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ORIGINAL ARTICLES

Suggestions for forecasting and monitoring facial growth

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If facial improvement is to be an objective of orthodontic treatment, it is first necessary to define good looks. For various reasons this has been a neglected field of research. This article draws on both previous and new research to define the basis of attractiveness, and then describes methods by which these features can be indexed. The use of such measurements is recommended for forecasting growth, and for monitoring it before, during, and after treatment. (AM J ORTHOD DENTOFAC ORTHOP 1993;104:105-20.)

Facial beauty is arguably the most powerful generator of human emotion. In addition to serving the obvious function of attracting the sexes to each other, it has also served to inspire great works of art, prompt sadistic acts, initiate ferocious wars, and reputedly launch 1000 ships.

It might be expected that beautiful faces would display some common features, but in reality, acknowledged beauties are often as different from each other as they are from the rest of us (Fig. 1). It would seem that we differ in our individual preferences, and it is widely accepted that "Beauty is in the eye of the beholder." This might explain why certain faces are popular in one decade and yet unfashionable in another. Peck and Peck[1] state "television, motion pictures, newspapers, and magazines all provide daily reinforcement for facial stereotype." Current fashion, as judged by dress mannikins (Fig. 2) depicts a thin face with a prominent chin.

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Appearance is important throughout the animal kingdom. In some species, minor differences in coloring, either natural or applied, may result in an animal becoming ostracized from its group. It would appear that animals have evolved to find the features they share in common with their own species attractive, and any differences unattractive. We, of course, are also animals; could it be that we are also preprogrammed to find certain patterns of facial appearance attractive?

An answer to this question may be found in a fascinating piece of research carried out by Samuels and Elwy.[2] Seeking to discover at what age young children could first appreciate facial esthetics, they took a sample of 35 6-month-old babies and placed them separately in front of two back projection screens. They then showed a selection of "attractive" faces on one screen, and a balanced group of "unattractive" faces at random on the other. The period that each child looked at the screens was timed. It is rare to find particularly significant results in this type of research, but on this occasion every one of the attractive faces received more attention than the unattractive faces. To establish the lower age limit, they repeated the experiment with 3-month-old babies, surprisingly the results were similar. This must suggest that we, like other animals, are preprogrammed

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Fig. 1. Final line up for Miss World 1985. The winner was the fourth from the left, Miss Hofi Karisdottir of Iceland. [By kind permission of *The Daily Mail.*]

Fig. 2. A modern dress dummy with a pointed face, and apparently a tendancy to Class III occlusion.

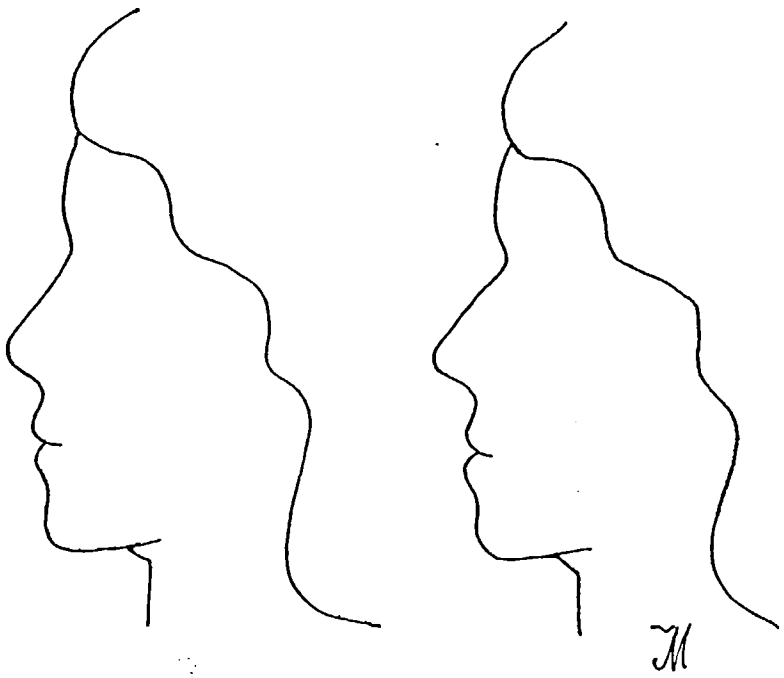


Fig. 3. Two constructed faces that differ by no more than a millimeter at any point on a life size scale, although hair line differs by several millimeters.

to find specific patterns of facial appearance attractive. Unattractiveness, on the other hand seems to be associated with a departure from that norm.

Of special interest are sex differences. Viewed analytically, all that distinguishes the facial shape of men from women is a few millimeters around the chin, lips, and cheeks. The differences between teenagers are even less, and yet they are sufficient to generate quite contrasting emotional responses. The difference between the two facial outlines in Fig. 3 is no more than 1 mm at any point on a life-size scale, but to our eye the contrast is quite obvious. The hairlines in the same illustration vary to a greater extent but are less apparent.

It seems that the human eye has a unique ability to detect small differences in facial form to an extent that all 4 billion people in this world could probably be recognized as different from each other. We probably see a person's hands as often as we do their faces, and yet we might find it difficult to recognize individual hands, even of our own family. Since the early work of Illiffe,[3] where readers of a newspaper placed faces in order of rank, it has been known that the general public is in close agreement about who is and who is not attractive, and subsequent work[4] has shown that this agreement runs across social, cultural, and even racial barriers. Many people find this difficult to accept because their personal preferences may differ from their friends and colleagues, and this aspect is discussed further in this article.

SOCIAL IMPACT OF FACIAL APPEARANCE

Almost without being aware of it, we judge new acquaintances by their facial appearance. Persons who are facially attractive are likely to be perceived as more intelligent, successful, and honest. However, these perceptions may well be false, as there is almost no evidence to show that valid personality judgements can be made on the basis of facial appearance, although one such study, found a significant difference between the personalities of persons with either long or short faces.[5]

FACIAL RESEARCH

In view of the apparent importance of facial appearance, it is a surprisingly poorly researched field, and most of the worthwhile material is relatively recent. There could be several reasons for this, as Cunningham[7] suggested "The pseudosciences of phrenology, and physiognomy may have made measuring the face seem disreputable to some scientists." Berscheid[6] believes "our collective reluctance to acknowledge the true impact of physical appearance has affected research." This taboo is illustrated by the contrasting impact of statements, such as "your daughter has irregular teeth," and "your daughter has an ugly face." However, develop-

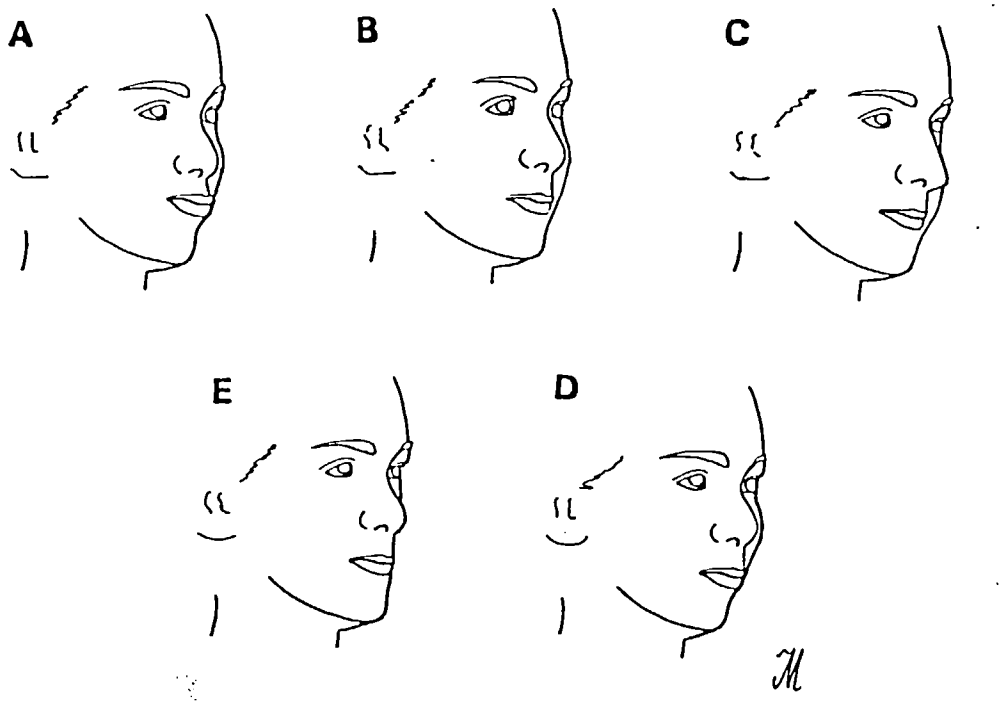


Fig. 4. Five faces each differing in one feature from an imaginary norm.

ments in facial surgery and facial orthotropics (growth guidance) may change future attitudes.

The only scientific means of measuring a subjective quality, such as facial beauty, is by means of a panel of judges. Where possible, details of hair, skin texture, and color should be disguised or removed. Much of the previous research in this field has been based on a series of line drawings, each of which differed by a set amount, so that mean preferences could be established. This has often resulted in unlifelike representations. Psychologists have tended to use full face views, whereas surgeons and orthodontists have relied largely on lateral views, neither of which adequately show the fullness of the cheek. It would seem that there is some logic to using three quarter profile line drawings taken from live subjects, if possible.[8]

I recently undertook some research on this aspect. Drawings of five faces (Fig. 4) were shown at random to 107 adults between the ages of 16 and 60 years. They were asked to decide (1) Which girl's face do you think is most attractive? and (2) Which girl's face do you think is second most attractive?

As can be seen, each face differs in only one respect. It may be thought that face E has a prominent chin, but in fact it is her cheeks that are flat. Because of this feature, her eyes are less appealing although they are, of course, the same shape as in the other drawings. The results showed that 74% thought face B most attractive, and 13% preferred face D. Face C was preferred by 8%; face A by 3%, and finally the girl with the flat cheeks, face E, was preferred by only 2%.

Of interest was the fact that there was little agreement as to who was second best, although all but four of those who did not place face B first placed it second. Face D was selected by 24% as second best; face C was selected by 23%; face B was selected by 19%; and faces A and E were each selected by 17%. Several conclusions can be drawn from this research.

1. The equal distribution of second preferences would suggest that the facial model is a fair one.
2. There is close agreement about which faces are considered most attractive, even though the differences were very small.
3. A change of a few millimeters in one feature is enough to alter the appeal of the rest of the face.
4. On the basis of this limited sample, it seems that flat cheeks do the most harm to a female face, followed by protrusive lips, large noses, and retruded chins, as least disadvantageous.
5. It would appear that although we agree when faces are very attractive, we tend to differ when it comes to the less attractive faces that populate the real world around us. This perhaps accounts for the variation of opinions held by the public at large, which gives rise to the belief that "beauty is in the eye of the beholder."

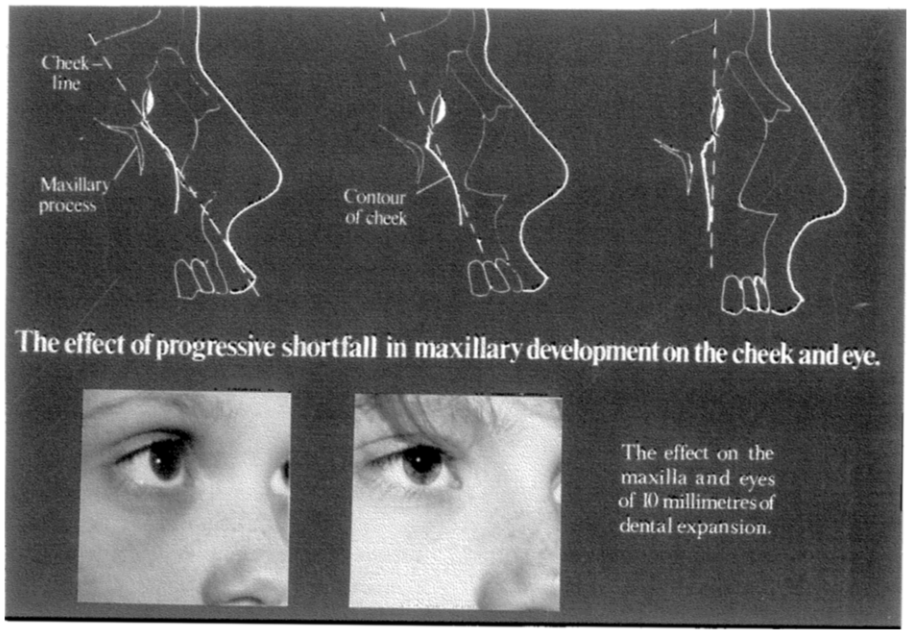


Fig. 5. Artist's drawing to illustrate effect of reduced maxillary size on contour of cheek and relative protrusion of eye.

DEFINING FACIAL ATTRACTIVENESS

If we are able to accept that appreciation of facial beauty is innate, then presumably it must depend on recognizable differences in our faces. If so, then in turn it should be possible to define and measure them. Research by Cross and Cross[4] and others has drawn attention to the importance of the eyes in facial attractiveness.

The eyeball itself appears to play little part in this, and it is a matter of direct observation that attractive eyes are associated with full cheek bones, and that flat cheeks by contrast provide less appeal. This is what the research with the five faces was able to confirm. The development of the maxilla may well play a role in these variations, (Fig. 5). It seems that the most pleasing form is for the line of the cheek to run forward from the lower eye lid parallel to the nose. It is interesting to note that babies naturally have this contour to their cheeks (Fig. 6), although in their case, it is due to their soft tissue contours, and it is obvious from the reaction of parents and other adults that chubby cheeks have a special appeal. In many species the young have special markings to protect them from adult competition, and such features may also be an important factor in the development of the parent-to-offspring bonding mechanism.

It is important to distinguish this type of fullness beneath the eye from the prominent cheek bones, as

Fig. 6. Newborn baby, showing appealing fullness of her cheeks.

Fig. 7. Patient who suffered from sleep apnea. Note the flat cheeks, receding chin, and prominent nose.

seen in many oriental faces, which are related to the zygomatic bone, and may still be accompanied with unattractively flat faces if the maxilla is small. It is equally important to distinguish the fullness immediately below the eye from the occasional hypertrophy of the buccinator and orbicularis (Fig. 15), which will be discussed later. As can be seen in Fig. 5, an undersized maxilla will leave the eye looking exophthalmic, a common occurrence in persons with flat faces.

Anatomically, the paired nasal bones are attached to the frontal bone, with the cartilaginous septum lying between them and the maxilla. It would seem that if, for any reason during growth, the dental skeleton fails to keep pace with the advancing frontal bone, the septum tends to hinge downward leaving a bump at the lower end of the nasal bones. Robinson[9] found that large noses "are associated with retrusive (Class II) mandibles." Not only may good development of the maxilla provide a fullness beneath the eye, but the lack of it may lead to a relative protrusion of the eyeball and nose (Fig. 5). Thus, the maxilla would seem to play a major role in facial appearance.

Research has constantly shown attractive faces are more prognathic than average[1] and faces that grow downwards are less attractive.[10] Downward growing faces are in turn associated with undersized maxillas and retrusive mandibles (Fig. 7). In contrast, forward movement of the maxilla achieved by surgery produces a dramatic improvement of appearance (Fig. 8). Lack of forward growth has been claimed to restrict the pharyngeal airway that may cause the head to be tilted back to restore patency.[11] This can also give the appearance of a sloping forehead and prominent nose, as is seen in Fig. 9, where Fig. 7 has been superimposed on a good looking face (Fig. 3) at soft tissue nasion and along the forehead. Cartoonists seem to be aware of the importance of forward maxillary development (Fig. 10), even if they ignore anatomic reality.

MEASURING FACIAL ATTRACTIVENESS

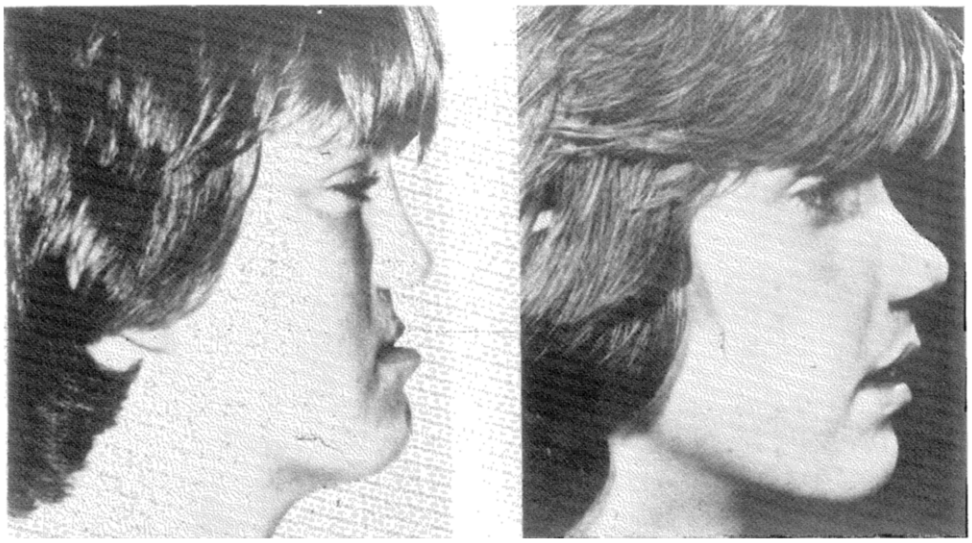
The face is difficult to measure. Its appearance is partly dependent on the shape of the soft tissues, and these are highly mobile. Photographs taken on different occasions are not easy to match, and minor differences of expression or lighting can alter appearance substantially. Robertson,[12] Rabey,[13] Powell and Rayson,[8] Burke,[14] and Moss et al.[15] have all described various techniques of assessment. The photographs for this article were taken with the patient sitting upright, looking at a line level with their eye, from a distance of 18 feet through a telephoto lense to reduce parallax.

The only reliable means of assessing beauty seems to be by the subjective opinion of a panel of judges referred to previously. However, this can hardly be used by the busy clinician, who needs a more convenient means of assessing facial problems and monitoring their correction.

Several authorities have proposed measurements intended to relate good aesthetics with the facial skeleton and soft tissues. Downs[16] was among the first in the 1930s to make use of Broadbent's lateral skull radiographs. Subsequently, Steiner,[17] Sassouni,[18] Bimler,[19] Ricketts,[20] MacNamara,[21] Bowbeer,[22] and many others have suggested various degrees of prognathism as being ideal. Unfortunately, these techniques are often less suitable for measuring downward growth. Fig. 9 shows how unusual faces tend to grow down and back. Such contrasts can be measured at the variously titled "cranial base," "facial," or "saddle," angle between sella-nasion and sella-basion. Houston[23] showed many years ago that this angle is increased in cases where the mandible is set back. Kerr and Hurst[24] have shown that the cranial base angle is "an accurate predictor (of normal or post normal growth) in approximately 73% of cases." Normally, any shortfall in facial growth runs diagonally to the horizontal and vertical planes. Rather than using a series of coordinates taken from both planes, it is more helpful to use a single coordinate set at about 45° to the vertical, which can measure the combined downward and backward vector of growth.

THE INDICATOR LINE

The indicator line uses this diagonal coordinate by measuring from the tip of the nose to the tip of the upper left central incisor (Fig. 11). The tip of the nose is defined as the furthest point from the tragus of the ear. It is suggested that at puberty this measurement should be approximately 36 mm for a girl and 38 mm for a boy, but it is usually higher than this. A random sample of 17 12-year-old British schoolboys averaged 43.8 mm, whereas 54 matching girls averaged 41.5 mm. For a sample of adults with SN mandibular angles



A facial improvement achieved by surgical forward movement of the maxilla .
(James and Brook 1985)

Fig. 8. Effect of surgical advancement of maxilla (James RJ, Brook K. Eur J Orthod 1985;7:231-47).

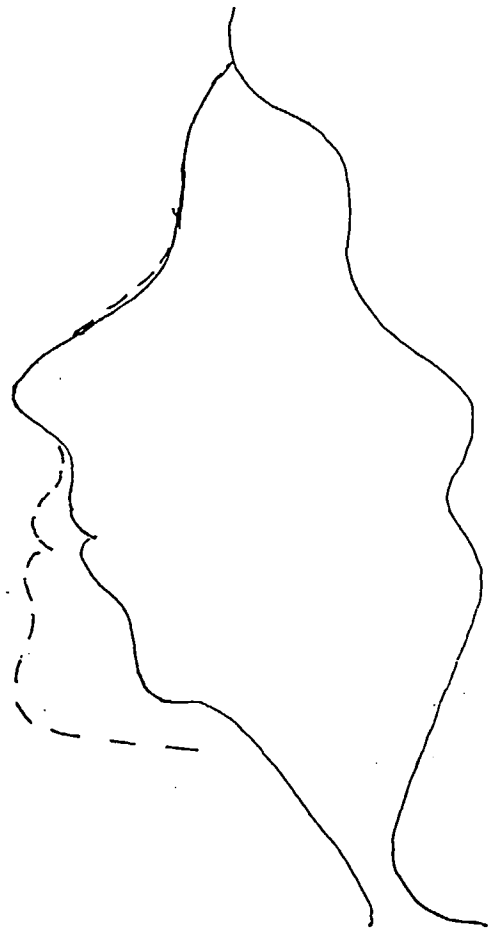


Fig. 9. Superimposition of Fig. 7 on a good-looking face (Fig. 3).

Fig. 10. Cartoonist's thoughts on good looks. ('Barbie' 'C' Mattel Inc. All rights reserved.)

of over 35°, it averaged 45 mm for both sexes. For a similar sample with angles under 30°, the average was 42 mm.

Between 5 years of age and puberty, it seems to increase by about 1 mm a year. Subsequently, it appears to increase for an irregular period,[25] but there is insufficient longitudinal material available to assess this. As has been discussed, the increase in the indicator line seems to relate more to relative fallback of the maxilla

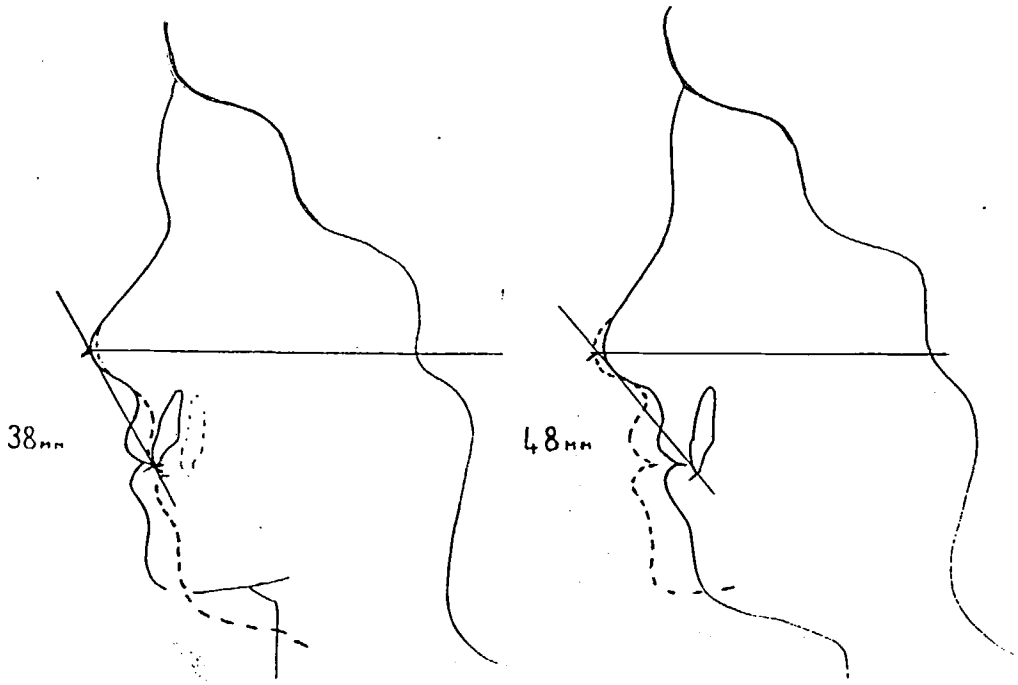


Fig. 11. Indicator line, measured from the tip of the upper left central incisor to the tip of the nose. (Farthest point from tragus of ear.)

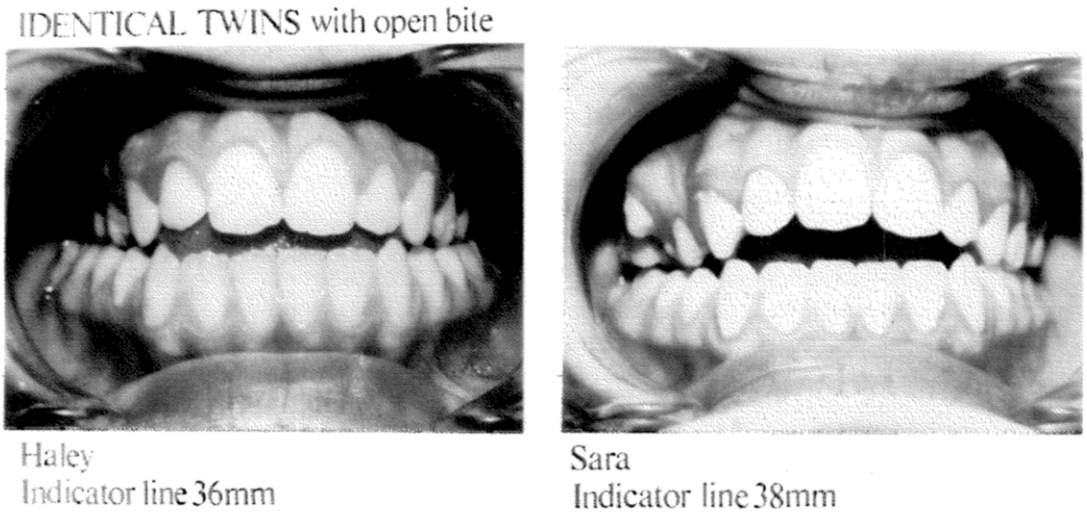


Fig. 12. Identical twin sisters with anterior open bites (AOB). Hāley who had an AOB of 2 mm had an indicator line of 36 mm, and Sara who has an AOB of 4 mm had an indicator line of 38 mm. This would suggest that AOBs are associated with downward growth and over eruption.

and incisors than to the growth of the nose. The indicator line can also be read from lateral x-ray film, but about an 8% reduction in the reading allows for enlargement.

For Class I patients with ideal occlusions the indicator line appears to vary no more with overall size than the distance S-N,[26] and an increase of 5 mm signifies an obvious change in the direction of growth. An

increase of 10 mm, which is not uncommon, would be accompanied by frank malocclusion and a markedly disproportionate face.

Although no more than an indication, the indicator line can prove very helpful both in assessing downward growth and establishing clinical objectives. For instance, it suggests that most anterior open bites involve overeruption of the buccal segments rather than reduced eruption of the anterior teeth (Fig. 12), whereas many deep bites are shown to be related to downward movement of the upper incisors rather than overeruption of the lower incisors. On the same basis, bimaxillary protrusions seem to involve dental proclination, accompanied by downward maxillary displacement.[26]

THE CHEEK LINE

As mentioned previously, undersized maxillae are associated with flat cheeks. This can be assessed by marking the skin 1 cm below the center of the lower eyelid in the sagittal plane. The line between these points is called the *cheek line* (Fig. 5), and ideally should run parallel to the surface of the upper third of the nose, but more normally it forms an angle of between 20° and 40°. It is usually measured directly from the face, but can be read from a lateral photograph if the marker is clear enough. Unlike the indicator line, it can not be measured from x-ray film. With small maxillae and flat cheeks, it will fall almost vertically, and not infrequently the lower eyelid will lie in front of the cheek, giving an unattractive exophthalmic appearance (Fig. 5).

THE LOWER INDICATOR LINE

Although the indicator and cheek lines can provide useful clinical and esthetic information about the maxilla, facial appearance is also dependent on the shape and the position of the mandible. There are fewer variables here and, provided that the incisors occlude correctly, it only requires that they are correctly related to the chin to ensure a nicely proportioned lower face. A third line is used to assess this. The lower indicator line measures the distance from the tip of the lower left central incisor to the pogonion, for this purpose the point on the chin farthest from the tragus when the mentalis is relaxed (Fig. 13). It is suggested that this should measure about 2 mm less than the upper indicator line. Like the upper line, it relates well with facial esthetics, and Talass[27] has shown that it is a good predictor of additional lower lip lengthening if retractive orthodontics are prescribed.

Measurements taken from the indicator line, the cheek line, and the lower indicator line will give a reasonable indication of the appeal of the facial skeleton, and apart from skin texture and condition, there remains only the need for an assessment of the soft tissues around the mouth. This will be considered after the next section.

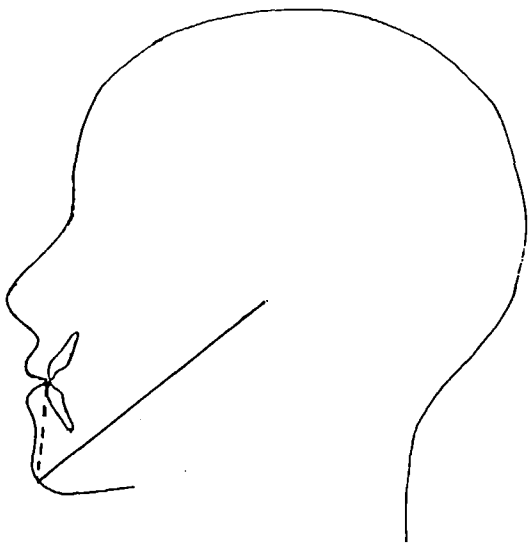


Fig. 13. Lower indicator line, measured from tip of lower left central to pogonion. (Farthest point from tragus of ear.)

FORECASTING FACIAL GROWTH

Forward growing faces are often referred to as "low angle" cases, and downward growing as "high angle" because of the difference in the mandibular angle. Low angle cases generally have more facial appeal than high angle, and the cheek line tends to run more parallel with the nose, although the indicator line may be increased if there is a deep bite. Although downward growers may look attractive while in the deciduous dentition, "growing up" can be associated with some unflattering developments (Fig. 14). Obviously, it would be of considerable value if such changes could be anticipated.

Although patterns of growth once established are usually maintained, Bjork[28] found that they do occasionally change. Kerr and Hirst,[24] found that between the ages of 5 and 15 years, 17% of postnormal cases became more normal, and 9% of normal cases became postnormal. Although computer forecasts based on lateral x-ray films prove very accurate on average, individual forecasts are often less so. As Hixon and Klein[29] suggested as long ago as 1972, "The most significant finding of the last two decades has been the lack of meaningful relationship between any cephalometric measure and future growth."

Fig. 14. Change in facial form of a 6-year-old girl with a high indicator line, who received no treatment.

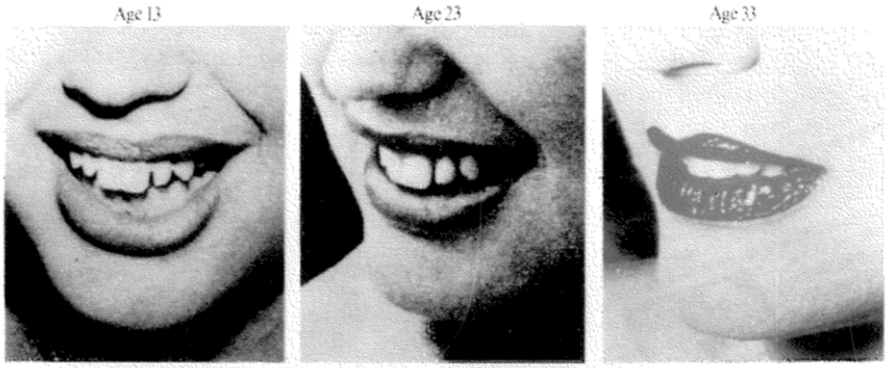


Fig. 15. Change in lip form after improved lip seal.

It is difficult to visually assess the facial skeleton of children under 5 years old because of their subcutaneous fat (Fig. 6). In this situation, the indicator line can prove helpful in forecasting their future pattern of growth. My research[25] would suggest that whenever the face is growing downwards, the indicator line will be increased, and vice versa. However, there is insufficient longitudinal material to establish how often this pattern may be reversed by treatment. The indicator line of the girl in Fig. 14 was 11 mm more than recommended for the age of 6 years, and increased by another 4 mm by the age of 9 years. Experience indicates that any child with an indicator line increased to this extent would follow the same pattern of downward growth.

SOFT TISSUE FORM

The remaining facial variable, and esthetically one of the most importance, is the soft tissue around the mouth. Because the lips are supported largely by muscle, lip form is closely related to lip function. This has been the subject of previous articles[11,30,31] where it was suggested that "The most satisfactory contours are associated with a gentle but constant lipseal maintained at rest and during swallowing" (Fig. 15). It was also

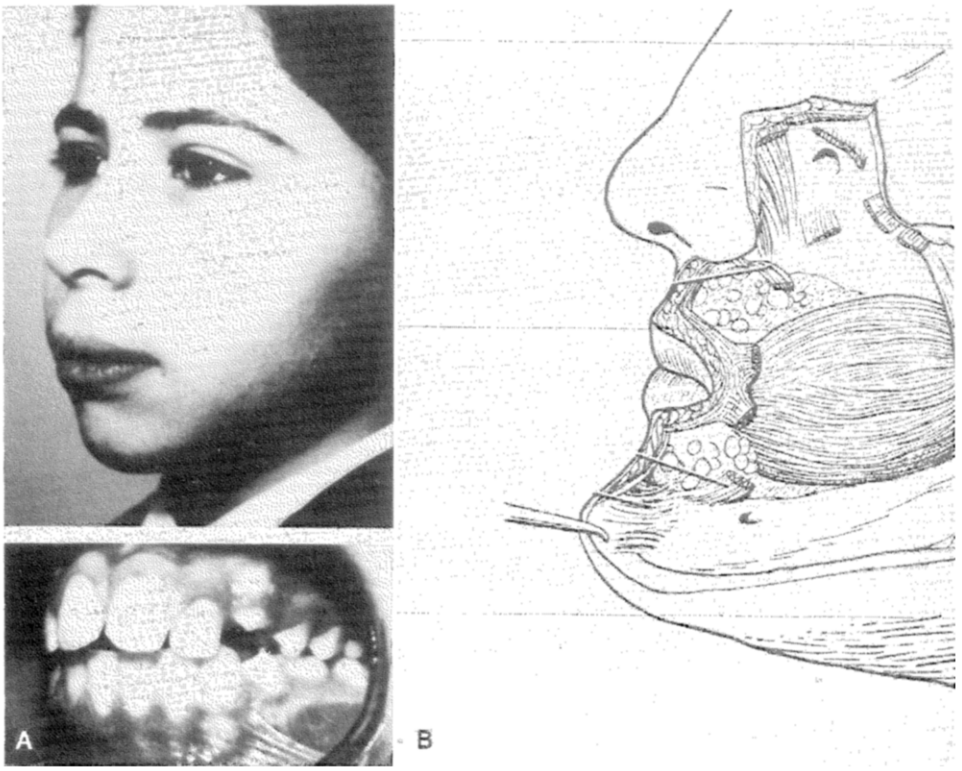


Fig. 16. Facial form and dentition of a girl who postured her tongue between her teeth and contracted buccinator and obicularis strongly when swallowing. The outline of the buccinator and obicularis Oris. (From Sicher, Oral Anatomy, Mosby, 1949.)

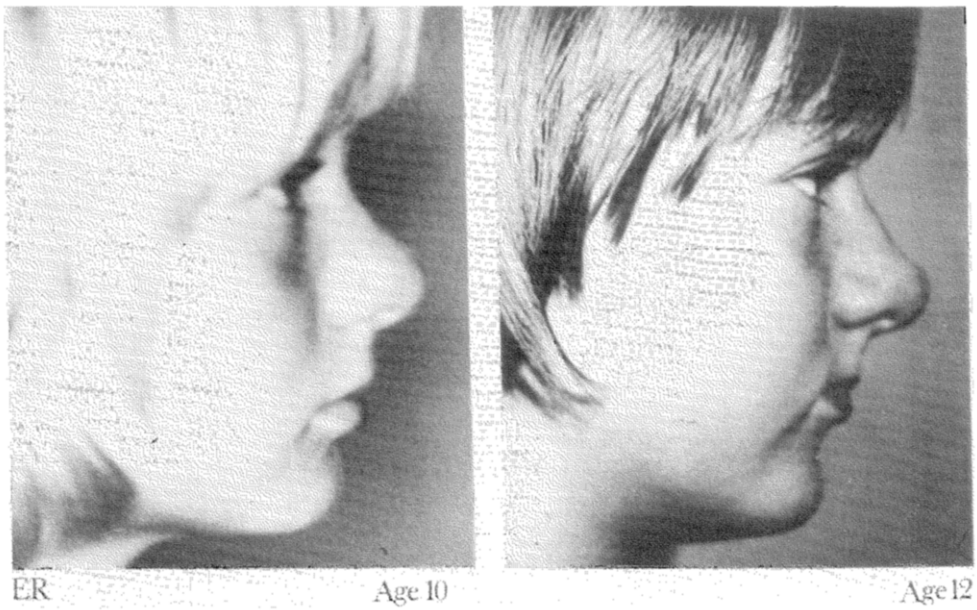


Fig. 17. Change in facial form of a girl with a high indicator line who was inappropriately treated by incisor retraction. (From Mew JRC. Funct Orthod 1987;4:37-43.)

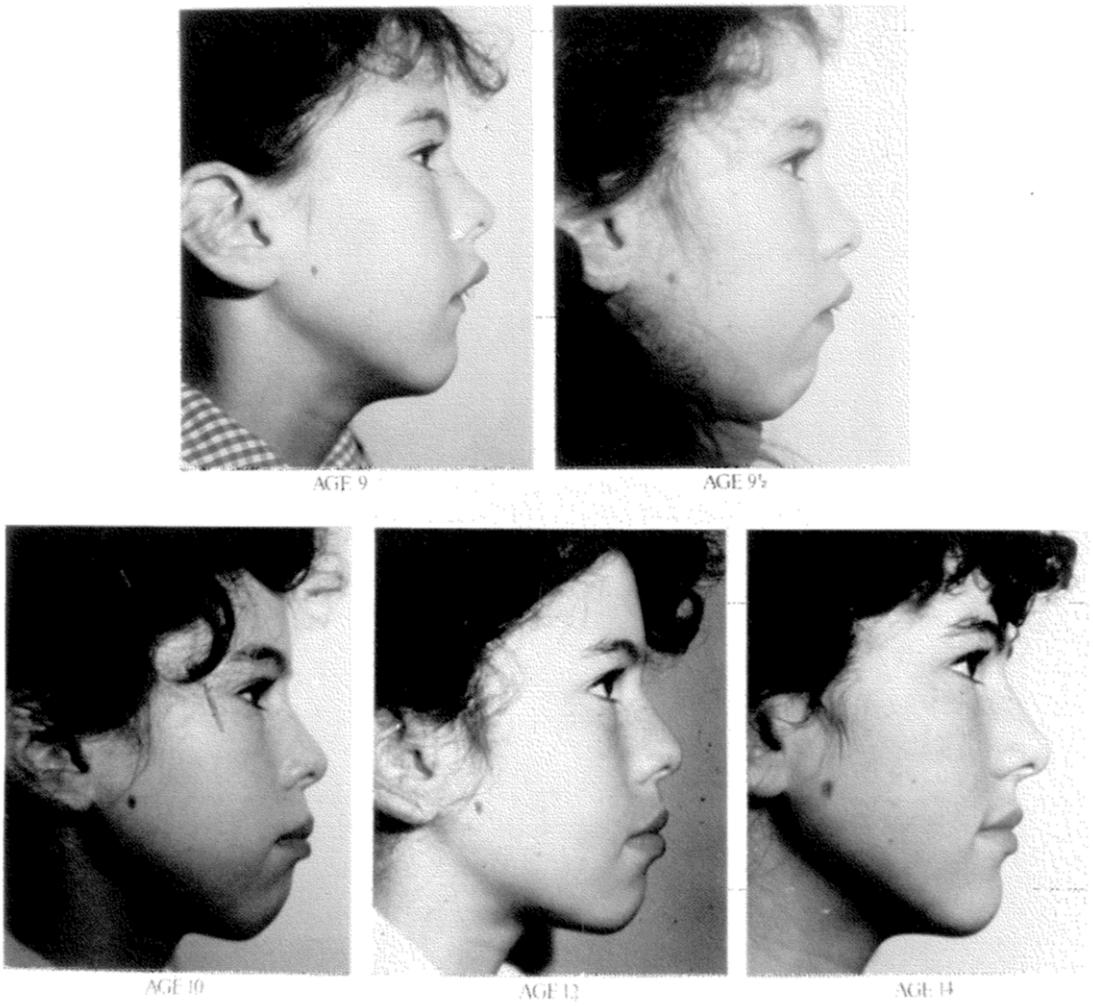


Fig. 18. Change in lip form of girl in Fig. 14, which took place between ages of 9 and 14 years achieved by encouraging forward growth and postural training.

hypothesized that lack of a resting lip seal necessitates intermittent contraction of the mentalis that raises the lip line and protrudes the lower lip in front of the upper. If the perioral musculature is overexercised, it hypertrophies as can be seen in Fig. 16, where the outline of the underlying orbicularis and buccinator (which is recruited to stabilize it) stands out. A natural hollow in the cheeks along the line of the occlusion is an important feature of very good-looking faces: Hypertrophy in this region is always to the disadvantage of the face, and is associated with a tongue-between-teeth posture. This combination frequently develops if tongue space is reduced during retractive orthodontics (Fig. 17). On the other hand, an improvement in posture, and function, can reduce these muscle bulges, and Fig. 18 illustrates the same girl as Fig. 14, after growth guidance therapy and myotherapy.

THE ETIOLOGY OF FACIAL CHANGE

For centuries it has been considered that the shape of the face is inherited. However, it is difficult to explain on this basis how there can be the occasional changes in the direction of facial growth just discussed, especially as they affect attractiveness so strongly, for better or worse. It has been suggested that posture may influence the direction of facial growth.[25,32] There seems to be clear evidence that patients who keep their mouths open have longer faces.[32,33] However it cannot be assumed that an open mouth posture will cause downward growth, because it can just as easily be argued that a child with a long face would find it more difficult to achieve a lip seal. On the other hand, it is not as easy to explain why a skeleton under genetic control should unpredictably change its growth direction. It is perhaps easier to imagine, and even observe, spontaneous

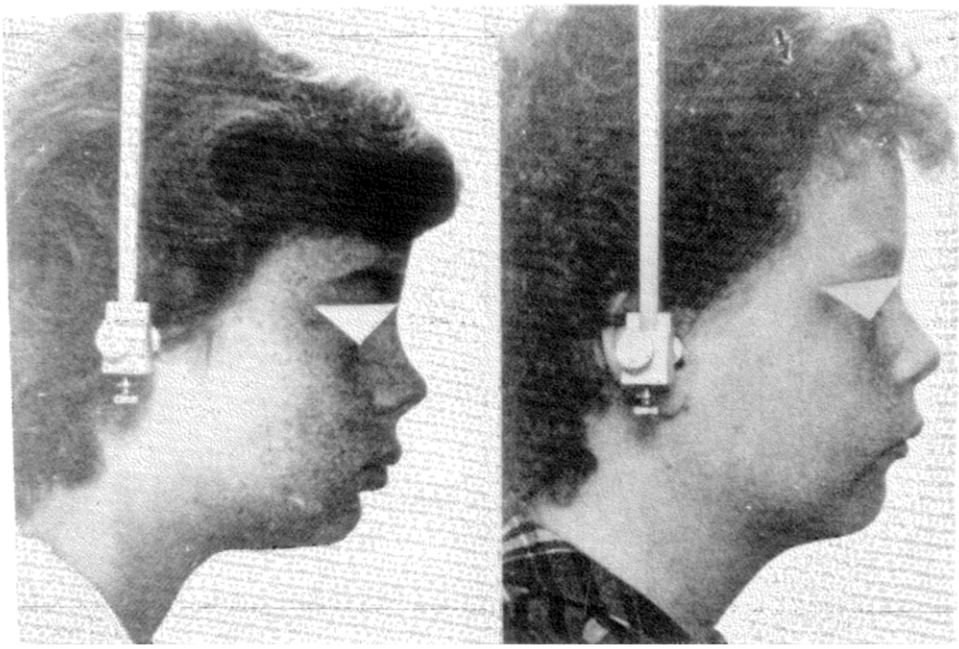


Fig. 19. 'Desirable facial change' of a girl, who had high-pull headgear to correct deep overbite. (From Barton JJ. Am J Orthod 1972;62:517-29.)

Fig. 20. Facial lengthening associated with treatment using functional appliances. (From Ahlin. Funct Orthod 1985;2:31-5.)

changes in a child's oral posture, especially around puberty, when both changes are most frequent.

INDUCED FACIAL CHANGE

If the direction of facial growth varies, for whatever reason, then it must be an open possibility that the vector could be influenced. Many patients with malocclusion have unattractive faces, but it is a mistake to assume that aligning the teeth will improve the face. In fact, there is a wealth of research to show that some types of orthodontic treatment tend to lengthen the face. This can at times harm facial appearance[10] especially

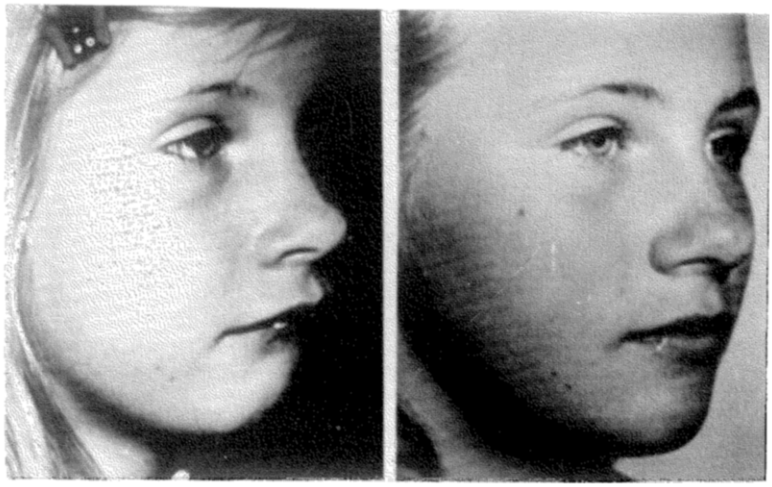


Fig. 21. Facial changes after orthotropic treatment. (From Mew JRC. Funct Orthod 1987;4:37-43.)

Fig. 22. Facial changes after orthotropic treatment.

if it is associated with lengthening of the lower lip[27] (Fig. 17). Although this patient had an increased indicator line, she was unwisely treated by extracting first premolars following which the incisors were retracted. Note how her cheek line has flattened, while at the same time she has developed a tongue-between-teeth posture, with Buccinator bulge, and a lengthened lower lip.

Some appliance systems which aim to "control the vertical" may in fact achieve dental correction at the expense of facial lengthening, by encouraging eruption of the lower molars (Fig. 19). Frankel appliances are amongst the few that seem able to avoid this, and of course they are known to have an influence on muscle posture. While Functional appliances are often prescribed to improve facial aesthetics, they also are not without risk, as the advantage of forward growth may be outweighed by the disadvantage of facial lengthening (Fig. 20). Facial lengthening may occasionally be helpful in low angle cases, but can sometimes be difficult to avoid in those high angle cases where it is least required.

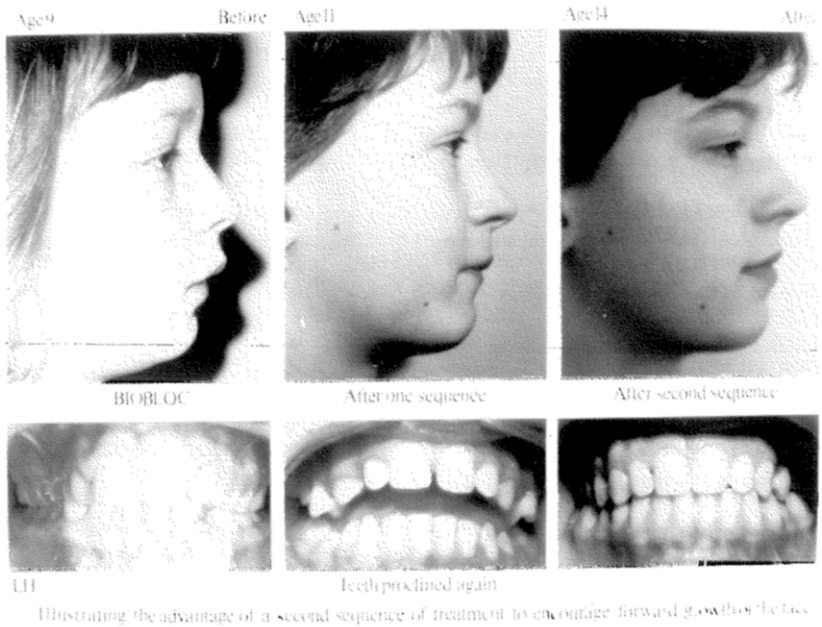


Fig. 23. Forward growth is facilitated by first proclaiming incisors to reduce indicator line.

There is an increasing interest in influencing growth (Orthotropics) while the patient is young (Figs. 20 and 21). This may be in preference to moving the teeth (Orthodontics), or the bone (Orthopaedics). As the skeleton is half grown at 3 years of age, and probably more than three quarters grown by 8 years, orthotropics is normally recommended before the age of 9 years, and in severe cases before 6 years. An improvement in the direction of growth can provide subtle benefits to the face as a whole and the eyes in particular (Figs. 21, 22, and 23).

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