Extraction versus non-extraction: evaluation by digital subtraction radiography

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SUMMARY The aim of this study was to investigate the facial profile changes of patients treated with and without extractions of four first premolars using novel computer-based digital subtraction software.

The pre- and post-treatment radiographic image pairs of 25 extraction (13 girls and 12 boys, mean age = 12.64 ± 1.82 years) and 24 non-extraction (12 girls and 12 boys, mean age = 12.48 ± 1.66 years) Class I patients were subtracted by the software. Student's *t*-tests were used to determine whether the subtraction values for the linear measurements of radiographic differences registered at various anatomical landmark parameters were statistically different between the groups. To further determine whether any variables related to upper and lower lip changes, regression analyses were performed.

The main soft tissue differences between the groups were established at labrale superior, labrale inferior, and sulcus inferior points, with extraction patients showing significantly more retruded upper and lower lips. However, the mean differences between the groups did not exceed 1 mm for these variables. Changes at labrale superior and labrale inferior were associated with sagittal movement of the maxillary (r = 0.549) and mandibular (r = 0.630) incisor midpoints. Changes at sulcus inferior were associated with sagittal and vertical displacement of mandibular incision point (r = 0.676).

Some dentofacial alterations were found but in view of the differences between the groups pretreatment, the inter-group differences reflect different treatment intent rather than differences arising from the extraction and non-extraction modalities.

Introduction

Facial aesthetics, as it relates to self-confidence and personal perceptional conception, has been regarded as one of the most important human characteristics. Therefore, anyone who works in the facial area needs to make careful judgements prior to any application that would produce direct consequences. The effect of orthodontic treatment on the balance and aesthetics of the face has become an ongoing research topic, originating from the extraction–non-extraction dilemma (Bernstein and Edward, 1992a,b; DiBiase and Sandler, 2001).

The outcome of extraction therapy on the final soft tissue profile has been extensively documented with the most common findings reported being retruded upper and lower lips (Bravo, 1994; Bishara *et al.*, 1995; Cummins *et al.*, 1995; Bravo *et al.*, 1997; Kocadereli, 2002), straighter profile (Bravo, 1994; Bishara *et al.*, 1995), and more upright maxillary and mandibular incisors (Bishara *et al.*, 1995; Kocadereli, 2002). However, it is reported that the actual percentage of patients who finish orthodontic treatment with extractions of four premolars and excessively flattened and distorted profiles is small (Drobocky and Smith, 1989; Young and Smith, 1993; Bravo, 1994; Boley *et al.*, 1998; James, 1998) conclude that the mean finished profile for both extraction and non-extraction

patients are within the normal and/or ideal aesthetic ranges of the parameters investigated.

Most of the former studies were limited, with assessment of soft tissue profile changes by various landmarks, lines, and conventional cephalometric radiography. In fact, the norms provided by reference lines may be considerably affected by shape, individual variations, and racial differences. In addition, a profile radiograph alone may not be sufficient to determine the balance of the face since even observable changes can be negated by the effects of nose and chin growth (Hazar *et al.*, 2004). Therefore, new methods and techniques are required in order to detect absolute changes in the facial profile as a result of orthodontic treatment.

Digital image subtraction is an efficient method for comparing and analysing images of the same source. Since the introduction of image subtraction by Zeides des Plantes in the 1930s (Baldonado *et al.*, 1997), various methods have been developed to unravel the changes in serial radiographs. Among these, digital subtraction radiography (DSR) has been introduced as a system which emphasizes differences between pairs of radiographs by reducing 'structural noise', in other words, eliminating the structures that remain the same between the radiograph pairs and displaying those as a neutral background in the subtracted 'resultant image' (Öztürk *et al.*, 2004). With the use of dental radiographs, all

underlying structures, such as teeth, are removed, thereby facilitating visualization of changes. By convention, areas of loss and gain are represented as either dark or light shades of grey against a neutral background (Figure 1).

The basic concept of the system is that a meaningful comparison between two images of the same object can be made when they have the same geometric orientation and the same contrast. Although conventional radiography is of limited value in determining small changes and is mostly observer dependent, computerized DSR has been shown to be a valuable diagnostic aid for the evaluation of subtle radiographic changes by removing all anatomical structures other than those of immediate interest. This method has been adopted successfully in dental practice for monitoring dental caries and apical pathology prognosis (Hintze et al., 1992; Wenzel and Halse, 1992; Perona and Wenzel, 1996; Reukers et al., 1998), alveolar bone loss (Jeffcoat et al., 1984; Allen and Hausmann, 1996; Hildebolt et al., 1996), the results of periodontal therapy (Bragger et al., 1988; Armitage et al., 1994; Christgau et al., 1997), functional evaluation of regular and irregular movements in the temporomandibular joint (Sato et al., 1998), and in dental implantology (Bragger et al., 1991; Reddy et al., 1992).

The purpose of this study was to propose a new method for investigation of the soft tissue profile changes of patients treated with and without extraction of four first premolars by application of novel computer-based digital subtraction software and to determine the associations of these changes with dentoskeletal variables.

Materials and method

An algorithm performing automated contrast correction, vertical and horizontal alignment, and angle correction was

developed (patent applied for) to provide both manual and automated manipulation of the radiographic images. The program had the functions of histogram smoothing and image warping for the standardization of radiographic density, contrast, and the geometric alignment of the images using a minimum of four reference points. Histogram smoothing was performed using an improved version of Ruttiman's algorithm that was based on smoothing the empirical distribution of the reference image using cardinal splines (Öztürk et al., 2004). Image warping was accomplished by affine, bilinear, and biquadratic transforms. A preliminary study (Güneri et al., 2007) revealed that this novel software was apparently more efficient in handling vertical and horizontal angulation errors than another popular software (Emago®, Oral Diagnostic Systems, c/o Department of Oral Radiology/ACTA, Amsterdam, Netherlands). Figure 2 shows the effectiveness of the software on angular and magnification faults on simulated lateral cephalograms. When two identical lateral cephalograms are subtracted from each other, the resultant image should be a complete neutral (grey) image. Both Emago[®] and the new software worked well when subtracting the same images (Figure 2a). However, an ideal DSR software should also be able to subtract the same images in the presence of angular and magnification differences and result in a neutral background. The second image was rotated 7 degrees clockwise to produce a simulated angulation difference. Emago® failed to result in a neutral background and produced an image as if there were differences between the same radiographs whereas the novel software effectively compensated for the angulation difference (Figure 2b). The second image was magnified to 107 per cent of its original size to simulate a magnification difference. Emago[®] failed to result in a neutral background and again produced an image as if there were differences



Figure 1 An example at digital subtraction radiography (DSR). Areas of loss and gain are represented as either dark or light shades of grey against the neutral background. (a) Root canal cavity is prepared. (b) Root canal therapy is accomplished, healing is observed at the root apex. (c) Subtraction is performed; root filling and healing zone are emphasized in light shades of grey by DSR.



Figure 2 A simple experiment was carried out to compare the effectiveness of the novel software for compensation of angular and magnification errors with a commercially available digital subtraction radiography software, Emago®. (a) Subtraction of the same images. (b) Subtraction of the original image with angulation simulation. (c) Subtraction of the same image with magnification simulation.

between the same radiographs whereas the novel software effectively compensated for the magnification difference (Figure 2c).

When comparing the reference and modified images, a standard evaluation was required to measure the overall difference between the two images. For this purpose, an accepted criterion commonly used to assess the quality of reconstructed images compared with the originals was used: the peak signal to noise ratio (PSNR; Öztürk *et al.*, 2004);

PSNR =
$$20 \log_{10} \frac{2^d - 1}{\left[\frac{1}{n} \sum_{k=1}^n (i_k - j_k)^2\right]^{\frac{1}{2}}},$$

where *d* is the colour depth; i_k and j_k are the pixel intensities at position *k* of the test and the modified images, respectively; and *n* is the total number of pixels in the image. The more the modified image resembles the reference image, the higher the resulting PSNR value. For a grey-scale image with *d* bits per pixel, the typical PSNR values range between 20 and 40. Therefore, radiographic pairs with PSNR values lower than 20 when subtracted by the software were not included in the study.

It was the aim to compare the effects of extraction therapy in a sample of skeletally normal individuals with good

vertical development. A total of 1254 patients from the faculty archives were evaluated, and 184 cases presenting an ANB of 2 and 3 degrees, GoGnSN of 27-37 degrees, and a Y-axis angle of 53-66 degrees were selected. Only good quality pre- and post-treatment cephalograms of 25 extraction (13 boys and 12 girls) and 24 non-extraction (12 boys and 12 girls) patients who displayed a Class I canine and molar relationship and had a normal overjet and overbite with well aligned and interdigitated teeth at the end of the treatment were enrolled into the study. The mean ages of the patients at the beginning of treatment were similar in both groups: 12.64 ± 1.82 years for the extraction group and 12.48 ± 1.66 years for the non-extraction group (P > 0.05). All subjects were treated with 0.018 \times 0.022 edgewise appliances. The average treatment times were 24.21 ± 10.75 months for the non-extraction and 27.02 ± 12.06 months for the extraction groups. Four first premolars were extracted in the extraction group. The extraction decision was based on the need for space to resolve crowding and to ideally align the incisors. The mean values of crowding were 3.79 ± 2.01 mm in the upper arch and 3.20 ± 1.78 mm in the lower arch and 7.33 ± 2.24 mm and 5.32 ± 2.43 mm for the non-extraction and the extraction groups, respectively.

Pre- and post-treatment cephalograms were taken using the same cephalometric unit with the patients in a standing position with the lips relaxed and the teeth in occlusion. All radiographs were digitized with a flatbed scanner with a transparency adaptor (Epson EXP 1680 Pro, Seiko Epson Corp., Nagano, Japan) with eight-bit grey-scale acquisition depth, and 600 dpi spatial resolutions. The image size was 1200×600 pixels and they had 256 grey levels. All digital images were saved in Tagged Image File Format into a personal computer. The subtraction functions of the new software were utilized to subtract the post-treatment radiograph from the pre-treatment radiograph to produce a resultant image of each image pairs. A trained and experienced orthodontist (SA) who had been working with the software performed the process. No other interventions (such as brightness/contrast/edge enhancement, filtration, etc.) were employed to the original images before subtraction. The validity of DSR in measuring the linear changes on cephalograms was established in a preliminary study (Akyalçın et al., 2006). For this purpose, pre- and posttreatment changes were initially measured using the conventional hand-tracing method which was performed by a single examiner (SA). The same examiner then performed the DSR technique on the same pre- and post-treatment digital images to measure the differences. As the results of this preliminary test revealed similarity of the measurements (P = 0.92), DSR was used as the measurement tool in this study.

Only the subtracted 'resultant' differences occurring at the hard and soft tissue landmarks (Table 1, Figure 3) were measured by computer with Image Tool for Windows version 3.00 (UTHSCSA, San Antonio, Texas, USA). Spatial measurements were calibrated by drawing a line of known length (ruler on the nasal rod of the cephalostat). Soft tissue changes which occurred outside the anatomic landmarks could not be evaluated numerically since only linear changes on predefined landmarks were investigated.

Both pre- and post-treatment radiographs were remeasured 1 month later by the same investigator to ensure measurement accuracy using paired *t*-tests. No differences were found for the remeasurements (P > 0.05); the mean values of the first and second measurements for each parameter were used in later analysis. Since the sample sizes were small, comparison of mean changes between the two genders in each group were carried out by Mann-Whitney U tests. As no significant influence of gender was found (P > 0.05), male and female data were combined and evaluated together in each group. Levene's test for equality of variances showed that data set was well distributed. Therefore, independent *t*-tests were used to test whether the subtraction values for the parameters studied were statistically different between the extraction and nonextraction groups. To further determine whether any variables were related to upper and lower lip changes, multiple regression analyses (backward) were performed. The Statistical Package for Social Sciences (v13.0, SPSS Inc., Chicago, Illinois, USA) was used for statistical analyses.

Results

Figure 4 shows examples of subtracted images for the extraction (1) and non-extraction (2) cases. The statistical changes in facial profile determined by analyses on DSR images following orthodontic treatment with and without

 Table 1
 Cephalometric landmarks and measurements used to evaluate profile changes.

Points	
Points A, Point A U1-Mid U1-Inc L1-Mid L1-Inc B, Point B Pog, pogonion Gn, gnathion Nt', nose tip Sn', subnasale Ss', sulcus superior Ls', labrale superior Li', labrale superior Li', labrale inferior Pog', soft tissue pogonion Gn', soft tissue gnathion Sagittal plane changes	Deepest point in the midsaggital plane between anterior nasal spine and prosthion Midpoint of the maxillary incisor crown Incision point of the mandibular incisor Deepest point of the mandibular incisor Deepest point in the midsaggital plane between infradentale and pogonion Most anterior point of the bony chin in the median plane Most anterior and inferior point of the bony chin in the median plane Most anterior opint on the anteroposterior contour of the nose Most posterior superior point on the nasolabial curvature Deepest point on the concavity between labrale superior and subnasale Most anterior point on the convexity of the upper lip Most anterior point on the convexity of the lower lip The point of greatest concavity in the midline between the lower lip and soft tissue chin Most anterior point on the soft tissue chin Differences occurring at the above landmarks were measured on the sagittal plane. If a variable moved
Vertical plane changes	back it was recorded as '-', or if it moved forward as '+'. Displacements of both maxillary and mandibular incision points were also measured in the vertical plane. These changes were classified as 'U1-Inc Vert' and 'L1-Inc Vert'. Intrusion was recorded as '-', and extrusion as '+'.



Figure 3 The measurements were undertaken on subtracted images. (a) nose tip (Nt'), (b) upper lip (Ls), (c) lower lip (Li), (e) mid point of the upper incisor (U1-Mid), and (f) pogonion (Pog) moved forward: changes were recorded as '+', (d) incision point of lower incisor was intruded: the amount intrusion was recorded as '-'.

four first premolar extractions are shown in Table 2. The changes in the maxillary and mandibular incisors observed at both incision and mid-crown points were statistically significant (P < 0.01). The soft tissue differences between the study groups were found to occur at labrale superior (Ls), labrale inferior (Li), and sulcus inferior (Si) points. In the extraction group soft tissue points Ls, Li, and Si moved backward whereas the non-extraction group had an opposite tendency. In the extraction group, the average changes for the upper and lower lips were 0.8 ± 1.1 and -0.9 ± 1.0 mm, respectively. The mean changes in the non-extraction group were smaller: 0.1 ± 0.9 mm for both upper and lower lips. The changes in lip protrusion (P < 0.05) proved to be significant; however, the mean differences between the two groups for these variables did not exceed 1 mm. There were no major differences for other hard and soft tissues between the groups (P > 0.05).

Multiple regression analysis (forward) was performed for Ls, Li, and Si points to detect the hard tissue variables which may be associated with the changes of these parameters and explain the differences between two groups. The relationship of the soft tissue landmark points to the hard tissue variables is summarized in Table 3. Regression analyses showed that changes at Ls and Li soft tissue points were associated with sagittal movement of the maxillary (r = 0.549) and mandibular (r = 0.630) incisor midpoints. Changes at Si were associated with both the sagittal and vertical displacement of the mandibular incision point (r = 0.676).

Discussion

The controversy concerning the detrimental effects of extracting teeth on the facial profile has not yet resulted in any consensus, and there is no specific method for measuring aesthetics. Currently, there exists no reliable means to clarify this dilemma and the establishment of an objective method for assessment of facial features has been difficult. Although numerous analyses (Ricketts, 1960, 1968; Steiner, 1960; Merrifield, 1966; Holdaway, 1983) have been advocated in an attempt to quantitatively evaluate the balance of lateral facial profiles, most of these methods appear to be based on the use of particular anterior reference lines to compare the protrusion of one facial component relative to another (Wholley and Woods, 2003). Furthermore, the dynamics of the facial components should not be underestimated, because the landmarks which constitute these reference lines are affected by growth, gender and ethnic differences, and individual variations in shape and texture. Assessment of growth and treatment changes in facial profile should therefore be based on individual and rational standards rather than rely on norms.

It may be that a profile radiograph alone is not sufficient to determine the balance of the face because even observable two-dimensional changes are often influenced by the negative effects of nose and chin growth, along with calibration and angulation errors. In this study, an algorithm performing both manual and automated image reconstructions and contrast correction was used for manipulation of the radiographic images which allowed investigation of the facial profile changes in extraction and non-extraction patients individually without any conflicts caused by landmarks and reference lines. The use of DSR (Hellsing et al., 1996; Perona and Wenzel, 1996; Papika et al., 1999; Cope and Samchukov, 2001) is not new for orthodontists; however, utilization of a computer-based digital subtraction software for manipulation of lateral cephalograms allowed measurement of anterior hard and soft tissue changes without any contamination of the data that could be caused by predetermined landmarks and constructed reference lines.

The strength of DSR lies in the requirements for its appropriate application: standardization of radiographic imaging parameters. When adequate geometric and densitometric standardizations are achieved, DSR allows quantitative measurements (Mol and Dunn, 2003) as well as qualitative evaluations. Although the principle underlying DSR is relatively simple, its clinical application is elaborate because of the need to obtain excellent densitometric and geometric standardization between radiographs (Wenzel, 1993; Vandre and Webber, 1995; Ellwood *et al.*, 1997; Mol, 1999; Mol and Dunn, 2003). By definition, subtraction of sequential radiographic images requires registration or alignment) of the two images before subtraction.



Figure 4 (1) An extraction case. (a) Pre-treatment radiograph. (b) Post-treatment radiograph. (c) Subtracted 'resultant' image: maxillary and mandibular incisor retraction and backward movement of Li and Si are emphasized by dark shades of grey, whereas anteroposterior projection of the nose and chin are shown as light grey. (2) A non-extraction case. (a) Pre-treatment radiograph. (b) Post-treatment radiograph. (c) Subtracted resultant image: advancement of the maxillary and mandibular incisors and slight protrusion in the lip area and nose are represented as light grey. The changes in lip protrusion, however, occurred away from Ls and Li points for this subject.

Table 2Comparison of changes in profile between the extractionand non-extraction groups.

Subtraction values	Extraction (n=25)		Non-extraction $(n=24)$		Р
	Mean (mm)	SD	Mean (mm)	SD	
А	0.03	0.36	0.03	0.22	
U1-Mid	-1.41	1.84	0.97	1.82	**
U1-Inc	-1.21	1.67	0.86	1.60	**
U1-Inc Vert	-0.67	0.73	0.22	1.34	
L1-Mid	-1.08	1.22	0.53	1.09	**
L1-Inc	-0.83	0.76	0.57	0.75	**
L1-Inc Vert	-0.38	0.74	-0.25	0.41	
В	0.09	0.41	0.06	0.63	
Pog	0.35	0.84	0.32	0.68	
Gn	0.38	0.89	0.31	0.78	
Nt'	0.89	0.95	0.81	0.79	
Sn'	0.17	0.55	0.11	0.38	
Ss'	0.11	0.82	0.14	0.44	
Ls'	-0.83	1.10	0.15	0.97	*
Li'	-0.91	1.06	0.11	0.94	*
Si'	-0.58	0.83	0.38	0.78	*
Pog'	0.26	0.75	0.21	0.67	
Gn'	0.29	0.76	0.23	0.79	

P* < 0.05; *P* < 0.01.

 Table 3
 Results of multiple regression analyses of soft tissue landmarks with independent variables.

Dependent soft tissue variables	Significant independent variables entered into regression equations ($P < 0.05$)	r
Labrale superior	U1-Mid (β =0.288)	0.549
Labrale inferior	L1-Mid (β =0.448)	0.630
Sulcus inferior	L1-Inc (β =0.520) L1-Inc Vert (β =-0.474)	0.676

Cephalograms are ideal for DSR because a cephalostat, which was defined (Jeffcoat *et al.*, 1987) as an aid to guarantee alignment of the radiographs, is readily in use which optimizes projection geometry. However, contrast differences and small misalignments such as magnification and angular variations should be compensated within the technique in order to achieve high precision. The novel software used in this study has been shown to be effective for contrast correction (Öztürk *et al.*, 2004). Angular and magnification differences were also controlled by affine, bilinear, and biquadratic transforms, in terms of image warping.

The results of this study show that upper and lower lips and Si moved slightly posteriorly following orthodontic treatment in the extraction group compared with the nonextraction group. These findings are consistent with other studies (Drobocky and Smith, 1989; Bravo, 1994; Bishara et al., 1995; Cummins et al., 1995; Bravo et al., 1997; Kocadereli, 2002; Hazar et al., 2004) which evaluated changes in soft tissue profile by conventional cephalometric measurements. The mean changes for Ls, Li, and Si were less than the results of the cited studies. This may be due to determination of only the absolute changes in profile provided by DSR, since the changes in lip position were not evaluated with respect to the nose and/or chin. As evident from the hard and soft tissue landmarks evaluated in this study, growth continued in both groups during treatment and the increase in nasal tip (Nt') was most pronounced. Genecov et al. (1989) reported that anteroposterior growth and subsequent increased anterior projection of the nose continued until 17 years of age in males. Bishara et al. (1998) found that the upper and lower lips became significantly more retruded in relation to the aesthetic line between 15 and 25 years of age in both males and females; the same trends continued between 25 and 45 years of age. Although differences between the two study groups were small and there was no gender bias, individual treatment planning should include careful consideration of age and gender factors to obtain a well-proportioned, balanced, and harmonious soft tissue profile at the end of the treatment, and this should be preserved in later ages.

Regression analyses showed that changes in lip position were associated with changes of both maxillary and mandibular incisor position as evaluated at the midpoint of the crown. This means that lip shape/support changed significantly when considerable crown movement was achieved. In contrast, lower lip sulcus had a more direct relationship with the incisor tip. Changes in Si were associated with both vertical and sagittal displacement of mandibular incisor tip. Sagittal displacement of the point L1-Inc was positively correlated with the lower lip, whereas vertical displacement of that point was negatively correlated with the lower lip, suggesting that retraction and intrusion of the mandibular incisor tips together had a marked impact in the deepening of Si.

Some studies (Riedel, 1957; Bloom, 1961; Rudee, 1964) have found a high degree of correlation between the incisor and lip retraction, indicating that a significant relationship between the soft tissue profile and incisor retraction occurs following orthodontic treatment. However, other investigations (Burstone, 1958; Neger, 1958; Hershey, 1972; Wisth, 1974; Rains and Nanda, 1982) reported that the soft tissues do not always respond favourably to hard tissue retraction. Rains and Nanda (1982) concluded that a complex interaction exists between dental movement, mandibular rotation, and the perioral soft tissues as well as within the soft tissues themselves. The present results indicate significant but very weak correlations between lip

position and dental movement as multiple r coefficients were smaller than 0.75 which indicates a moderately high correlation for the prediction equation. Therefore, the results of the current study do not strongly support the view that proportional change in the profile accompanies the position of the dentition. Oliver (1982) attributes this to lip thickness and lip strain, concluding that the soft tissues may vary enough in thickness, length, and postural tone to cause the response of soft to hard tissue retraction to be different in subjects with thick upper lips compared with those with thin upper lips. Changes in profile seem to be related to variables such as pre-treatment lip strain, variations in lip structure, and thickness, together with incisor retraction (Battagel, 1989).

Qualitative assessment of the subtracted resultant images showed that the shape of lip adaptation to treatment mechanics or dental movements could not be precisely defined. The curvatures of the upper and lower lips did not follow regular pathways while being adapted on final positions of dentoskeletal structures. For instance, either retraction or protraction of the lips might not occur in a continuous fashion. Although the vermillion border of the lips remained unchanged on some of the images, upper and lower vermillion borders showed changes due to vertical movements of the lips (Figure 4, 2c). Since these regions were not defined as anatomical landmarks, they could not be objectively evaluated within the limitations of this study. In order to correctly establish treatment consequences, both quantitative and qualitative methods need to be utilized when using DSR for individual patients.

The results of this study should be viewed cautiously because differences pre-treatment between the extraction and non-extraction groups would mean that had there been any statistically significant differences in the profile changes they would probably have resulted from selection bias. Further investigations using DSR with larger samples of subjects with different malocclusions and ages may be beneficial for the interpretation of the current findings.

The findings of this research showed the potential use of DSR in evaluation of the profile following orthodontic treatment, given a correct projection alignment. Only points were used in this study as a means of analysis for comparison of the pre- and post-treatment outcomes; however, areas or volumes should also be used to establish the accuracy of DSR versus conventional cephalometric tracings. The software is still under development to provide area/volume and even bone densitometry analysis.

Conclusions

1. The outcomes of non-extraction and extraction therapies on the facial profile were evaluated effectively using the DSR method. The mean soft tissue differences in skeletally similar Class I subjects indicated a slight retraction in both upper and lower lips and inferior sulcus in extraction cases.

- 2. Changes in the dentition resulted in some slight proportional changes in the soft tissue profile.
- The differences in the pre-treatment occlusions mean that no conclusions can be drawn concerning the relative effects of extraction and non-extraction treatment on the profile.

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