visiting the hospital aged 30–40 years, who were unrelated to the patients and with no working or educational knowledge of dentistry or orthodontics.

Animated facial laser scans of patients before and after treatment with the TB appliance were assessed on a visual analogue scale (VAS) by both groups of assessors.

Patients treated with the TB appliance were selected from a clinical trial, that compared the hard and soft tissue effects of the TB and Dynamax appliances (Lee *et al.*, 2007). The subjects were originally recruited on the basis of overjet (at least 7 mm) and age (males were aged 12–14 years and females 11–13 years). Based on the results from a pilot study, it was decided to present pre- and post-treatment laser scans of 16 patients (nine males and seven females) to maintain the duration of the facial normality exercise to approximately 15 minutes. This time limit was enforced to keep the interest of the assessors. No bias was introduced in selection of the laser scans with the first 16 names on the database of treated patients being chosen. The patients had been recruited on an intention to treat basis and had varying degrees of treatment success. This meant that patients were available for collection of records prior to the start of TB therapy and 12 months later, regardless of their compliance with wear.

In the current study, each laser scan was resized and positioned with the Frankfort plane parallel to the base of the screen. The animation smoothly moved the face through profile, three-quarter and frontal views, demonstrated diagrammatically in Figure 1. The 32 moving images were presented in a set random order. The participants were asked to assess the level of facial normality on a 100 mm VAS ranging from 'abnormal' to 'normal (ideal)'. No background information on treatment was provided during the presentation. The viewer was informed that animated laser scans were to be used that did not show skin colour or texture. This was followed by an example of an animated scan that was not used in the study. The main question underlying each of the images during the presentation was: 'do you believe the face shown has normal facial proportions?' To rate facial normality, assessors were instructed to 'consider the size and relationship of different facial features to one another'.

Clinical measurements

Soft tissue measurements were obtained from facial laser scans using a 'Mark and Measure' method (Sharma and Lee, 2005; Lee *et al.*, 2007) and a new 'Orientated' technique.

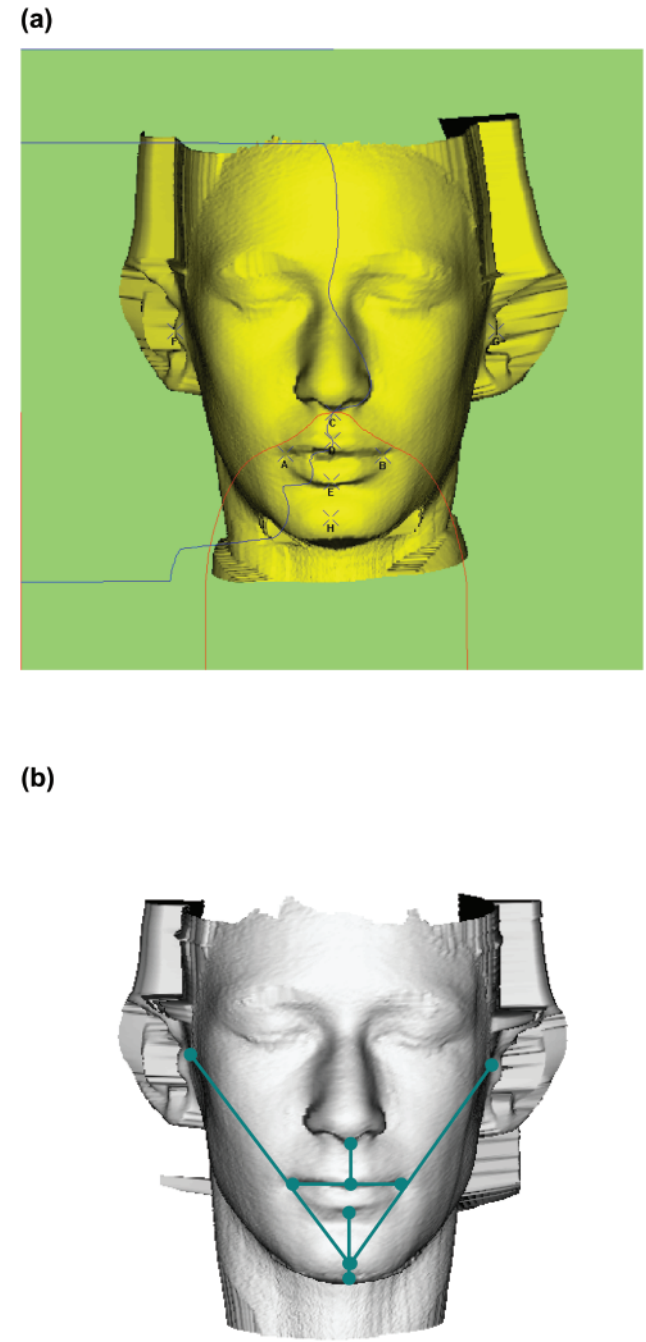

Figure 2 The Mark and Measure method of obtaining soft tissue dimensions. (**a**) Initially a number of landmarks are digitized (see Table 1). (**b**) Soft tissue dimensions obtained using the method were unit mandibular length (left and right sides), upper and lower lip lengths, and commissural width (see Table 2).

The Mark and Measure method involved identification and digitization of landmarks (Table 1) to quantify various soft tissue dimension (Table 2). Dimensions obtained were commissural width, upper and lower lip length, and soft

Table 3 Soft tissue dimensions obtained using the Orientated method.

Dimension	Additional point used
Horizontal projection of maxillary reference point to facial vertical	G: Deepest concavity of philtrum
Horizontal projection of mandibular reference point to facial vertical	H: Deepest concavity of labiomental fold
Horizontal projection of soft tissue pogonion to facial vertical	I: Most prominent mid-sagittal point of the soft tissue chin
Soft tissue upper face height (ST UFH)	F: Maximum depth of concavity occurring at the junction of columellar base and the upper lip
Soft tissue lower face height (ST LFH)	Direct subtraction of ST UFH from ST TFH
Soft tissue total face height (ST TFH)	J: Lowest point on the lower border of the chin in the mid-sagittal plane

For each dimension, an additional point is used once the facial laser scan is correctly orientated.

tissue mandibular length on the left and right sides (Figure 2). The average soft tissue mandibular unit length was obtained from measurements on the left and right sides.

The Orientated technique involved orientation of the facial laser scan to the Frankfort plane with registration at soft tissue nasion. Thereafter, the horizontal projections of four landmarks (mandidular and maxillary reference points and soft tissue pogonion) relative to a facial vertical through soft tissue nasion were quantified. This new technique also provided measurements of vertical facial proportions (upper, lower, and total face heights) relative to this facial vertical (Table 3, Figure 3).

Overjet measurements were recorded in the Lee *et al.* (2007) trial at the start and after 12 months of TB therapy by independent clinicians who took repeated measurements using digital callipers, which were averaged.

Data analysis

Analysis of data was carried out using the Statistical Package for Social Sciences, Version 14 (SPSS, Inc., Chicago, Illinois, USA). All scores in the facial normality exercise were calculated by measuring the distance of the marked vertical line from the abnormal end of the VAS.

Data were not considered to be normally distributed; hence, non-parametric tests were used.

The Mann–Whitney test was selected to compare the differences in the facial normality score of untreated Class II division I patients between orthodontists and lay people. The Wilcoxon signed-value test was employed to compare, for each assessor group, the change in facial normality score before and after TB therapy. Finally, Spearman's rank-order correlation was used to calculate the strength of the relationship between changes in facial normality and changes in clinical measurements (soft tissue dimensions and overjet). The level of statistical significance was set at 0.05.

Results

Analysis of facial normality

Thirty-five eligible people in each assessor group were approached to participate in the study. Overall, 34 orthodontists and 35 lay people agreed, representing a response rate of 97.1 and 100 per cent, respectively.

A mean facial normality score for 16 patients with untreated Class II malocclusions was calculated for both groups. Lay people provided a higher mean score for facial normality (50.9 mm) than orthodontists (46.2 mm). However, this difference was not statistically significant ($P = 0.120$).

Orthodontists and lay people provided higher mean facial normality scores, 54.8 and 57.8 mm, respectively, following TB therapy. This change was highly statistically significant ($P = 0.000$).

Based on a 5 per cent threshold, as indicating a significant change in facial attractiveness (Shell and Woods, 2003), the change in each patient's facial normality score following TB therapy was categorized into three groups: 'improvement', 'deterioration', or 'no change'. Scores following TB therapy greater than +5 per cent were categorized as improvement, less than −5 per cent as deterioration, and up to a level of ±5 per cent as no change.

The frequency distribution of the overall types of change in facial normality of all patients following TB therapy as assessed by orthodontists and lay people is given in Table 4. In total, the majority of all assessors (87 per cent) perceived an improvement. This was perceived in similar proportions of orthodontists (85.3 per cent) and lay people (88.6 per cent).

Relationship between changes in facial normality and clinical measurements

The strength of association between the patients' change in each of the 10 soft tissue dimensions and the change in their facial normality scores was also investigated (Table 5). Lay people recorded a strong positive correlation ($r = 0.515$) between the change in facial normality and that of soft tissue lower face height (ST LFH), following TB therapy. This association was of statistical significance ($P = 0.041$). A weaker relationship between the change in ST LFH and that in facial normality as assessed by orthodontists was recorded (Figure 4a).

A strong negative correlation was found between the change in facial normality reported by orthodontists and

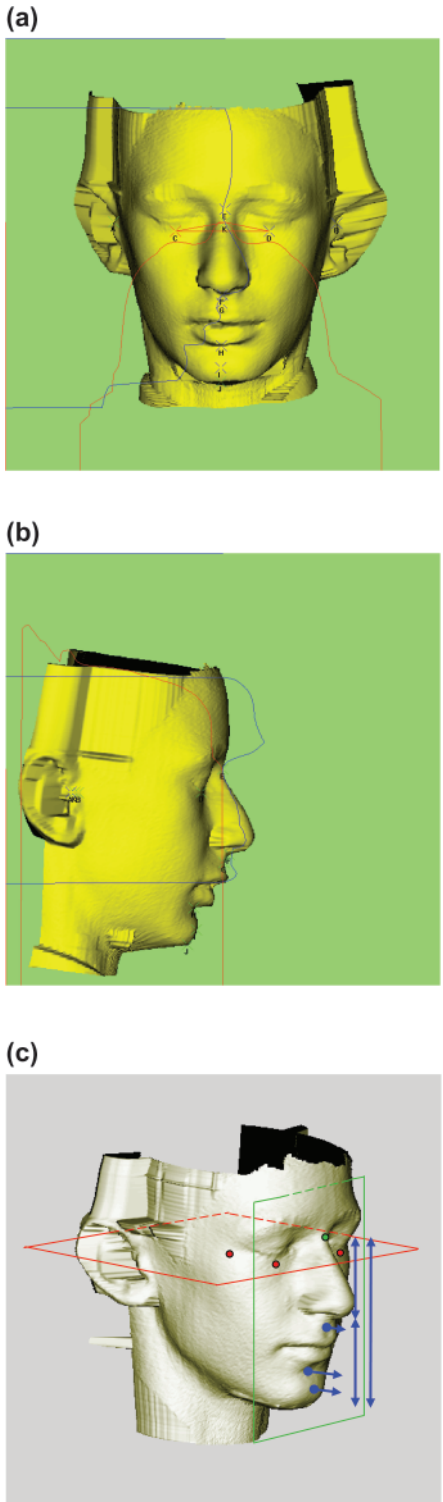

Figure 3 The Orientated technique is a new method of obtaining soft tissue measurements from facial laser scans. (**a**) Initially the Frankfort plane is constructed using three points, i.e. right and left infra-orbital, C and D, and inter-tragal, K, points. K is the mid-point of right and left tragal points, A and B. (**b**) Next, there is horizontal orientation of the facial laser scan relative to the Frankfort plane and registration at soft tissue nasion, E. (**c**) Horizontal and vertical dimensions (blue) are obtained relative to a facial vertical (green) perpendicular to the constructed Frankfort plane (red).

Table 4 Frequency distribution of facial normality changes, as assessed by orthodontists and lay people following Twin Block therapy.

	Improvement	No change	Deterioration	Total
Orthodontists	29 (85.3%)	4 (11.8%)	1 (2.9%)	34 (100%)
Lay people	31 (88.6%)	0 (0%)	4 (11.4%)	35 (100%)
Total	60 (87.0%)	4 (5.8%)	5 (7.2%)	69 (100%)

the change in overjet ($r = -0.505$), which was statistically significant ($P = 0.046$). This relationship was not statistically significant when assessed by lay people ($r = -0.332$, $P = 0.210$; Figure 4b).

Measurement reliability

Repeatability of the facial normality exercise was assessed using Cohen's kappa coefficient. Seven assessors in each group repeated the facial normality exercise 2 weeks after the main study. The overall change in patients' facial normality was categorized into 'improvement' (change in the VAS greater than +5 mm) and 'no improvement' (change in the VAS less than or equal to +5 mm). Orthodontists demonstrated perfect agreement (kappa = 1.00) and lay people showed moderate to strong agreement (kappa = 0.59).

The repeatability of soft tissue measurements using the Mark and Measure and Orientated techniques was tested by repeating measurements of 50 per cent of the scans 4 weeks after the main study. The validity of soft tissue measurements was assessed using graphical techniques described by Bland and Altman (1986). Both techniques demonstrated a good level of agreement between repeated measurements with variation of less than 2 mm being accepted.

Discussion

In the current study, no bias was introduced in the selection of patients for laser scanning. The first 16 names chosen from the database of subjects (Lee *et al.*, 2007) were cases with varying levels of success with TB therapy. They may be considered as representative of a typical cohort of patients treated in everyday practice.

A matched, untreated, randomized control group was not recruited, as it was unethical to withhold treatment from patients considered to be at an optimal time for treatment. Nevertheless, a similar Class II group of 38 patients aged 9–14 years with laser scan records were recruited by Barnes (2005). Over 1 year, the dimensional and proportional changes were minimal. It is, however, accepted that the natural growth of adolescents with Class II division 1 malocclusions is favourable with a reduction in the Skeletal II discrepancy (You *et al.*, 2001; Chung and Wong, 2002) and the current study investigated identifiable change in facial normality following TB therapy, which

Table 5 Spearman's correlation between soft tissue changes and changes in facial normality following Twin Block therapy assessed by orthodontists and lay people.

Soft tissue changes		Dimensions obtained using the Mark and Measure technique				Dimensions obtained using the new Orientated technique					
		Commissural width	Upper lip length	Lower lip length	Soft tissue unit mandibular length	Horizontal projection of maxillary reference point	Horizontal projection of mandibular reference point	Horizontal projection of soft tissue pogonion	Soft tissue upper face height	Soft tissue lower face height	Soft tissue total face height
Orthodontists ($n = 34$)	Correlation coefficient (r)	−0.379	0.312	0.294	−0.224	−0.710	0.144	0.121	−0.035	0.418	0.265
	P-value	0.147	0.240	0.269	0.405	0.795	0.594	0.656	0.897	0.107	0.32
Lay people ($n = 35$)	Correlation coefficient (r)	−0.388	0.171	0.332	−0.329	−0.288	−0.024	−0.138	−0.030	0.515	0.315
	P-value	0.137	0.528	0.208	0.213	0.279	0.931	0.610	0.991	0.041*	0.235

*P = Significant at the 5% level. (Scale 2: 1).

would be as a result of appliance wear and natural growth.

The use of animated 3D laser scans to identify facial shape change eliminates potential bias from observation of the colour and texture of eyes, hair, and skin. Spyropoulos and Halazonetis (2001) reported that while hairstyle does not affect the perception of the most attractive faces, it can affect opinion of less attractive ones. Laser scans may also be considered more appropriate for lay peoples' interpretation than two-dimensional profile silhouettes, as 3D form is encountered during interaction with other people.

There was no statistically significant difference between facial normality assessed by orthodontists and lay people. Most other studies have shown that professionals are more critical of facial attractiveness than lay people (Bell *et al.*, 1985; Kiekens *et al.*, 2005, 2007); however, the converse has also been reported (Spyropoulos and Halazonetis, 2001). For both assessor groups, the average VAS score following TB therapy increased and was highly statistically significant. Using a 5 per cent threshold, a change in facial normality score may be categorized into overall improvement. This is in agreement with studies considering facial attractiveness following correction of this occlusal trait (Kerr and O'Donnell, 1990; Shell and Woods, 2003).

The current study also aimed to investigate whether changes in certain clinical measurements were associated with higher facial normality scores.

For orthodontists, the strongest correlation was found between the change in ST LFH and that of facial normality ($r = 0.418$). However, a level of statistical significance was not reached ($P = 0.107$), which may be due to utilization of an insufficient number of patients and the inclusion of a group of patients with varying degrees of clinical success. It was not practical to include more animated scans, which would excessively prolong the presentation. This could also lead to assessors losing interest and the repeatability of the facial normality exercise becoming unacceptably low. No other change in specific soft tissue dimensions was associated with an improved perception of facial normality.

An increase in ST LFH was associated with an improved facial normality score provided by lay people. This supports the work of Romani *et al.* (1993) who found that lay people were more sensitive to changes in lower face height than orthodontists. Mills and McCulloch (1998) reported that TB therapy results in two-thirds of the additional increase in mandibular length being manifested in the vertical and only one-third in the antero-posterior dimension. In this sample, overjet reduction was associated with improved facial normality by orthodontists, but not by lay people.

Tulloch *et al.* (1993) also found a strong correlation between the reduction in overjet and facial attractiveness following treatment, when assessed by undergraduates, dental students, and orthodontic residents. A greater reduction in overjet may be associated with a greater change, in particular, in soft tissue dimensions, such as lip

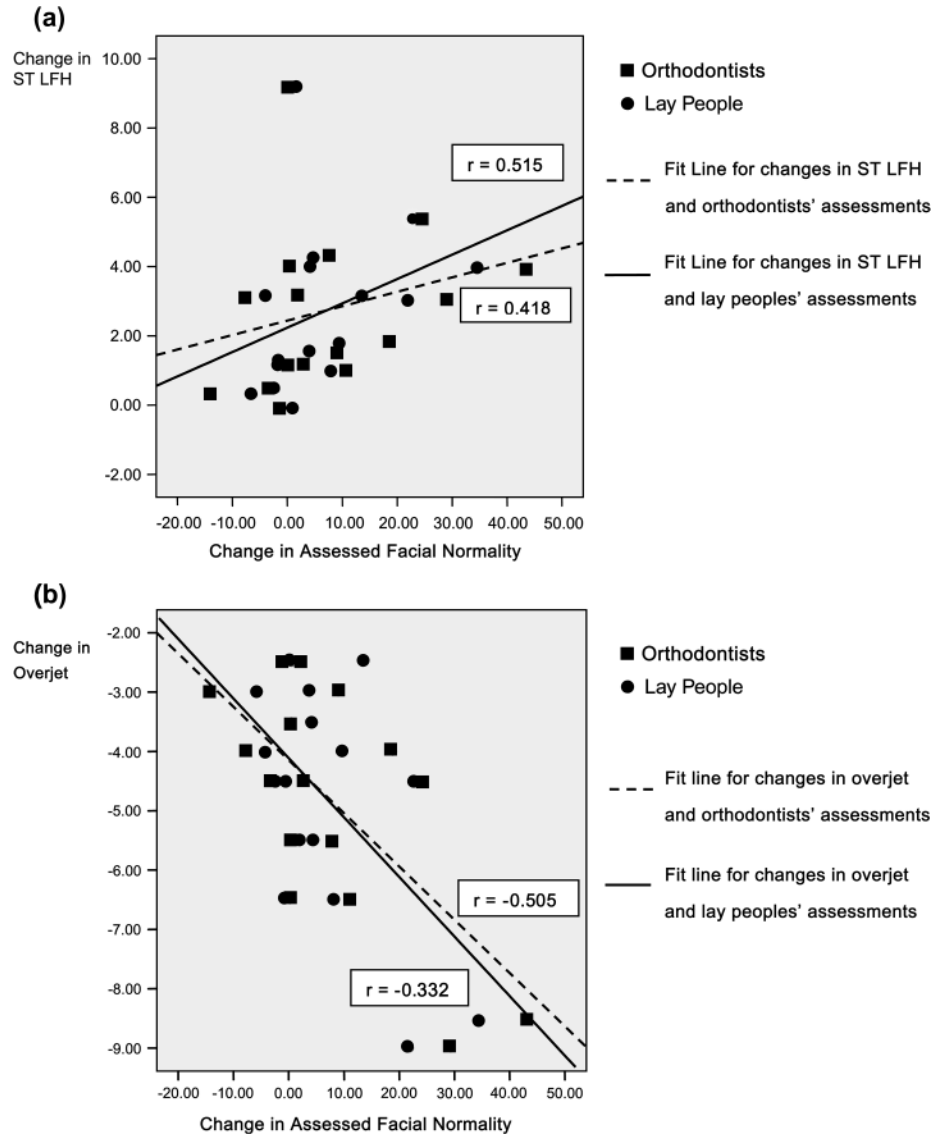

Figure 4 Relationship between the changes in ST LFH and change in facial normality (**a**) and between the change in overjet and change in facial normality (**b**), as assessed by orthodontists and lay people.

length and positioning, which can be identified by orthodontists.

In the current study, a new system of assessing soft tissue dimensions from laser scans was developed called the Orientated technique. It is more time consuming than the Mark and Measure method but is reliable in obtaining alternative measurements, such as the anterior projection of facial landmark relative to a facial vertical and vertical facial proportions, when the scan in orientated relative to the Frankfort plane.

Conclusion

1. Orthodontists and lay people assess the facial normality of patients with Class II division 1 malocclusions, similarly.
2. There was an identifiable change in facial normality following TB therapy.
3. An increase in ST LFH led to facial normality change identifiable by lay people.
4. Overjet reduction led to facial normality change identifiable by orthodontists.

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References

Albino J E, Alley T R, Tedesco L A, Tobiasen J A, Kiyak H A, Lawrence S D 1990 Aesthetic issues in behavioural dentistry. Annals of Behavioural Medicine 12: 148–155

Alley T R, Cunningham M R 1990 Average faces are attractive, but very attractive faces are not average. Psychological Science 2: 123–125

Barnes E 2005 A prospective cephalometric and optical surface scanning study of skeletal, dental and soft tissue changes in untreated Skeletal II adolescents. Thesis, University of London

Bland J M, Altman D G 1986 Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 41: 307–310

Bell R, Kiyak H A, Joondeph D R, McNeill R W, Wallen T R 1985 Perceptions of facial profile and their influence on the decision to undergo orthognathic surgery. American Journal of Orthodontics 88: 323–332

Burcel R G, Laskin D M, Sperry T P 1987 Recognition of profile change after stimulated orthognathic surgery. Journal of Oral and Maxillofacial Surgery 45: 666–670

Chung C, Wong W 2002 Craniofacial growth in untreated skeletal Class II subjects: a longitudinal study. American Journal of Orthodontics and Dentofacial Orthopedics 122: 619–626

Cochrane S M, Cunningham S J, Hunt N P 1990 Perceptions of facial appearance by orthodontists and the general public. Journal of Clinical Orthodontics 31: 164–168

Czarnecki S T, Nanda R S, Currier G F 1993 Perceptions of a balanced facial profile. American Journal of Orthodontics and Dentofacial Orthopedics 104: 180–187

De Smit A, Dermaut L 1984 Soft-tissue profile preferences. American Journal of Orthodontics 86: 67–73

Illing H M, Morris D O, Lee R T 1998 A prospective evaluation of Bass, Bionator and Twin Block appliances. Part I—the hard tissues. European Journal of Orthodontics 20: 501–516

Iliffe A H 1960 A study of preferences in feminine beauty. British Journal of Psychology 51: 267–273

Johnston C, Hunt O, Burden D, Stevenson M, Hepper P 2005 The influence of mandibular prominence on facial attractiveness. European Journal of Orthodontics 27: 129–133

Johnson D J, Hunt O, Johnston C D, Burden D J, Stevenson M, Hepper P 2005 The influence of lower face vertical proportion on facial attractiveness. European Journal of Orthodontics 27: 349–354

Kerr W J, O'Donnell J M 1990 Panel perception of facial attractiveness. British Journal of Orthodontics 17: 299–304

Kiekens R M, Maltha J C, van 't Hof M A, Kuijpers-Jagtman A M 2005 A measuring system for facial aesthetics in Caucasian adolescents: reproducibility and validity. European Journal of Orthodontics 27: 579–584

Kiekens R M, van 't Hof M A, Straatman H, Kuijpers-Jagtman A M, Maltha J C 2007 Influence of panel composition on aesthetic evaluation of adolescent faces. European Journal of Orthodontics 29: 95–99

Knight H, Keith O 1990 Ranking facial attractiveness. European Journal of Orthodontics 27: 340–348

Langlois J H, Roggman L A 1990 Attractive faces are only average. Psychological Science 1: 115–121

Lee R T, Mack G M, Kyi C S 2007 A controlled clinical trial of the effects of the Twin Block and Dynamax appliances on the hard and soft tissues. European Journal of Orthodontics 29: 272–282

Lund D I, Sandler P J 1998 The effects of Twin Blocks: a prospective controlled study. American Journal of Orthodontics and Dentofacial Orthopedics 113: 104–110

Mills C M, McCulloch K J 1998 Treatment effects of the Twin Block appliance: a cephalometric study. American Journal of Orthodontics and Dentofacial Orthopedics 114: 15–24

Morris D O, Illing H M, Lee R T 1998 A prospective evaluation of Bass, Bionator and Twin Block appliances. Part II—the soft tissues. European Journal of Orthodontics 20: 663–684

Moss J P, Linney A D, Grindrod S R, Mosse C A 1989 A laser scanning system for the measurement of facial surface morphology. Optics and Lasers in Engineering 10: 179–190

O'Neill K, Harkness M, Knight R 2000 Ratings of profile attractiveness after functional appliance treatment. American Journal of Orthodontics and Dentofacial Orthopedics 118: 371–376

Peck S, Peck H 1970 A concept of facial esthetics. Angle Orthodontist 40: 284–318

Quintão C, Helena I, Brunharo V P, Menezes R C, Almeida M A 2006 Soft tissue facial profile changes following functional appliance therapy. European Journal of Orthodontics 28: 35–41

Romani K L, Agahi F, Nanda N, Zernik J H 1993 Evaluation of horizontal and vertical differences in facial profiles by orthodontists and lay people. Angle Orthodontist 63: 175–182

Sharma A, Lee R T 2005 Prospective clinical trial comparing the effects of conventional Twin-block and mini-block appliances Part 2: soft tissue changes. American Journal of Orthodontics and Dentofacial Orthopedics 127: 473–482

Shell T L, Woods M G 2003 Perception of facial esthetics: a comparison of similar Class II cases treated with attempted growth modification or later orthognathic surgery. Angle Orthodontist 73: 365–373

Singh G D, Clark W J 2005 Soft tissue changes in patients with Class II division 1 malocclusions treated using Twin Block appliances: finite-element scaling analysis. European Journal of Orthodontics 25: 225–230

Spyropoulos M N, Halazonetis D J 2001 Significance of the soft tissue profile on facial esthetics. American Journal of Orthodontics and Dentofacial Orthopedics 119: 464–471

Tulloch C, Phillips C, Dann C 1993 Cephalometric measures as indicators of facial attractiveness. International Journal of Adult Orthodontics and Orthognathic Surgery 8: 171–179

Udry J R 1965 Structural correlates of feminine beauty preferences in Britain and the United States: a comparison. Sociology and Social Research 49: 330

You Z, Fishman L S, Rosenblum R E, Subtelny J D 2001 Dentoalveolar changes related to mandibular forward growth in untreated Class II persons. American Journal of Orthodontics and Dentofacial Orthopedics 120: 598–607