European Journal of Orthodontics 29 (2007) i102–i106
doi:10.1093/ejo/cjl100

© European Orthodontic Society. Published by Oxford University Press on behalf of the European Orthodontic Society.

Effect of cervical anchorage studied by the implant method

Birte Melsen and Hans Enemark
Aarhus, Denmark

(Transactions of the European Orthodontic Society 1969 pp. 435–444)

SUMMARY Two groups each of 10 patients with distal molar relation, identical as regards dental stage, were treated, with the Kloehn headgear only, for eight months. As related to the occlusal plane, the extraoral arch of the headgear was tilted 20 degrees upwards in one group, and 20 degrees downwards in the other. By the implant method, it is possible to distinguish between growth changes and intramaxillary tooth movements. The local influence on the tipping, mesiodistal change in position and extrusion of the first upper molar was measured, and facial growth pattern recorded.

In the group with upward tilt of the extraoral arch, only slight tooth movements occurred, but the entire maxillary complex shifted backwards and downwards in relation to the anterior cranial base during the period of treatment, resulting in an approach to normal molar relationships. In the group with downward tilt of the extraoral arch, greater intramaxillary tooth movements were measured; in particular, a distal tipping of the first molar occurred. In these patients no influence on the maxillary complex could be measured during the period of treatment.

Introduction

Extraoral anchorage was revived as an important method for the establishment of normal molar relations following the works of Oppenheim (1936) and Kloehn (1947). However, on the basis of cephalometric studies, the interpretation of the results obtained varied widely.

Both intramaxillary tooth movement (Epstein, 1948; Newcomb, 1955) and the effect on the entire alveolar process with ensuing reduction of alveolar prognathism (Kloehn, 1947; Nelson, 1953; Graber, 1955; King, 1957; Blueher, 1959) were ascribed to the extraoral force. Klein (1959), Ricketts (1960) and Poulton (1967) claimed that the entire maxillary complex moved downwards and backwards by the pull of the headgear. Finally, it has been pointed out that it should be possible to change the growth pattern by a counterclockwise tilting of the spheno-ethmoidal plane after 3 to 4 years' treatment with headgear (Wieslander, 1963).

That the type of headgear as well as the force applied and the direction of the pull may influence the result has been emphasised by Closson (1950), Gould (1957), Parker (1958), Poulton (1959), and others.

Owing to the lack of reliable reference structures in the maxilla it is difficult to assess the effect of the extraoral force applied. It is thus impossible to distinguish intramaxillary tooth movements from changes in the alveolar process and shifts of the entire maxillary complex.

However, by using implants in the maxilla as reference points, it is possible to measure with great accuracy the tooth movements which occur in the maxilla, and to distinguish these movements from growth changes of the maxillary complex.

The purpose of the study presented here was firstly to clarify the effect of the application of the Kloehn headgear by means of the implant method, and secondly to find whether the tilt of the extraoral bow in the horizontal plane exerts any influence on this effect.

Clinic material

The series studied consisted of 20 children (12 boys and 8 girls) in the late mixed dentition, DS 2 and 3 (Björk *et al.*, 1964) with a distal molar relation of from half to one premolar-width, harmonious lower jaw, and without extreme deviations in overjet and overbite. The children were carefully selected on the basis of willingness and ability to co-operate, as they were required to wear the headgear for exactly 12 hours daily. In order to check this the patients were given a time chart which was to be filled in every day. The period of observation was 8 months in all cases, and no other form of orthodontic appliance was used during that period.

Method of investigation

The patients were randomly divided into two groups, each consisting of 10 children. Group I consisted of 3 girls and 7 boys, Group II of 5 girls and 5 boys. Skeletal age was determined from radiographs of the left hand as described by Tanner and Whitehouse (1969); this method revealed no difference between the two groups. The average skeletal age of Group I was 9.7 years, ranging from 8.1 to 10.3, and of Group II, 9.6 years, ranging from 8.4 to 10.4. The sex distribution of the two groups was disregarded as no difference has been shown in the growth intensity of boys and girls in the age group concerned (Tanner, 1964).

In Group I, the Kloehn headgear was applied with the extraoral bow tilted 20 degrees upwards in relation to the inner arch, which was placed parallel to the occlusal plane. In Group II, the extraoral bow was tilted 20 degrees downwards in relation to the occlusal plane. The angles were adjusted by means of a specially designed apparatus, and the adjustment was checked once every month. The force applied was 400 grams.

According to the Björk technique (1968) four implants were inserted into the maxilla of each patient – one below the anterior nasal spine, two into the infra-zygomatic crest on the right side and one on the left side. The left side implant was used as a control only.

With the patient placed in a cephalostat, profile radiographs were taken at the beginning of the experiment, and after the lapse of three and eight months, that is to say, at the end of the experiment. The mutual stability of the implants was checked on the three-month radiograph. The film-focus distance was 190 cm, and the distance from the mid-sagittal plane to the film was 10 cm. This gave an average magnification of 5.6 per cent, but this magnification was disregarded on the subsequent measurements. In the measurements the following reference points were used (Fig. 1).

By means of transparencies on which the contours of the first molar and its longitudinal axis were traced, the longitudinal axis of the first molar was transferred to the individual profile radiographs, and the measurements were then made direct on the films (Björk and Solow, 1964); the linear measurements to the nearest half millimetre and the angular measurements to the nearest half degree. All measurements were repeated after the lapse of a week, and the error of the method was calculated by the formula:

$$e = \sqrt{\frac{(x_1 - x_2)^2}{2N}}$$

Student's t-test did not reveal any systematic errors (Table 1).

In order to check the uniformity of the two groups, the profile radiographs taken at the beginning of the experiment were analysed by the method of Björk (1963), and the measurements obtained in the two groups were compared by means of Student's t-test. No significant differences between the two groups were revealed.

Results

The effect of the headgear used, as reflected by the changes which occurred in the individual variables during the period of treatment, is shown in Table 2. This table shows the average changes and the range of the individual variables for each of the two groups of patients.

The t-values expressing the differences between the means of the changes which occurred in the variables in the two groups are listed to the extreme right. Significant differences of 1 per cent and 5 per cent are indicated by one and two asterisks, respectively.

The evaluation of the growth of the maxillary complex was determined by superimposing the first and last profile radiographs on the anterior cranial base. The direction of growth was found by connecting the indicators on the first and last radiographs and measuring the angles which these lines formed with NSL. The growth intensity was expressed by the distance between the indicators on the first and last radiographs (Table 3 and Figure 2).

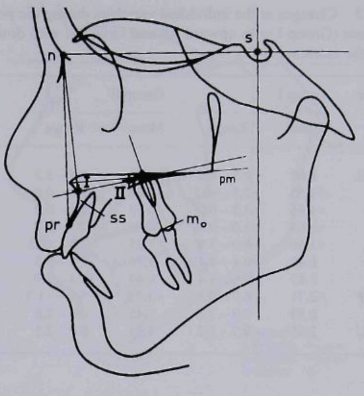

Figure 1 Reference points and lines.
n - Nasion, the most anterior point of the frontonasal suture.
s - Sella, the centre of the sella turcica.
ss - Subspinale, the most posterior point of the anterior contour of the upper alveolar arch.
pr - Prosthion, the most antero-inferior point of the upper alveolar margin,
pm - Pterygomaxillare, the intersection between the nasal floor and the posterior contour of the maxilla.
I - Implant inserted below the anterior nasal spine.
II - One of the implants inserted into the infrazygomatic crest on the right side,
m_0 - Intersection between the longitudinal axis of the first molar and the occlusal surface.
The reference lines were as follows:
mol - Longitudinal axis of the first molar through the trifurcation.
n-I - Line through nasion and the most posterior limit of implant I.
n-pr - Line through nasion and prosthion.
NL - Nasal line, line through the apex of the anterior nasal spine and pm.
IL - Implant line, the line through implants I and n.
NSL - Nasion-sella line, the line through n and s.
NSP - Nasion-sella perpendicular, a line at right angle to NSL through the sella.
I_0-I_8 - A line through implant I at the beginning of the experiment (II_0) and after 8 months (II_8) when superimposing the first and the last radiograph on the anterior cranial base.
II_0-II_8 - A line through implant II at the beginning of the experiment (II_0) and after 8 months (II_8) when superimposing the first and the last radiograph on the anterior cranial base.

Table 1 The error of the method, as checked by duplicate measurements on 10 radiographs.

Angular measurements		Linear measurements	
NSL/NL	0.59	m/-IL	0.78
s-n-pr	0.32	m/-NSP	0.82
s-n-ss	0.85	I-mol	0.70
s-n-I	0.69	I-m_0	0.69
Mol/IL	1.23	I_0-I_8	0.59
I_0-I_s/NSL	1.11	II_0-II_8	0.67
II_0-II_8/NSL	0.93		

Table 2 Changes in the individual variables during the period of treatment (Group I with upward tilt and Group II with downward tilt of the extraoral arch).

Variable	Group I		Group II		
	Mean	Range	Mean	Range	t
NSL/NL	1.60	0.5 – 4.0	0.63	÷0.5 – 3.5	1.85
s-n-pr	÷1.55	÷2.5 –÷0.5	÷0.80	÷2.0 – 0.0	2.67*
s-n-ss	÷1.45	÷3.0 – 0.0	÷0.75	÷2.5 – 0.0	1.64
s-n-I	÷1.63	÷3.0 – 0.0	÷0.80	÷2.5 – 0.0	2.44*
mol/IL	÷1.50	÷8.0 – 3.0	7.25	2.0 – 17.5	4.36**
I-m_0	1.48	÷0.4 – 4.1	3.75	1.4 – 5.5	3.72**
I-mol	1.45	0.6 – 3.4	0.49	÷1.4 – 1.9	2.28
m_0-NSP	÷2.71	÷6.7 – 0.5	÷3.75	÷5.6 – ÷1.7	1.34
M_0-IL	2.30	0.9 – 3.6	1.42	0.0 – 2.8	1.52
IL/NSL	2.05	0.3 – 3.2	1.25	0.0 – 2.5	1.90

Table 3 Growth direction and intensity of the maxillary complex.

Variable	Group I		Group II		
	Mean	Range	Mean	Range	t
Growth direction I/NSL	57.40	44.0–71.0	80.10	60.0–96.10	4.7**
Growth direction II/NSL	53.85	36.0–76.0	74.90	51.0–94.0	3.25**
Growth intensity I	2.62	1.2–3.8	1.56	0.4–3.1	2.78*
Growth intensity II	2.05	0.3–3.2	1.41	0.2–2.9	1.52

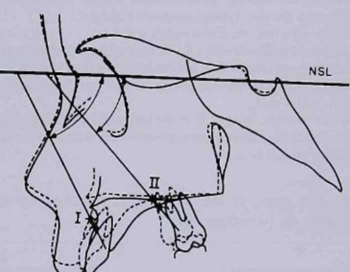

Figure 2 Growth direction and intensity of the maxillary complex analysed by the implant technique.

It is obvious that the intramaxillary distal movement of the first molar as manifested by the increase in the distance from I to the point m_0 on the occlusal surface of the first molar was significantly greater in the group of patients whose extraoral bow was tilted downwards. In all these patients, the first molar was at the same time tipped distally quite appreciably, as is indicated by the change in the angle m_0l/IL (7.25 degrees). In the group in which the extraoral bow was tilted upwards, this angle showed no significant

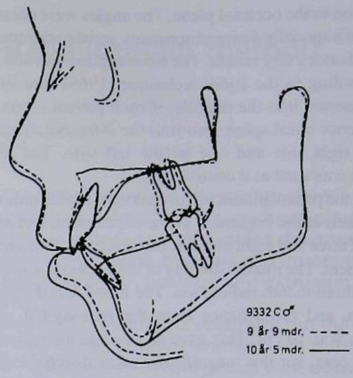

Figure 3 Changes in the position of the upper first molar in relation to the implants. Patient from Group I (9 years 9 months --- .; 10 years 5 months ———)

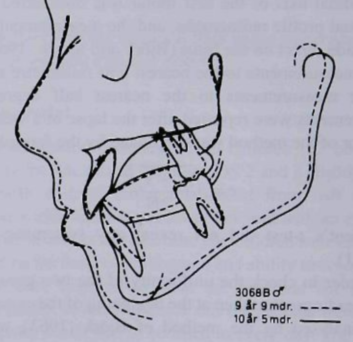

Figure 4 Changes in the position of the upper first molar in relation to the implants. Patient from Group II (9 years 9 months --- .; 10 years 5 months ———)

change (Figures 3 and 4). Both groups of patients showed extrusion of the first molar as measured by the increase in the distance from m_0 to a line through the implant I and II (IL), but the two groups showed no significant difference in the extrusion. Changes in the position of the maxilla in relation to the anterior cranial base were expressed both by the changes in the maxillary prognathism s-n-ss and s-n-pr and by the changes in the position of the set of implants in relation to the anterior cranial base. These changes revealed a significant difference in the two groups, the maxillary prognathism being noticeably reduced in the group with the extraoral bow tilted upwards. In the group with the extraoral bow tilted downwards, the prognathism was unchanged in some cases, and increased or decreased in the other. If the lowering of the implants was taken as an expression of the

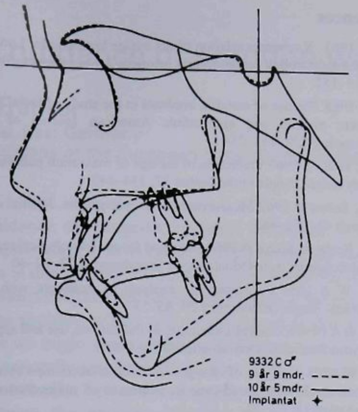

Figure 5 Facial growth during the period of treatment in a patient from Group I (9 years 9 months --- .; 10 years 5 months ———)

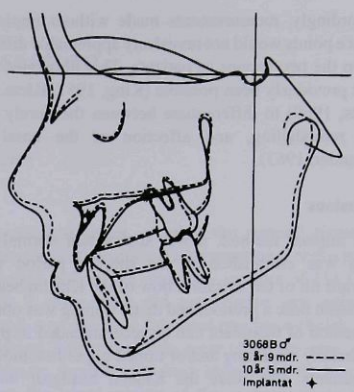

Figure 6 Facial growth during the period of treatment in a patient from Group II (9 year 9 months --- .; 10 years 5 months ———)

direction of growth of the maxilla, the analysis gave similar results (Figures 5 and 6).

Discussion

It is reasonable to divide the results obtained into two groups, namely, one in which intramaxillary tooth movements were observed, and the other in which the position of the maxillary complex was changed in relation to the cranial base. The movements of the molars were related to the implants. The shift of the maxilla was expressed by movements of the set of implants in relation to the anterior cranial base. By the method used, as distinct from other measuring methods, it is thus possible to distinguish between intramaxillary tooth movements and changes in the position of the maxilla. The group with the extraoral bow of the Kloehn headgear tilted downwards revealed the greatest intramaxillary movements of the first molars (Figures 3 and 4), ranging from 1.8 to 5 mm and averaging 3.5 mm, but at the same time a distal tipping invariably occurred. From a purely theoretical point of view, this is only what would be expected (Gould, 1957), since the extension of the direction of the pull will fall below the fulcrum of the tooth. The changes in the maxillary prognathism observed during the period of treatment were only slight (from +0.5 to –1.5), and the direction of growth of the maxilla in relation to the anterior cranial base did not deviate from that expected in a normal series (Björk, 1964). In the group of patients with the extraoral bow tilted upwards the tooth movements in relation to the implants were appreciably smaller (Figs. 5 and 6). On the other hand, all these patients showed a change in the maxillary prognathism, manifested partly by a reduction of the angles s-n-ss and s-n-pr and partly by a change in the position of the implants downwards and backwards in relation to the cranial base.

The two angles, s-n-ss and s-n-pr, are affected by the maxillary shift as well as by local remodelling of the maxilla and forward growth of nasion. The last mentioned factors will not affect the direction of movement of the set of implants. This means that the translation of the implants in relation to the anterior cranial base gives a better expression of the shift of the maxillary complex during the period of treatment than do the angles of prognathism. That the reduced maxillary prognathism produced by treatment with the Kloehn headgear is due to the effect on the entire maxillary complex and cannot be ascribed to local remodelling due to movement of the incisors, can be seen from the change in the position of the implants, because the latter, owing to their unchanged position in the maxilla, must be regarded as representing the maxilla. The lowering of implant I in relation to the anterior cranial base was in most cases greater than the lowering of implant II. As a simultaneous increase in the angle between NSL and IL occurred, the explanation of this difference may be that the entire maxillary complex rotated posteriorly. The rotation was greatest in the group of patients in whom the extraoral bow of the headgear was tilted upwards. The increase in the angle between NSL and NL is another manifestation of the posterior rotation. However, both groups of patients revealed a smaller increase in angle NSL/NL than in angle IL/NSL, which may possibly be explained by a process of remodelling. If the tooth movement had been measured without regard to the implants, for example by measuring the distance from m_0 to NSP, the change would have been greater than that ascertained with the implants as reference points. This is due to the fact that by the latter method the measurements would also include growth changes, that is to say the posterior shift of the entire maxillary complex would be included in the measurement of the distal shift of the first molar.

Accordingly, measurements made without implants as reference points would not reveal any appreciable difference between the two groups of patients. This illustrates why it has not previously been possible (King, 1957; Klein, 1957; Ricketts, 1960) to differentiate between the purely dental effect, remodelling, and affection of the basal parts (Wieslander, 1963).

Conclusions

By the implant method, it was shown that normal molar relation was established in the shortest period with a downward tilt of the extraoral bow of the Kloehn headgear. At the same time a pronounced distal tipping was obtained. This method of treatment can be recommended in patients with mesially migrating and/or tipped upper first molars.

In patients who wore the Kloehn headgear with the extraoral bow tilted upwards, a downward and backward growth direction of the maxilla was demonstrated. Accordingly, this method of treatment seems to be suitable for patients with relative protrusion of the maxilla.

Discussion

Dr Hasund asked whether there was any difference in the extrusion of the molars when the treatment was carried out in the mixed dentition when there is vertical growth or later on in the permanent dentition. Did Dr Melsen think that the vertical ILm_0 change was a natural growth situation or a consequence of the treatment? Dr Melsen replied that they had found some extrusion in all patients but that they had not had sufficient experience to say at what stage this occurred. She felt that after a follow-up study of a year they would be in a better position to answer Dr Hasund's question.

Mr Lovius asked whether the direction of growth had been observed before starting the study. Dr Melsen said that there had not been observation before the study began but they had run a control group.

Mr Burke asked Dr Melsen whether any of the patients who had the implants ever reacted unfavourably. Dr Melsen replied that there had been no unfavourable reactions and she had in fact made histological studies on monkeys who had had implants inserted for a long period and there was no reaction in the bone at all.

Professor Hallett asked Dr Melsen if she could define precisely where, anatomically, the anterior implant was placed relative to the central incisors and relative to the anterior nasal spine. Was the implant exactly in the midline? Dr Melsen replied that the implant was placed as high as one could reach and as near to the mid-line as possible. She did not know whether it was exactly in the suture.

The Chairman, Mr Burke, thanked Dr Melsen for her most interesting paper and he thanked the members who had taken part in the discussion.

References

Björk A 1963 . Kaebernes relation til det ovrige kranium. In: Lundström A (ed) Nordisk larobok i odontologisk ortopedi. 2. Supplement, Stockholm, pp. 115–152

Björk A 1968 The use of metallic implants in the study of facial growth in children: method and application. American Journal of Physical Anthropology 29: 243–254

Björk A, Helm S 1967 Prediction of the age of maximum pubertal growth in body height. Angle Orthodontist 37: 134–143

Björk A, Solow B 1962 Measurements on radiographs. Journal of Dental Research 41: 671–683

Björk A, Krebs Å, Solow B 1964 A method for epidemiological registration of malocclusion. Acta Odontologica Scandinavica 22: 27–40

Blueher W A 1959 Cephalometric analysis of treatment with cervical anchorage. Angle Orthodontist 29: 45–53

Closson D A 1950 Extraoral anchorage, its indications, use and application. American Journal of Orthodontics 36: 265–280

Epstein W 1948 Analysis of changes in molar relationships by means of extraoral anchorage (head-cap) in treatment of malocclusion. Angle Orthodontist 18: 63–70

Gould E 1957 Mechanical principles in extraoral anchorage. American Journal of Orthodontics 43: 319–333

Graber T M 1955 Extraoral force – facts and fallacies. American Journal of Orthodontics 41: 490–505

Ketterhagen D 1957 Taking a second look on headcap therapy. Angle Orthodontist 27: 93–97

King E W 1957 Cervical anchorage in Class II, div. 1 treatment, a cephalometric appraisal. Angle Orthodontist 27: 98–104

Klein P L 1957 An evaluation of cervical traction on the maxilla and the upper first permanent molar. Angle Orthodontist 27: 61–68

Kloehn S J 1947 Guiding alveolar growth and eruption of teeth to reduce treatment time and produce a more balanced denture and face. Angle Orthodontist 17: 10–33

Kloehn S J 1961 Evaluation of cervical anchorage force in treatment. Angle Orthodontist 31: 91–104

Nelson B G 1953 Extraoral anchorage in the treatment of Class II, div. 1 malocclusions – its possibilities and limitations. Angle Orthodontist 23: 121–133

Newcomb M R 1958 Some observations on extraoral treatment. Angle Orthodontist 28: 131–148

Oppenheim A 1936 Biologic orthodontic therapy and reality. Angle Orthodontist 6: 153–183

Parker W S 1958 A technique for treatment with cervical gear. Angle Orthodontist 28: 198–209

Poulton D R 1959 Changes in Class II malocclusions with and without occipital headgear therapy. Angle Orthodontist 29: 234–250

Poulton D R 1964 A three-year survey of Class II malocclusions with and without headgear therapy. Angle Orthodontist 34: 181–193

Ricketts R M 1960 The influence of orthodontic treatment in facial growth and development. Angle Orthodontist 30: 103–131

Tanner J M 1964 Growth at adolescence. 2nd edn. Blackwell Scientific Publications, Oxford

Tanner J, Whitehouse R, Healy M 1962 A new system for estimating skeletal maturity from the hand and wrist, with standards derived from a study of 2600 healthy British children. Part II: The scoring system. International Children's Centre, Paris

Wieslander L 1963 The effect of orthodontic treatment on the concurrent development of the craniofacial complex. American Journal of Orthodontics 49: 15–27

Copyright of European Journal of Orthodontics is the property of Oxford University Press / UK and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.