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FACIAL CHANGES IN IDENTICAL TWINS TREATED BY DIFFERENT ORTHODONTIC TECHNIQUES

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Despite the known influence of orthodontic treatment on facial appearance, there have been few comparative studies of the effect of different treatments, and none of these appear to have looked at the long-term consequences. This study compared the effect of traditional fixed appliances and orthotropic (growth guidance) treatment without fixed appliances on a series of 12 identical twins, 10 years after treatment. Facial changes were assessed by a panel of 12 lay judges. A comparison was also made of the dental changes and an error study undertaken. The results showed that most of the traditionally treated twins were judged to look less attractive after treatment, while most treated by orthotropics were judged to have improved. There was little difference in the dental results, but the traditionally treated cases seemed to relapse more frequently. World J Orthod 2007;8:174-188.

Orthodontic techniques fall broadly into 2 groups that reflect differing views about the cause of the irregularity of the teeth. Practitioners within the more "traditional" of these groups hold the view that the dimensions of the jaws are largely predetermined at birth. If there is insufficient room for the teeth, some are usually extracted and the remainder aligned with fixed appliances. More severe cases are treated with orthognathic surgery. The second group places greater emphasis on orthopedic factors, using expansion to widen narrow jaws and functional appliances to reduce interarch differences, prior to completing treatment with traditional fixed appliances. There is also a third, much smaller, group that believes malocclusion is primarily due to adverse soft tissue posture and activity. This group avoids fixed appliances if possible because of their perceived tendency to increase vertical growth. Instead they base treatment on the "tropic premise," which says that "If the tongue rests against the palate with the lips sealed

and the teeth in or near contact then the facial growth will be near ideal and the teeth naturally straight." They use Biobloc appliances to encourage horizontal growth while children are still young. This study compared identical twins treated by traditional and orthotropic (growth guidance) methods.

PREVIOUS STUDIES

While there have been many studies of facial changes during and following treatment, most of them have been relatively short-term and few, if any, have explored the long-term influence of different orthodontic treatments on the face. Many have been limited to profile outlines, which have limited esthetic interpretation and, in the author's view, none of them display robust evidence about the relative benefits or disadvantages of any treatment. Comparisons are made additionally difficult by the fact that faces continue to change throughout life whether treatment is provided or not.¹

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The problem of assessing long-term facial changes is illustrated by 2 of the papers on this subject.^{2,3} In the first, only 57 out of an initial population of 2,500 returned for final assessment. Satisfied patients are naturally more likely to return and this may create bias. Selecting suitable patients can also present difficulties. For instance, the second study excluded "poor" treatment results, as well as patients who completed treatment without a natural lip seal, although this latter exclusion did not seem to have been applied at the start of treatment. Under these circumstances, it is hard to say if any improvement was the result of the treatment or because some of the patients had learned to keep their mouths closed.

FACIAL BEAUTY

Many people think that beauty lies in the eye of the beholder and that its appreciation is strongly influenced by cultural values. However, the classic study by Samuels and Ewy⁴ showed convincingly that babies as young as 6 months have a strong preference for the same good looks that adults appreciate, suggesting that these esthetic values are probably innate. It has been known for many years that most people agree about who is attractive,⁵ and it seems that our personal preferences only diverge when considering less attractive faces within the general population.⁶ It is interesting that orthodontists find a straighter (vertical) profile more attractive than the general public, who prefer a more horizontally growing face.⁷ It is important that this bias is allowed for when debating the impact of treatment on the face.

The only way a scientific assessment can be made of a subjective factor, such as facial beauty, is to use a panel of judges. These normally register a high degree of concordance,⁸ even if the judges and subjects are from varying racial groups. However, it is more difficult to rate the attractiveness of the same individual at different ages because of the effect of maturity. This, together with photographic problems, variations in

facial expression, and skin condition, is probably why little is known about the long-term effect of orthodontic treatment on the appearance of the face. This problem is now being addressed by the use of laser recordings, as these appear to be more accurate in recognizing soft-tissue changes, especially of vertical growth, than are lateral skull radiographs.⁹ However, laser images may measure the soft-tissue profile quite accurately but are not suitable for esthetic judgments. In the future, digital photography may enable a more detailed analysis.¹⁰

ALTERNATIVE RESEARCH PROTOCOLS

Many problems arise when comparing the effects of different types of treatment on either the teeth or face, mainly because of the large genetic variation within the population. Problems also occur if the different methods are technique-sensitive, because the variation in operator skills can exceed that of the treatment effect. Moreover, operators tend to have preferred methods and their enthusiasm alone can influence the results. However, as discussed above, the greatest problem is that of eliminating bias. The current "gold standard" for research is the randomized prospective study, but these too have ethical and financial limitations¹¹ and large numbers are required to balance genetic variations. This increases the number of clinicians involved, and thus the variation in clinical skills. These shortcomings may be why their orthodontic findings have in the past tended to be rather negative.

Almost the only way of eliminating genetic variables is to use identical twins. This prospective study compared consecutive identical twins, over 10 years out of all retention, treated by different experienced operators, each convinced that their preferred method was the best. It included every case, regardless of success or failure.

Table 1 Case classification

Pair	Traditional	Orthotropic	Control
1		Be	E
2	An		J
3	M	M—retreatment	A
4	D	C	
5		S	H
6	B	Q	
Total	4	5	4

IDENTICAL TWINS

Truly identical twins are monozygote but can still be different in some respects. For instance, cleft palates or missing teeth can exist in one twin but not the other. However, birth defects of this nature are easily separated from the variations in the amount and direction of facial growth that cause many of the problems in orthodontics. Identical twins can at times display marked differences, questioning the whole concept of using them for comparative research; this issue is addressed in the Discussion section.

Blood tests have traditionally been used to confirm zygosity; DNA testing has become available more recently. However, blood tests are expensive and often refused by patients, and Cohen et al¹² have shown that if twins look alike they are 90% likely to be identical. Fairpo¹³ subsequently supported Cohen's work, which became the accepted standard for epidemiologic research. Probability can be increased if other features, such as the arrangement of dental cusps are included. Cohen's technique was used to establish the zygosity for the twins in this study, but, for added confirmation, 4 of the 12 children were also given blood tests and were shown to be the same for 10 different factors.

The principal objective here was to study the long-term effect of either traditional or orthotropic treatment on facial appearance. A subsidiary objective was to record some of the dental changes. Although cephalometric records were taken, these are not included in this study.

MATERIAL

It is difficult to assemble a large group of identical twins, and especially so to treat them differently. During the last 30 years of clinical practice, the author has encountered only 9 pairs of identical twins. Three pairs received the same treatment and so were not included in this study; however, in 12 instances (6 pairs), the twins were treated differently. Five were treated by the author with orthotropics; 4 were treated by more traditional methods at other centers. One of this traditionally treated group was subsequently re-treated by orthotropics. The remaining 4 were never treated and served as controls (Table 1).

It is now generally agreed that patients should be at least 10 years out of retention before a long-term assessment can be made. The patients treated in this study were, on average, more than 10 years out of retention (the traditionally treated group ranged between 2 and 25 years out of treatment; the orthotropic group between 5 and 19 years). This extended the overall period of the study to nearly 30 years. Some of the original records look rather dated while others have been lost, although copies of all have been retained. Clearly similar problems arise in all long-term research, but because ethical standards have now changed, this study would be difficult to repeat, making this material to some extent unique.

Selection

All the twins were recorded prospectively, except for pair 2, who attended for an opinion some years after treatment and were analyzed from retrospective records. In pairs 1, 3, 5, and 6, only 1 twin was initially recommended for treatment, and it can thus be reasonably assumed that they initially had a more severe malocclusion than their sibling; all of these were treated by orthotropics. There was no selection of patients for either treatment. Therefore, all the twins who required treatment were offered either traditional or orthotropic treatment, depending only on the establishment they attended. The dentist who referred pair 6 later decided that the second twin would also need treatment, and by prior arrangement he was treated traditionally by another orthodontist. The parents of the fourth pair of twins agreed for them to be treated differently from the outset, and the orthodontist who provided traditional treatment selected the twin he preferred to treat, while the other was treated by the author with orthotropics. Thus any "selection" appears to have been weighed against the patients treated by orthotropics. This conclusion is supported by the fact that the panel of judges (to be described shortly) judged all the twins who received orthotropic treatment as looking less attractive than their siblings before treatment.

The 12 twins were divided into 3 groups:

Group 1. In this group, 4 twins received traditional orthodontic treatment, as described. Of necessity, long-term studies reflect techniques used many years ago and sometimes since abandoned. However, the fixed appliances and extractions used for these cases bear many similarities to systems currently in use.

Group 2. This group consisted of 5 twins who received orthotropic (growth guidance) treatment. Biobloc appliances were used to expand the maxilla at a semi-rapid rate of 1 mm per week for 8 to 12 weeks,¹⁴ and at the same time both arches were lengthened with removable appliances, with the aim of increasing

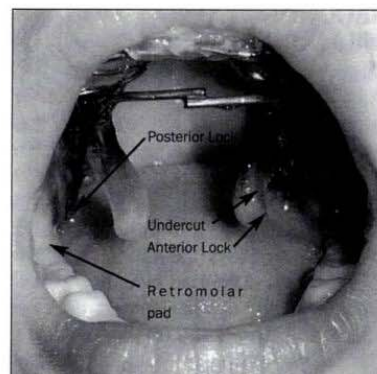


Fig 1 Biobloc orthotropic appliance is used to train the child to keep the mouth closed.

room for the tongue. It is claimed that if this specific rate of opening is used, the maxillary suture will split in all juvenile and most adult cases, and at the same time the whole maxilla will move forward.¹⁵ Figure 7 illustrates how this movement caused an increase in the overjet of patient Q (pair 6) from 9 to 16 mm at the end of the first stage of treatment. A Biobloc postural appliance (Fig 1) was then provided to correct the overjet and train the patient to adopt the "tropic" posture. It is not easy to change the resting position of the tongue, lips, and jaws, but if this can be achieved while the child is young, it is suggested that the face will grow forward and the teeth align spontaneously and remain stable. No fixed appliances were used for any of the orthotropic cases. Note that the effect of these postural appliances is different from functional appliances, which tend to restrict maxillary growth. One of this group had previously been treated with traditional treatment, but was retreated with orthotropics, which is why she appears in the tables twice.

Group 3. Four twins received no treatment and served as controls for their treated siblings.

RECORDS AND MEASUREMENTS

Photographs and models were taken at each stage of treatment, at the end of retention, and an average of 10 years later. Radiographic tracings were available for all but 1 pair. The alignment of the maxillary and mandibular anterior teeth was assessed using the "irregularity index," as described by Little,¹⁶ which measures the slipped contacts and was adapted for use in the maxilla by Mew.¹⁴ The overjet was also measured at each stage. The width of the maxilla was measured as the minimum distance between the maxillary first molars, using the method previously described by Mew.¹⁴

Comparison of faces

It is not easy to assess a subjective factor such as facial attractiveness. The current gold standard is to use a panel of 3 to 6 judges and convert their combined opinions to scientific indices.¹⁷ To improve the scientific accuracy, a panel of 10 judges was recruited. Using the method recommended by Shaw,¹⁷ 5 men and 5 women were selected from a group of recent postgraduates, none of whom had any dental training or special knowledge of either type of treatment. They were first provided with an instruction sheet which asked them to judge the attractiveness of each face at first sight, without consideration of the individual's possible character, and regardless of age, race, or weight. They were then shown photographs of the twins taken before and an average of 10 years after treatment, and asked to decide which twin looked most attractive (Figs 2 to 7). To ensure that the study was "blind," the pairs were mounted at random on a pasteboard with no other information and, to increase sensitivity, the judges were not given the option of "no difference" between the before and after views. Some of the photographs had been taken nearly 30 years previously and were in black and white (however, all are reproduced in black and white here) and not from the same angle, although all facial judgments were based on matching pairs.

The judges were also asked whether the individual faces had improved or become worse.

Repeatability of measurements

Three of the judges were asked to repeat their assessments of the faces on a subsequent occasion. Kappa statistics (corrected for chance) were used to assess inter- and intra-rater agreement.

The repeatability of the dental measurements was the same as used in a previous study¹⁴: Measurements of the slipped contacts were repeated after an interval of 1 week in 10 cases (5 in the permanent dentition and 5 in the mixed dentition).

RESULTS

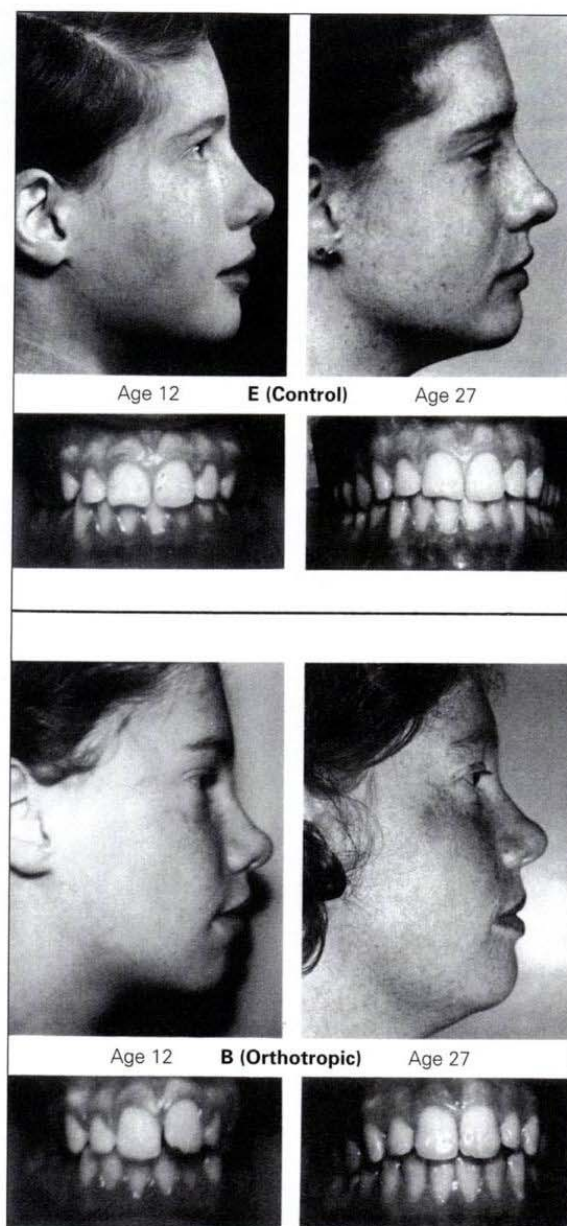
Table 2 shows the summary of the individual judgments. Because the 10 judges each had a series of choices, the judgments are presented in the results as percentages.

Facial appearance

Before treatment, the patients who were subsequently treated traditionally were found to be more attractive than those treated by orthotropics in 90% of cases (Table 2). After treatment, patients who had received orthotropics were rated as more attractive in 70% of the cases. Of more concern, patients who received traditional treatment were judged to look less attractive after treatment than before in 83% of cases, while the orthotropic patients were judged to have improved in 86%. Of the controls, 37% were judged to look worse and 50% better.

Expansion

The twins who received semi-rapid expansion maintained an average gain in width of 4.48 mm (range 1.2 to 11.4 mm) 10 years after treatment. There was little change in width for the twins who had

Fig 2 Treatment changes for pair 1.

received traditional treatment or for the untreated controls. Similar findings with semi-rapid expansion have been reported previously,¹⁴ but the technique is demanding and others have found the

results difficult to replicate.¹⁸ Some of these difficulties may have been because the 1-mm rate of expansion had not been precisely adhered to, as was certainly the case in one such study.¹⁸

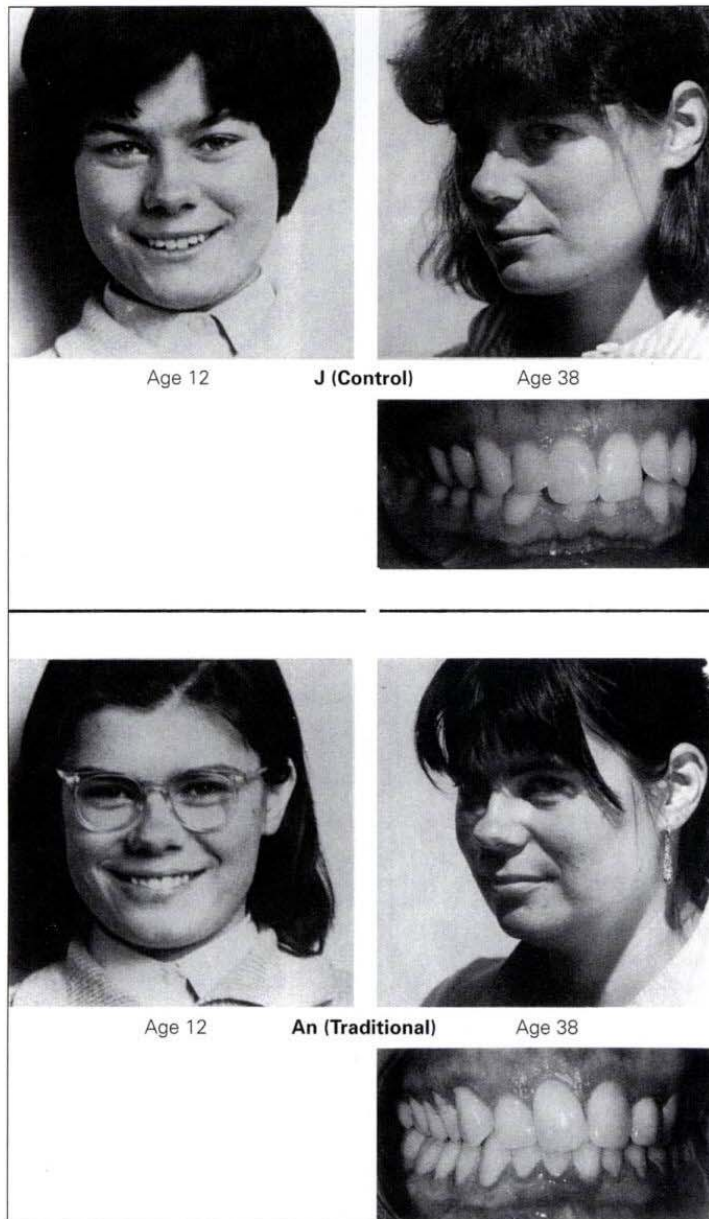


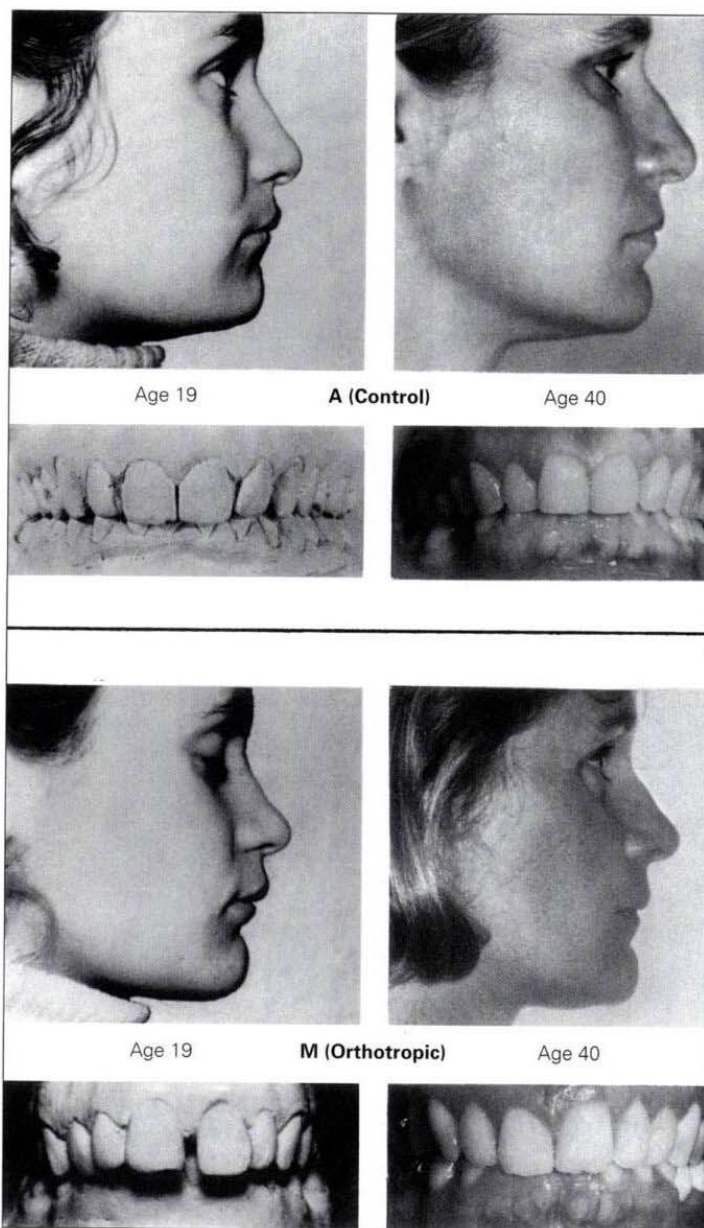
Fig 3 Treatment changes for pair 2.

Irregularity/stability of the dentition

There was little difference in the amount of incisor crowding at the end of the study between any of the groups, regard-

less of extractions, although the teeth of orthotropic patients were slightly less crowded. The overjet at the end of treatment was similar for all 3 groups.

Increasing irregularity of the teeth throughout life is now accepted as a nat-

Fig 4 Treatment changes for pair 3.

ural phenomenon and most orthodontists recommend long-term or permanent retention, as was prescribed for patient B. This attitude seems to be justified by the fact that all the other traditionally treated patients suffered significant

relapse. Patients M and D were retreated, while patient A has accepted her 6-mm overjet. All the patients treated by orthotropics remained almost completely stable, despite the fact that 1 patient had been retreated after signifi-

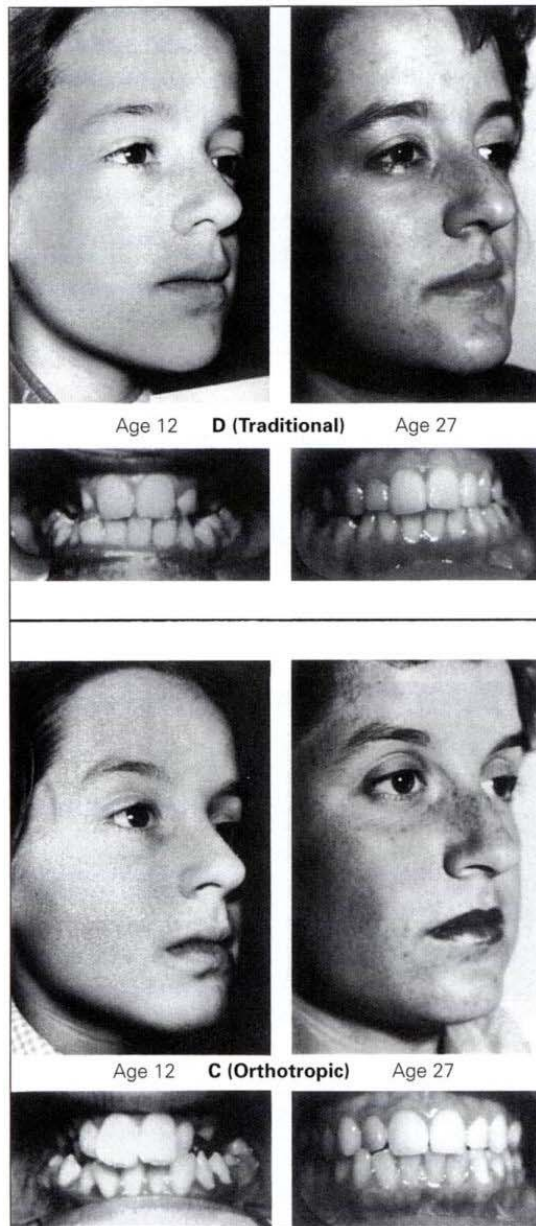
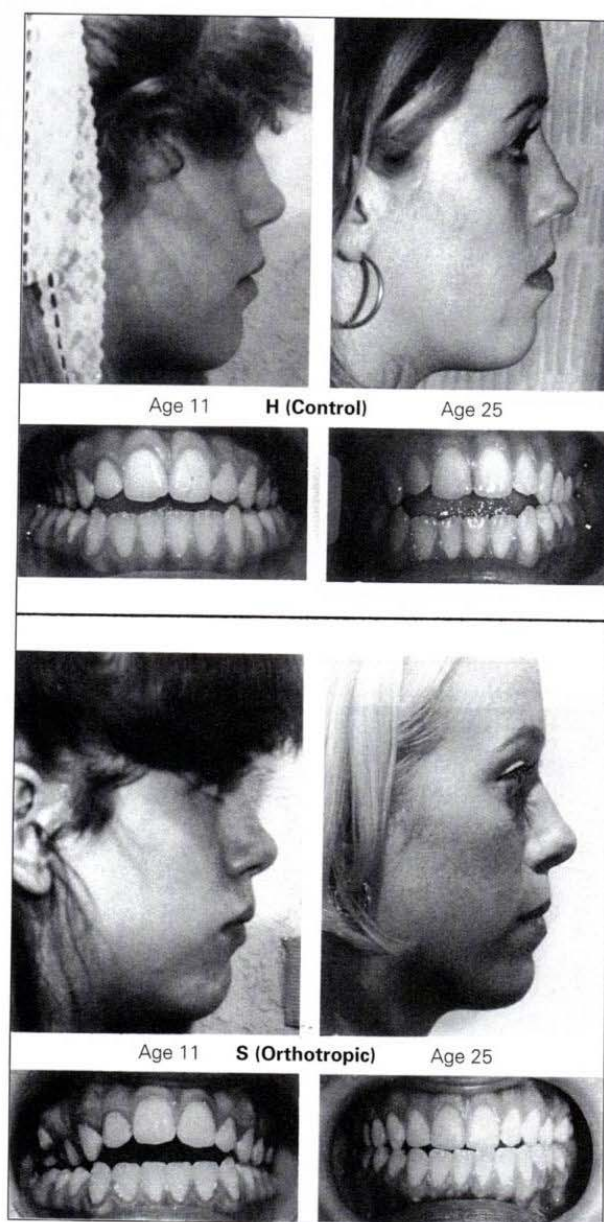


Fig 5 Treatment changes for pair 4; illustrates the expansion of the maxilla.

cant relapse following a previous course of traditional treatment. Of interest, 1 of the untreated controls, patient H, who started with an almost normal occlusion, developed a severe anterior open bite. The dental results are shown in Table 3.

Radiographic findings will be presented in another article.

Fig 6 Treatment changes for pair 5.

Repeatability of measurements

The inter-rater agreement (Kappa) of these judgments was 0.35, which is only fair for a clinical measurement,¹⁹ but Altman²⁰ suggests the score is quite high

for a subjective opinion. This is in line with the almost universal finding that ratings of facial appearance are remarkably constant.^{5,8}

The test-retest reliability for the 3 judges who were asked to repeat their assess-

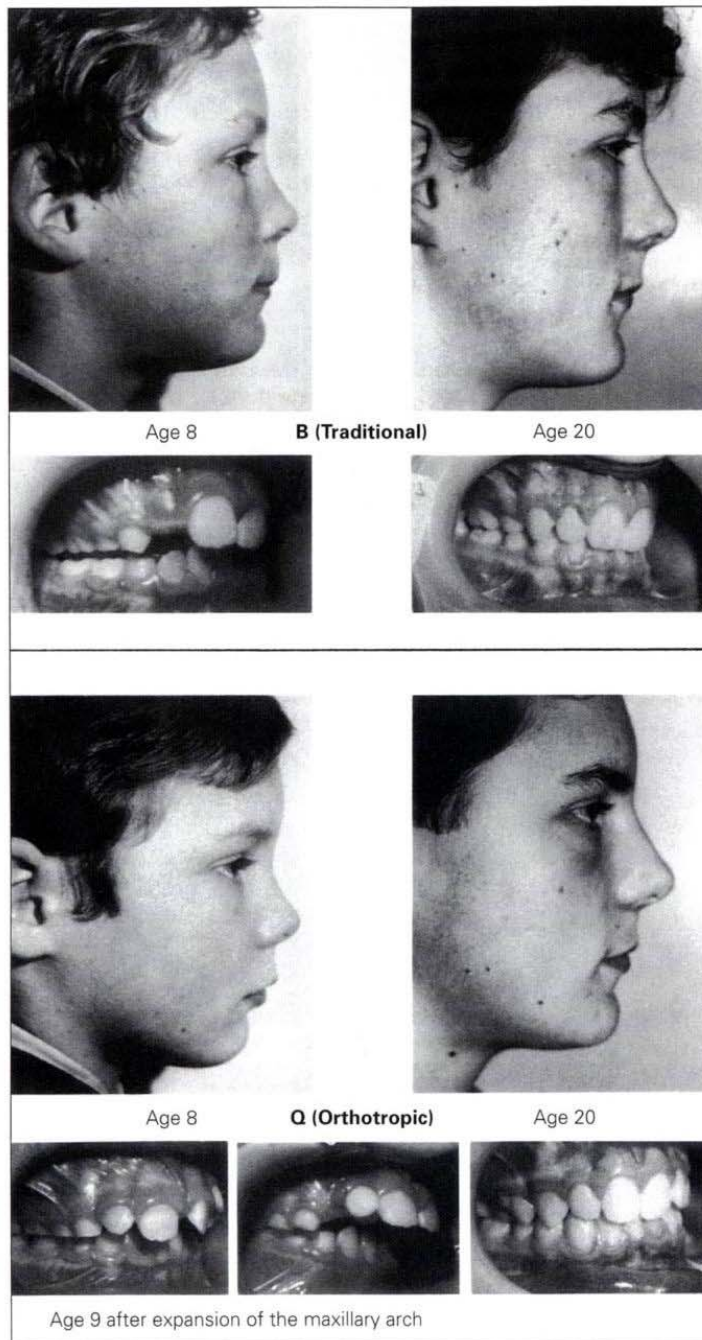


Fig 7 Treatment changes for pair 6; illustrates how patient Q's overjet increased from 9 to 16 mm.

Table 2 Results of the panel of 10 judges

Identical twins	Which twin was best looking before?	Which twin was best looking after?	Did this twin improve?	Or worsen?
E	10	7	6	4
Be	0	3	5	5
J	2	9	7	3
An	8	1	3	7
A	8	3	5	5
M	2	7	9	1
D	10	2	1	9
C	0	8	9	1
H	8	1	7	3
S	2	9	10	0
B	9	2	1	9
Q	1	8	10	0

Table 3 Dental results

Name	Type of treatment and years out of retention	Maxillary molar width (mm)		Maxillary Little's Index (mm)		Mandibular Little's Index (mm)		Overjet (mm)	
		Before	After	Before	After	Before	After	Before	After
E	None	31.9	32.2	1.5	1.0	0.5	1.5	3.3	2.4
Be	Orthotropic 10 years	28.9	30.4	4.5	0.5	0.0	2.0	8.2	2.7
J	None	N/A	32.4	N/A	6.5	N/A	9.5	N/A	3.5
An	Traditional 25 years	N/A	31.8	N/A	2.5	N/A	3.0	N/A	6.0
An	None	33.4	33.3	1.0	1.5	1.0	1.0	2.8	2.8
M	Orthotropic 19 years	30.8	32.0	2.7	0.0	3.0	1.0	7.3	2.4
D	Traditional 10 years	26.0	26.8	7.5	2.0	4.5	2.5	6.2	2.9
C	Orthotropic 12 years	27.8	38.2	6.0	1.5	4.0	2.0	3.1	2.3
H	None	31.8	29.9	0.0	1.5	1.0	1.0	4.2	2.3
S	Orthotropic 6 years	32.0	38.0	1.0	0.0	0.5	1.5	7.4	2.9
B	Traditional 2 years	27.1	27.3	2.0	2.5	3.5	1.5	8.1	3.5
Q	Orthotropic 5 years	29.2	32.5	11.5	2.0	3.0	0.5	8.6	3.2

ments (judges 7, 8, and 9) was 0.42, which again is relatively high for an esthetic opinion.²⁰ Surprisingly, in view of the subjective nature of the test, all of judge 7's opinions were the same; however, judge 8 changed her opinion in 3 instances and judge 9 in 5. Shaw²¹ considers that it is easier to compare pairs than to rate individuals within a group, and this is probably even more true with identical twins.

In the measurements of the slipped contacts repeated after 1 week, the standard deviation between the first 2 sets was 0.8 mm; it was slightly higher (1.48) for the mixed dentition cases, which required some estimation. The standard deviation for the 10 intermolar widths was only 0.03 mm. The reason for this was probably that the minimum unit of measurement (0.1 mm) was large enough for several cases to achieve identical figures on re-measurement.¹⁴

DISCUSSION

Possible confounding factors

The results appear unusually powerful for a clinical study and it is essential that all the possible confounding factors be taken into account:

Initial differences. All the twins displayed noticeable differences before treatment, but in his study of 30 pairs, Lobb²² found that such variation is the norm rather than the exception. The reason has often been debated, but it must presumably be related to different pre- and postnatal environmental influences, as the germ plasma is identical. Horowitz et al,²³ in their original study of adult twins, found that "highly significant variations occur in anterior cranial base, mandibular body length, total face height, and lower face height." This is particularly interesting, as these measurements are closely associated with the direction of facial growth and also with both malocclusion and unattractive faces, suggesting that the differences between the twins is due to contrasting horizontal or vertical growth. If the germ plasma is identical, then this variation is probably environmental rather than genetic.

This concept is supported by Lobb,²² who found that in twins "the greatest variation in each group was in the spatial arrangement of the component parts of the craniofacial complex rather than within these components." Björk et al,²⁴ using implants, had come to the same conclusion several years previously, and the 'tropic premise'^{25,26} upon which orthotropic treatment is based suggests that there is fairly strict genetic control of skeletal form but that the actual direction of growth of the facial components is open to a range of postural influences, especially motor tone and tongue position, which could account for the initial differences between the twins.

There is evidence to suggest that Biobloc appliances, which are based on the "tropic premise," are able to increase the horizontal component of growth more effectively than some other appliances,²⁷ and this might explain the subsequent

changes in facial form. The author knows of no other technique that places such emphasis on the correction of oral posture, and this may be why these results appear different from previous findings.

Selection. This is one of the greatest risks in clinical research. These 6 pairs were the only ones available to the author; all but 1 were selected before treatment commenced and all were included in the final analysis, which would have prevented any selection on the basis of results.

Undoubtedly, the malocclusions in some twins were more severe than in others. However, as stated earlier, it would appear that the worst occlusions and least attractive faces fell into the orthotropic group, which ultimately showed the best results.

This raises a secondary issue. For obvious reasons, there is a greater opportunity for improving an unattractive face than an attractive one, and this may partly explain why the twins treated with orthotropics achieved a relative improvement. However, this alone cannot explain why the traditionally treated twins were considered less attractive after treatment than before.

One pair (patients Q and B) commenced treatment at different ages, 8 and 11 years of age, respectively, because B had a less obvious malocclusion. It could be argued that this damaged the comparison, but it would have been equally valueless to enforce an age restriction on clinicians who prefer to treat at different ages.

Clinical standards. Two of the 3 "traditional" clinicians had international reputations and were fully aware of the competitive nature of the research. The orthotropic cases were all treated by the same experienced clinician.

Twin Studies

The overwhelming advantage of using identical twins in research projects is that all contrasts in skeletal growth, beyond the error of measurement, can be assumed to be nongenetic and therefore the result of either pre- or postnatal environmental influences. It seems prob-

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able that the most powerful oral environmental influence during the period of this study was the treatment itself. Aware that this study required special analysis, the author took advice from a number of leading statistical authorities, but found that there appears to be no existing statistical analysis for significance in this situation. Student *t* test is clearly inappropriate, as identical twins render it unnecessary to use large numbers of patients to overcome the genetic variability; it seems equally inappropriate to use paired observation *t* tests.

Some will see this article as no more than 12 individual case reports and reject it on the grounds of its small sample size. However, readers are here studying the physiologic response to the application of oral forces over a relatively short period in an otherwise constant environment. The additional elimination of genetic variables would seem to raise these comparisons close to the experimental ideal and considerably above clinical comparisons between unrelated individuals living in different environments. Indeed, each individual pair of twins provides a clear example of environmental influence unaffected by genetic variance.

Facial changes

It is interesting to speculate why some faces improved and some did not. Horizontally growing faces are known to be better looking and have less long-term crowding,^{7,28} and this might also account for the greater stability of the orthotropic cases.

This would seem to be the first time that a series of identical twins has been used to compare long-term changes in facial appearance following different types of orthodontic treatment. Faces normally mature in different ways, rendering longitudinal comparisons difficult. Twins provide a visual control as to how the face might have looked, had no treatment or different treatment been provided; indeed, twins may be the only population within which long-term changes in facial appearance can be monitored and compared.

Dentists want to create straight teeth, and over the last 100 years fixed appli-

ances have been perfected to this aim. The time has now come to look at a wider horizon. It is known that fixed appliances tend to increase vertical growth and that this can be associated with less attractive faces and recurrent crowding. Many orthodontists might be worried about trying to align teeth without fixed appliances, but the teeth of individuals with good oral posture and forward growth align themselves naturally. So should we consider other options?

CONCLUSIONS

It would be inappropriate to draw too many general conclusions from such a small sample, but the contrasts are so powerful that, in the absence of genetic variables, it might reasonably be concluded that: (1) traditional fixed appliance techniques used in this study appeared to damage the appearance of these faces and further research is required to establish if current methods are avoiding this; (2) use of orthotropic treatment with postural training, but avoiding fixed appliances, was able in these cases to provide permanent alignment of the teeth and to improve the appearance of the face without extractions, despite the initial dental crowding; (3) traditional fixed appliances appear more prone to relapse than orthotropics without fixed appliances.

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