Evaluation of horizontal and vertical differences in facial profiles by orthodontists and lay people

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In the last two decades combined orthodontic and orthognathic treatment has gained widespread acceptance. One of the major reasons patients opt for this treatment versus orthodontic treatment alone is the potential for change in the facial profile. For the diagnosis, treatment planning, and patient counseling, orthodontists and oral surgeons use cephalometric analysis combined with subjective clinical judgment. This judgment is based on preferences acquired during their professional training and subsequent clinical experience[1].

Professional opinions regarding evaluation of facial esthetics may not coincide with the perceptions and expectations of patients or laypeople. Bell and co-authors found that lay people were significantly more likely than orthodontists or oral surgeons to assign normal ratings to profile drawing.[2] Prahl-Anderson and co-authors found that orthodontists rated a greater number of line drawings of facial profiles as abnormal than did parents of children participating in the Nymegen Growth Study.[3] Similarly, following orthognathic surgery with technically adequate results, a corrected malformation may appear significantly improved to the surgeon, but an untrained person may have little appreciation of the result. Some orthognathic surgery patients may even fail to notice major changes in their own appearance[4].

Thus, it is essential first to formulate guidelines for the esthetic evaluation of facial morphology in relation to orthodontics and orthognathic surgery, and second, to establish to what degree these guidelines conform with the sensitivities and esthetic preferences of patients and lay people.

The two patients depicted in Figure 1 demonstrate profiles with horizontal discrepancies (convex profile in A, and concave profile in B). The

Abstract

A novel video image processing technique was used to evaluate changes in the facial profile mimicking the effects of various orthognathic surgical techniques. Incremental changes were introduced in male and female images simulating the effects of mandibular advancement or set-back, maxillary advancement or set-back, and maxillary impaction. Twenty-two clinicians and 22 lay people completed questionnaires evaluating their level of sensitivity to changes in the facial profiles and their preferences regarding alternative profiles. The results indicate that in judging realistic color video images, both orthodontists and lay people are sensitive to relatively small horizontal changes in the facial profile. In contrast, orthodontists are less sensitive to relatively large vertical changes but more sensitive to horizontal mandiublar changes.

Key Words

Soft tissue analysis • Anterior facial height • Orthognathic surgery • Imaging

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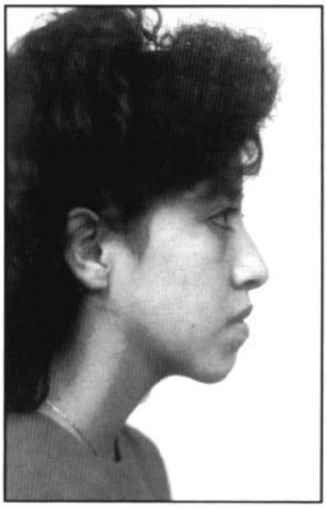

Figure 1A

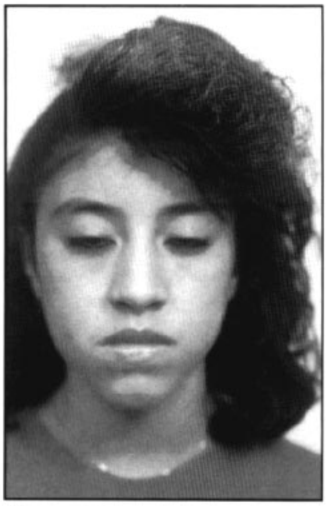

Figure 1B

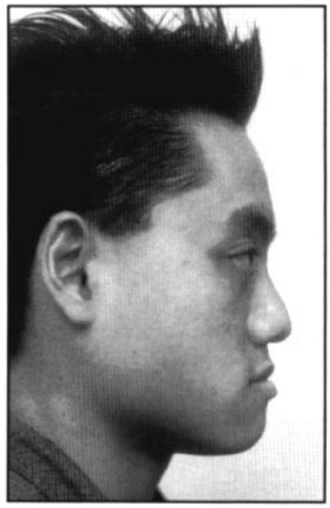

Figure 1C

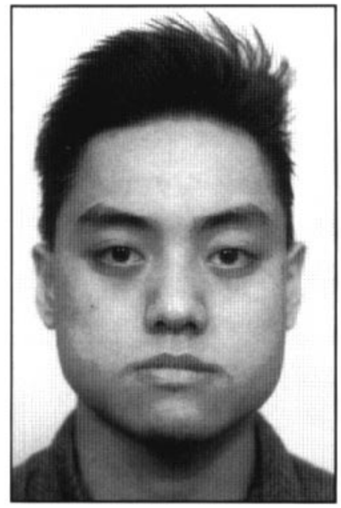

Figure 1D

Figure 1A-D
The two patients demonstrated in this figure are candidates for orthognathic surgery. Their profiles reveal substantial horizontal discrepancy (convex profile in the female patient, and concave profile in the male patient).

Figure 2A-B
Methods used in quantitative evaluation of profiles in the current study:
A. Soft tissue profile convexity was measured as the G-Sn-Pg angle, formed between a line connecting soft tissue Glabella and soft tissue Subnasale, and a line connecting Subnasale with soft tissue Pogonion.
B. Upper to lower facial height ratio was measured as the ratio between the distance from Glabella and Subnasale and the distance between Sub-nasale and soft tissue Menton.

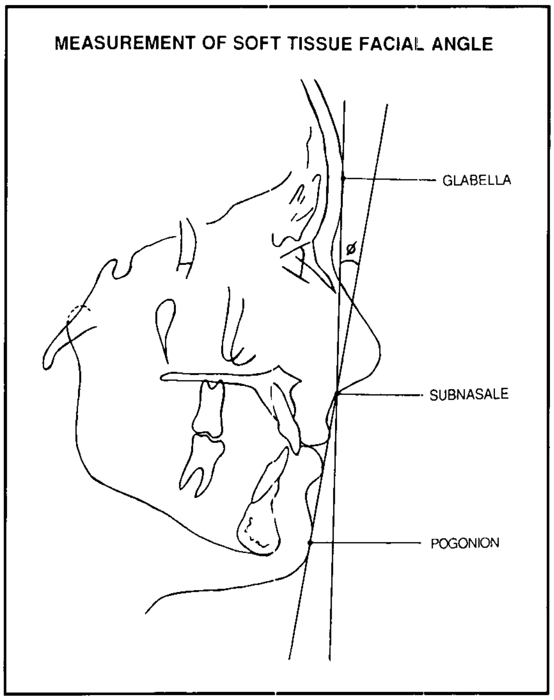

Figure 2A

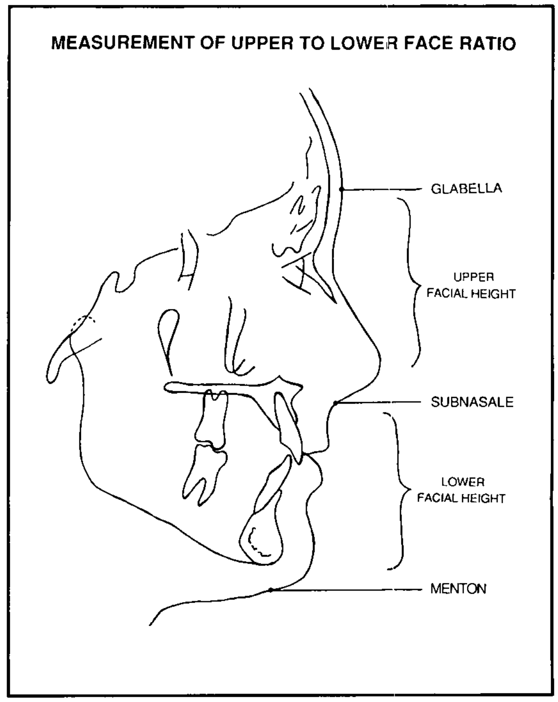

Figure 2B

patient in panel B also demonstrates substantial vertical discrepancy, with increased lower facial height. Current methods used in quantitative evaluation of profiles are demonstrated in Figure 2. The horizontal relationship of the maxilla and mandible relative to other cranial structures can be evaluated in relation to "soft tissue profile convexity". Soft tissue profile convexity is measured as the G-Sn-Pg angle, formed between a line connecting soft tissue Glabella and soft tissue Subnasale, and a line connecting Subnasale with soft tissue Pogonion.[5] The mean adult measurement for soft tissue profile convexity is about 12°. The vertical proportion of the upper and lower facial height can be expressed as "upper to lower facial height ratio", measured as the ratio between the distance from Glabella to Subnasale and the distance from Subnasale to soft tissue Menton.[5] The mean adult measurement for upper to lower facial height ratio is around 1.0.

Several studies have investigated the question: ***Do orthodontists and lay people differ in what they consider to be an esthetically pleasing profile[2,3,6] ?*** Lines and colleagues found several profile preference differences between orthodontists and untrained people, but none of these differences were statistically significant.[6] The question can also be asked: ***Do orthodontists differ from lay people regarding their ability to detect differ-***

Figure 3A

Figure 3B

Figure 3A-B
An example of two images of a female produced by the Dolphin system. These two images differ by 2mm in mandibular horizontal position.

ences in facial profile? Burcal and colleagues found orthodontists and oral-maxillofacial surgeons to be slightly more sensitive than lay people to horizontal changes of 2 mm or more in mandibular position.[4]

However, most of these studies concentrated on relatively large surgical changes, which were more relevant at the time these studies were conducted. In addition, most of these studies concentrated on horizontal changes in mandibular position with little emphasis on maxillary changes, and none of these studies evaluated the effect of vertical changes as perceived by orthodontists or lay people.

The advent of digital image processors and their increasing popularity has led to their use as tools in the treatment planning of orthognathic surgery and in counseling patients regarding treatment options. The assumptions underlying their use are that orthodontists and oral-maxillofacial surgeons can plan treatment more effectively using realistic visual aides, and that patients respond more favorably to such visual presentations. Image quality and treatment plan presentation material prepared using an image processor are indeed of superior quality compared to older techniques. However, digital image processors, like previous methods, use mean data to predict soft tissue change, and it is clear that actual treatment results for a particular individual may be substantially different from those predicted. In addition, since presentation materials produced in this way appear realistic and "scientific", concerns have been raised regarding professional liability.

Previous studies investigating the evaluation of facial profiles used techniques common at the time, such as profile drawings, paper cut-outs, wooden forms, shadow photographs, or altered black and white photographs of profiles. In contrast, current technology enables us to produce realistic color images simulating a wide range of surgical changes including changes in horizontal mandibular and maxillary positions, as well as vertical changes in maxillary positions. Thus, the purpose of the current study is to evaluate the sensitivities and esthetic preferences of orthodontists and lay people to various facial changes, as demonstrated using a digital image processor.

Materials and methods

Image Processing:

The Dolphin video image processor was used to capture the images of one male and one female adult. Incremental changes were introduced in these images, simulating mandibular protrusion and set-back, maxillary advancement and set-back, and mandibular down-grafting and impaction. Incision lines were automatically airbrushed out by the program, maintaining the natural appearance of each subject. Color prints differing in soft tissue facial convexity and height proportions were generated from these images (Fig. 3) and were randomly arranged in pairs as well as series for evaluation.

Questionnaires:

Questions were developed to accompany the images and were aimed at detecting the level of sensitivity and the esthetic preference of respondents. The questionnaire was divided into two equal parts, the first part contained only female images, while the second part contained only male images. The questionnaire was completed by 22 orthodontists and 22 lay people. Of the 22 orthodontists, 19 were men and 3 were women. Of the 22 lay people, 11 were men and 11 were women. All participants were from the greater Hartford, Connecticut area.

Figure 4
Sensitivity of orthodontists and lay people to horizontal changes in the mandible in male and in female images. "Percent detection" indicated the fraction of orthodontists or lay people who detected the difference between two color prints of images including horizontal changes in mandibular position.

Figure 5
Sensitivity of orthodontists and lay people to horizontal changes in the maxilla in male and in female images. "Percent detection" indicated the fraction of orthodontists or lay people who detected the difference between two color prints of images including the horizontal changes in maxillary position.

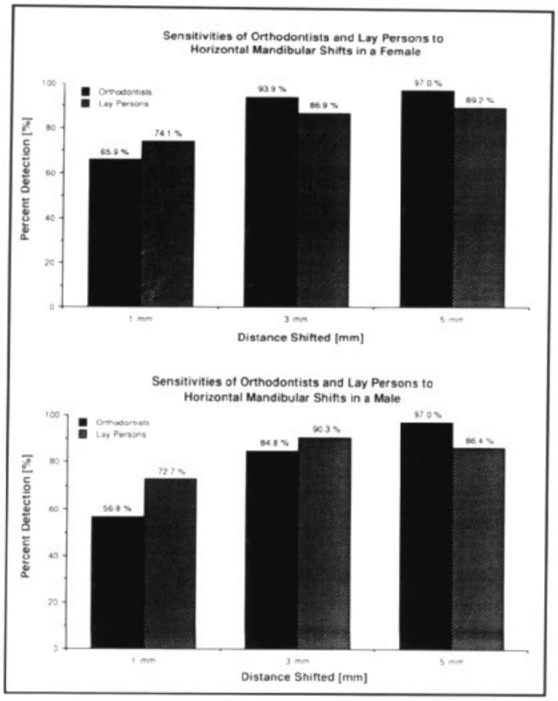

Figure 4

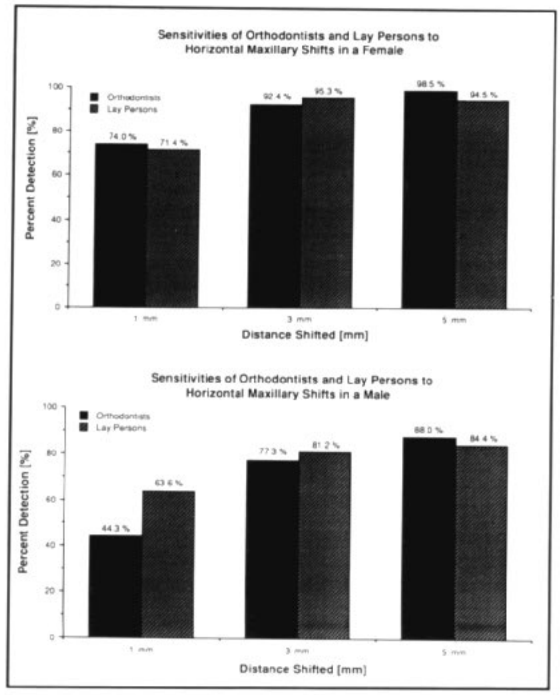

Figure 5

To measure sensitivity, respondents evaluated pairs of color images and were asked to determine whether a difference existed between the two images. Images were paired together if they differed in the same jaw (mandible or maxilla) and had been changed in the same axis (vertical or horizontal). Respondents evaluated pairs of images differing by 1, 3, or 5 mm in horizontal mandibular or maxillary position, and pairs of images differing by 2, 4, 6, and 10 mm in vertical maxillary position. For each pair, the respondents had to decide whether or not there was a difference between the two images.

To measure esthetic preference, three series of male images and three series of female images were assembled. Each series was composed of randomly ordered color prints. Of the six series, two series (one of 10 male images and one of 10 female images) included prints with different horizontal positions of the mandible. Likewise, two series (male and female, 10 images each) included prints differing in maxillary horizontal position, and two series (male and female, 6 images each) included prints differing in vertical maxillary position. The participants were asked if they could detect any differences among the images in each series, and if they answered positively, they were further instructed to select the most pleasing profile from the series.

Data Analysis

The sensitivity data was analyzed using contingency tables (chi-square) to see if the horizontal detection levels at 1, 3, and 5 mm, or vertical detection levels at 2, 4, 6, and 10 mm were significantly different, within the male and female images first, and further between orthodontists and lay people. Results are presented regarding significance at the 0.05 and 0.01 alpha levels, the 0.01 level being more conservative.

Facial profile angles were measured for each image by drawing lines from soft tissue Glabella to Subnasale, and from Subnasale to Pogonion. The angle formed by these two lines is defined as the facial profile angle of a given image (Fig. 2). These angles were used to determine the degree of soft tissue facial convexity selected as the most pleasing by the participants. Similarly, facial height changes were expressed as the ratio between the distance from soft tissue Glabella and Subnasale, and the distance between soft tissue Subnasale and Menton, as measured for specific images (Fig. 2).

Results

Sensitivities of orthodontists and lay people to horizontal mandibular changes in the female and male are shown in Figure 4. The orthodontists could detect a 1 mm change in the female mandible in 65.9% of the cases. Detection sensitivity substantially increased, to 93.9%, for a 3 mm change (statistically significant at $p<0.01$), and further to 97% for a 5 mm change. The orthodontists displayed similar sensitivity to horizontal mandibular shifts in the male (Fig 4). Detection levels for a 1 mm change in the male mandible were 56.8%, and they increased substantially, to 94.8% for a 3

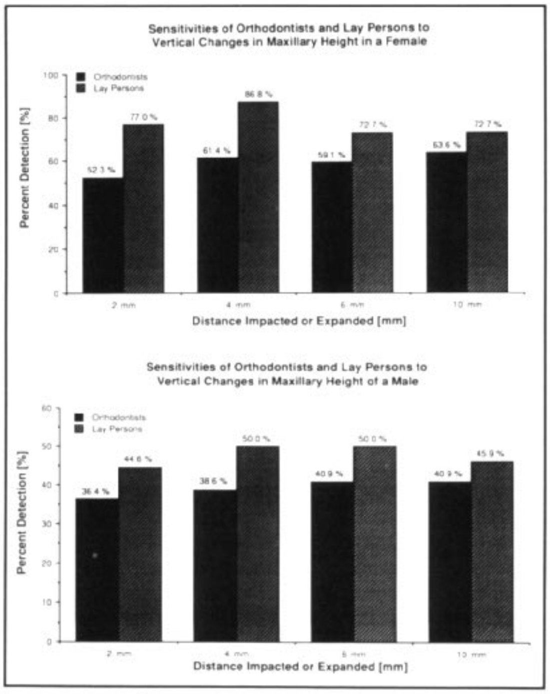

Figure 6

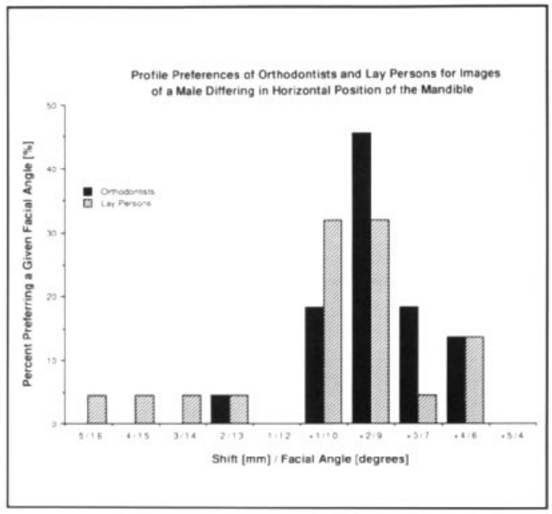

Figure 7A

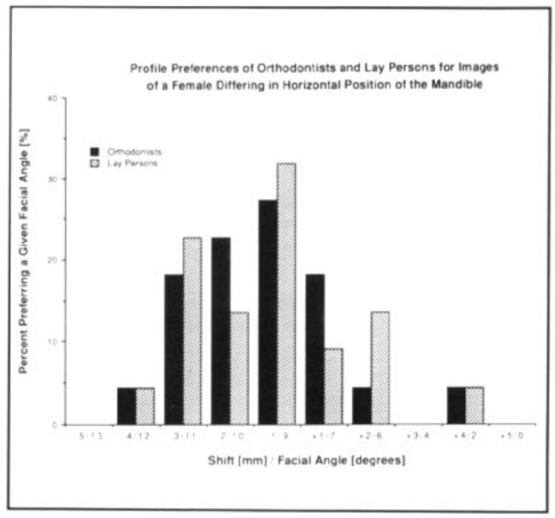

Figure 7B

Figure 6
Sensitivity of orthodontists and lay people to vertical changes in the maxilla in male and in female images. "Percent detection" indicated the fraction of orthodontists or lay people who detected the difference between two color prints of images including the vertical changes in maxillary position.

Figure 7
Preferences of orthodontists and lay people for male (A) and female (B) images differing in mandibular horizontal position.

mm change (statistically significant increase at the p<0.01). Again, detection levels further increased at a 5 mm difference. Although orthodontists appeared to be more sensitive to mandibular changes of 1mm and 3 mm in females compared to similar changes in males, the differences were not statistically significant.

Similar levels of detection were found for lay people. The apparent differences in detection levels between the two populations were statistically significant at the 0.05 level, but not at the 0.01 level.

Sensitivity of orthodontists and lay people to horizontal maxillary changes in the female and male images are shown in Figure 5. Orthodontists detected 1 mm changes in the female in 74% of the cases, and detection levels increased substantially to 92.4% (statistically significant, p<0.01) for changes of 3 mm. Detection levels further increased to 98.5% for changes of 5 mm. However, the orthodontists correctly identified only 44.3% of the pairs of male images differing by 1 mm in horizontal maxillary position. Detection level improved to 77.3% for changes of 3 mm, and further for changes of 5 mm. For changes of 2mm and 5 mm the orthodontists were more sensitive in evaluating the female images compared to the male images (p<0.05).

Lay people showed a pattern of sensitivity to maxillary changes similar to that of the orthodontists, with a significant increase in detection level as horizontal maxillary changes increased from 1 to 3 mm in the female. Overall, the differences between orthodontists and lay people in sensitivity of detection for maxillary changes were not found to be significant.

Sensitivities of orthodontists and lay people to vertical changes in maxillary height are shown for the female and male images in Figure 6. Although a substantial percentage of both orthodontists and lay people identified changes between the presented images, there were no significant differences in their ability to recognize differences of 2mm, 4mm, 6mm or 10 mm in maxillary height. Detection levels for 10 mm of maxillary impaction or disimpaction were not statistically different from detection level for 2 mm changes. Lay people were consistently better able to detect these changes in maxillary height in females than in males. Moreover, lay people consistently showed higher sensitivity than orthodontists in detecting vertical maxillary changes.

Figure 7 presents the profile preferences of orthodontists and lay people for the female and male

Figure 8
Preferences of orthodontists and lay people for male (A) and female (B) images differing in maxillary horizontal position.

Figure 9
Preferences of orthodontists and lay people for male (A) and female (B) images differing in maxillary vertical position.

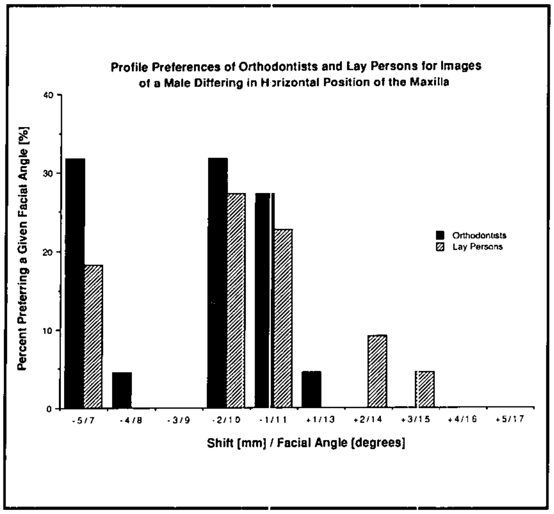

Figure 8A

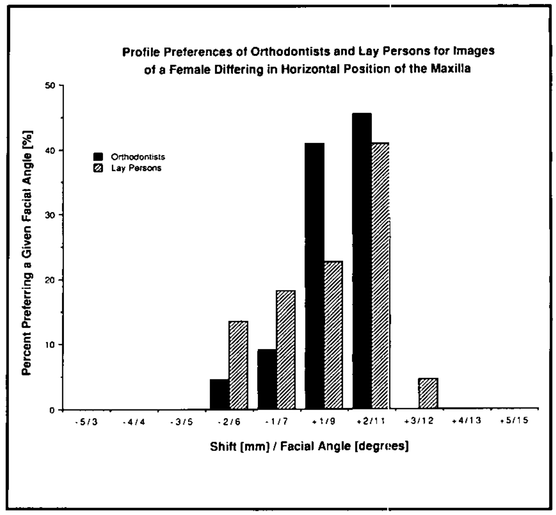

Figure 8B

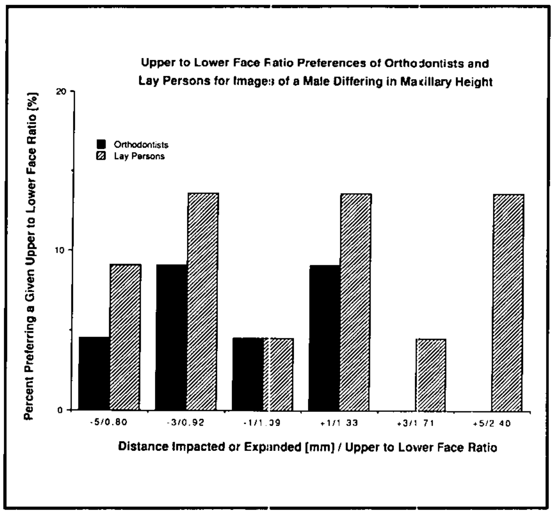

Figure 9A

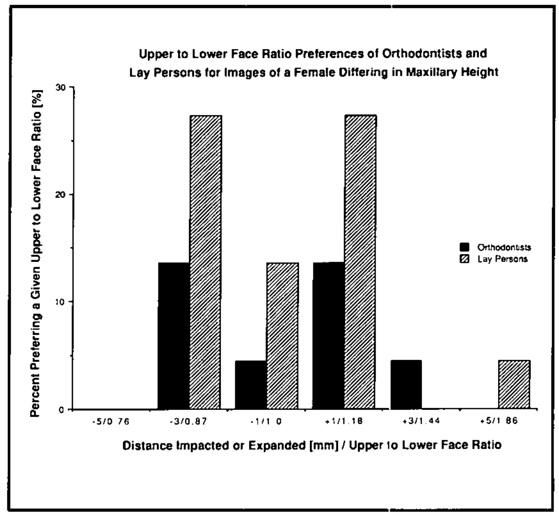

Figure 9B

images differing in horizontal mandibular position. Both populations showed a clear central tendency for preferring a soft tissue facial convexity of approximately 9° in both females and males. Similar results are presented in Figure 8 regarding profile preferences of the orthodontists and lay people for horizontal shifts in the maxilla of the female and the male. Both groups favored a soft tissue facial convexity of approximately 11° in females, and approximately 10° in males. These results contrast with results presented in Figure 9 showing the esthetic preferences of orthodontists and lay people regarding vertical maxillary changes. After observing a series of images ranging in upper to lower facial height ratio from 0.76 to 1.86, 63% of the orthodontists and 27% of the lay people could not detect any differences among the images and hence did not select a preferred profile. Thus, Figure 9 shows the profile preferences only of those orthodontists and lay people who were able to detect such differences. Similarly, after reviewing a series of male images ranging in upper to lower facial ratios from 0.80 to 2.40, 72.7% of the orthodontists and 41.0% of the lay people could not detect any differences among the images and did not select a preferred profile. For both male and female images, and for both orthodontists and lay people, there were no clear central tendencies regarding the preferred profiles following these vertical changes.

Discussion

We have performed an extensive study of orthodontists' and lay people's sensitivity and esthetic preferences in relation to facial images produced using a digital image processor to simulate orthognathic surgical changes. Our results demonstrate that both orthodontists and lay people are relatively sensitive to horizontal changes in mandibular position, particularly changes of 3 mm or more. A high degree of sensitivity was also observed in both groups for horizontal maxillary changes of the same magnitude. In contrast, both orthodontists and lay people were less sensitive to vertical changes in maxillary position. One interesting finding of the study is that lay people were consistently and substantially more sensitive than the orthodontists to changes in upper to lower facial ratio in both female and male images.

The fact that 16 of 22 orthodontists surveyed could not detect any differences among a series of male images differing by as much as 10 mm in maxillary height stands in stark contrast with the emphasis often placed on vertical discrepancies in maxillary position during diagnosis and treatment planning. These results can be related to the fact that although orthodontists and oral-maxillofacial surgeons often diagnose patients with vertical maxillary discrepancies, these professionals may rely primarily on different criteria in evaluating vertical maxillary relationships. Such criteria include the degree to which maxillary incisors and gum tissue show under the upper lip with the lips at rest or in the smiling position. These features, which are essential for evaluating facial esthetics, are not reflected in the current study.

Consistent with the findings of Burcal and associates,[4] both orthodontists and lay people are more sensitive to changes in female images than to the same changes in the male images. Our study demonstrates this preferential sensitivity to the female profile also regarding vertical changes which have not been previously studied.

We cannot derive clear conclusions regarding potential differences between male and female respondents in our study. Although an equal number of male and female lay people completed the survey (11 each), only 3 of the 22 orthodontists who participated in the study were women.

Our study shows similarity in most aspects of sensitivity and esthetic preference between orthodontists and lay people. Esthetic preferences were best defined for horizontal differences in mandibular position, with a clear tendency toward a soft tissue facial profile angle of 9°. A less clearly defined tendency was observed following horizontal maxillary changes. In contrast, we could not detect a clear preference following vertical changes in the maxilla that resulted in differences in upper to lower facial height ratios. As mentioned above, evaluation of facial height is often included in the diagnosis and treatment planning of surgical patients.[5] In spite of the finding in our current study, practitioners and lay people may in fact have clear esthetic preferences regarding the vertical relationships between the facial soft tissues and the dentition.

Finally, using video image capture combined with a digital image processor allowed us to produce a study which is more extensive than previous studies in this area. There is no doubt that this technology makes facial image processing fast and easy. However, the question remains open regarding the efficacy of image processor derived color facial photographs versus other techniques (e.g., profile line drawings) in counseling and treatment presentation to patients.

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