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The effect of a maxillary lip bumper on tooth positions

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SUMMARY The effect of the use of a lip bumper with anterior vestibular shields on the maxilla was studied in twenty-two 9–14-year-old children with a space deficiency in the maxillary dental arch. The lip bumper was used for 1 year.

The effect of the treatment was evaluated from dental casts and profile cephalograms made before and after treatment. Both the width of the maxillary dental arch at the premolars and the length of the arch increased significantly by about 2 mm. The effect of the treatment on the antero-posterior position of the first molars was small. In one subject the molar was distalized 2.8 mm. The average effect was, however, a reduction in the anterior movement of the molar within the face by about 0.5 mm, i.e. the maxilla moved anteriorly 1 mm, but the molar only 0.4 mm. No skeletal effects were found when the group of subjects treated with a lip bumper was compared with a reference sample of untreated individuals. The main effects of a maxillary lip bumper thus seem to be a widening of the dental arch across the premolars, a moderate increase in arch length due to eruption and slight proclination of the incisors, and moderate distal tipping of the first molars.

Introduction

The effects of a lip bumper on the mandibular dentition are well documented. The use of the appliance results in an appreciable widening of the dental arch at the canines and premolars (Cetlin and Ten Hoeve, 1983; Nevant *et al.*, 1991; Osborn *et al.*, 1991; Werner *et al.*, 1994; Grossen and Ingervall, 1995), and a slight proclination of the incisors (Nevant *et al.*, 1991; Osborn *et al.*, 1991; Werner *et al.*, 1994; Grossen and Ingervall, 1995). The distalizing effect on the first molars has in some studies been found to be small and, therefore, the increase in arch length (a result of incisor proclination and molar distalization) to be only moderate (Nevant *et al.*, 1991; Osborn *et al.*, 1991; Werner *et al.*, 1994; Grossen and Ingervall, 1995). In one study (Nevant *et al.*, 1991), more distal movement and distal tipping of the molar crown was found in patients wearing a lip bumper with a vestibular shield than in subjects having had only a lip bumper of round wire covered with plastic tubing. This was in line with the results of Bjerregaard *et al.* (1980), who reported considerable distal molar tipping from the use of a lip bumper with a vestibular shield. In a recent study by O'Donnell *et al.* (1998), where a wire lip bumper was tied in for 1 year, the effect on the molar was intermediate between that usually found with a wire lip bumper (Nevant *et al.*, 1991; Osborn *et al.*, 1991; Grossen and Ingervall, 1995) and that produced by a shield lip bumper (Bjerregaard *et al.*, 1980; Nevant *et al.*, 1991). When a wire lip bumper was used in the mixed dentition, the first molars in most cases moved mesially into the leeway space (Werner *et al.*, 1994).

Most of the studies of the effect of a lower lip bumper indicate that the increase in arch perimeter may be attributed to an increase in arch width, rather than in arch length (Nevant *et al.*, 1991; Osborn *et al.*, 1991; Werner *et al.*, 1994; Grossen and Ingervall, 1995). In a recent study by Davidovitch *et al.* (1997), however, where tomography was used to record molar movement and angulation, more effect on the molar from the lip bumper was noted compared with that found with conventional cephalometry. The use of tomography has the advantage of allowing analysis of the right and left sides separately, in contrast to the inevitable superimposition with conventional cephalometry.

While the picture of the effect of a lip bumper on the mandibular dentition is relatively clear, nothing is known about the effects of such an appliance when used in the maxilla. A lip bumper in the maxilla could be a good alternative for increasing the arch perimeter in the interceptive treatment of subjects with a Class III tendency. In such cases with a retrognathic and small maxilla, there is often an obvious space deficiency. Extraction of maxillary teeth is an unfavourable solution because it exaggerates the discrepancy in size between the maxillary and mandibular dental arches. The possibilities of proclining the incisors or transversally expanding the dental arch are limited for reasons of stability. Distalization of the molars would be a possible way to gain space, but cannot be carried out with headgear because of the risk of increasing the maxillary retrognathism through the orthopaedic effect. This risk would be less with a lip bumper which, simultaneously to the holding or distalization of the molars, could bring about a slight proclination of the incisors and a transverse development of the dental arch.

The present study was undertaken in order to evaluate the effects of a lip bumper on the maxillary dentition.

Subjects and methods

Seven boys and 15 girls participated in the study. Their ages varied between 9 years 3 months and 13 years 7 months (median age 10 years 6 months). The children were treated with a lip bumper in the maxilla for 10–14 months (median 12 months). In addition to the lip bumper, nine of the children also had a Goshgarian transpalatal arch (TPA) anchored to the first permanent molars. Five children wore the TPA throughout the period of treatment with the lip bumper and the remaining four children for 1.5–9 months of this period. No other appliance was used in the maxilla during this period.

The children were treated at the Department of Orthodontics, University of Bern. The lip bumper was inserted in an attempt to gain space in the maxilla. A headgear for distalization of the maxillary molars in order to gain space was contra-indicated in these children because of their Class III or tendency to Class III skeletal intermaxillary relation.

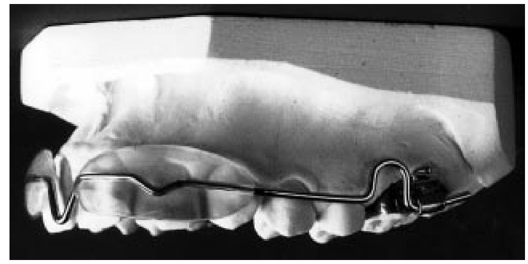

Figure 1 Type of lip bumper used for the treatment.

The type of lip bumper used is shown in Figure 1. It was made of 1.1-mm stainless steel and had custom-made acrylic shields in the labial fold opposite the anterior teeth (on each side in the region between the canine and the central incisor). The shield covered the gingiva 2–3 mm above the gingival margin and reached 6–7 mm occlusal to the gingival margin. The lip bumper was anchored in buccal tubes on the maxillary first permanent molars and was adjusted to lie 2–3 mm away from the labial surfaces of the incisors and canines, and from the buccal surfaces of the premolars. The children were instructed to wear their lip bumper day and night, and to remove it only for meals or for tooth brushing. Control visits were scheduled every second month, at which time the position of the lip bumper was checked and adjusted if necessary. The lip bumper was used passively, i.e. it was not adjusted for active expansion.

The effects of the lip bumper were documented by measurements on dental casts and profile cephalograms made immediately before and after treatment. The recording on the cast included measurement of the width of the maxillary dental arch at the first permanent molars, premolars and canines. The measuring points are shown in Figure 2. When the premolars or permanent canines were not erupted, the corresponding points on the deciduous teeth were used. No measurement was made when a deciduous tooth was replaced by its successor during the period of observation. The length of the dental arch was measured from a line connecting the tip of the mesiobuccal cusp of the

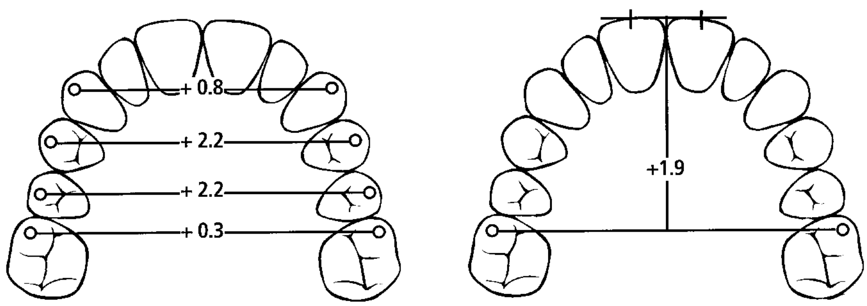

Figure 2 Measuring points used in the recording of the dental arch dimensions. The figure also shows the median changes in widths and arch length during the period of observation.

right and left first molars to the mid-point of the incisal edge of the two central incisors. The mean of the measurement to the right and left incisor was used as the variable for arch length. All measurements were made with electronic dial calipers to the next tenth of a millimetre. The results of the measurements of the dental arch dimensions were compared with the annual changes of the same dimensions in the untreated group of Moyers *et al.* (1976). For this comparison, their sample was matched with the present individuals with regard to sex and age. This matching was undertaken separately for each variable.

The reference points and lines used in the cephalometric analysis are shown in Figure 3. The point m was located on the distal surface of the first molar band. Before radiography a metal rod was inserted in the buccal tubes of the right and left first permanent molar bands, respectively. The length of the straight metal rod, which extended vertically gingivally and occlusally mesial to the mesial opening of the buccal tubes, was 15 mm. The metal rod was used to measure the inclination of the first molars in relation to OLP. The design of the rod on the right and left sides was different so that a differentiation could be made. In the cephalometric analysis the change in position of point m, as well as in the inclination of the molar on the two sides was averaged. The dimensions measured on the cephalograms were reduced to zero magnification. The changes of the distances ss–pm, pr–pm, and is–pm, as well as of the angle IL_s/NL in the treated group were compared with the annual changes of the same variables in the untreated sample of Bahtia and Leighton (1993). Their sample was matched with the present individuals with regard to sex and age. This was carried out individually for each variable. Analysis of antero-posterior linear changes was performed with the method of Pancherz (1982). A co-ordinate system, consisting of the occlusal line (OL) and a perpendicular to this line through the point sella (OLP), was drawn on a tracing of the pre-treatment cephalogram. The co-ordinate system was transferred to the post-treatment cephalogram by superimposing on structures of the anterior cranial base as described by Björk (1968). All variables recorded on the casts or cephalograms were measured twice with new markings on the casts or new tracings. The mean of the two measurements was used in the analysis.

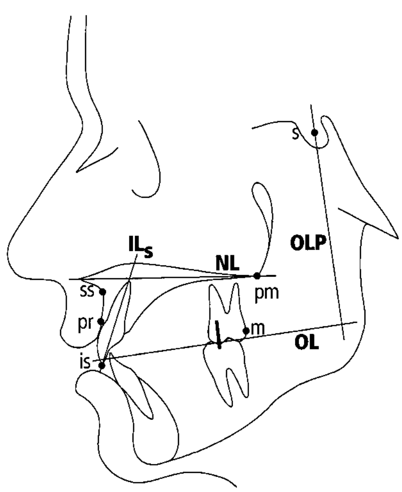

Figure 3 Reference points and lines used in the measurements on the cephalograms.

Errors of the method and statistical methods used

The errors of the method were calculated from the duplicate measurements made before and after treatment. Systematic differences between the duplicate measurements were tested with Wilcoxon's matched pairs, signed ranks test. The accidental errors of the method (s_i) were calculated with the formula

$$s_i = \sqrt{\Sigma d^2/2n},$$

where d is the difference between two measurements and n the number of recordings.

Differences between distributions were tested with Mann–Whitney's U-test and between paired observations with Wilcoxon's matched pairs, signed ranks test.

The number of duplicate determinations of the variables measured on the casts varied between 18 and 44. No systematic differences were found for these variables. The accidental errors varied from 0.16 to 0.41 mm. The number of duplicate determinations of the cephalometric variables was 36. One systematic difference was found. The angle IL_s/NL was, on average, 0.40 degrees larger at the second than at the first measurement ($0.01 < P < 0.05$). The accidental errors for the measurement of distances on the cephalograms varied between 0.20 and 0.31 mm. The errors for the measurement of the molar inclination and for the angle IL_s/NL were 0.71 and 0.81 degrees, respectively. Because the analysis of the results of the treatment was based on replicated measurements, the errors were reduced by a factor of 0.7.

Results

The changes of the dimensions of the maxillary dental arch during treatment are given in Table 1. The variation in number of observations in Table 1 and in Figure 4 is due to the fact that the widths at the premolars/deciduous molars and at the canines could not be measured in all subjects due to the varying stage of development of the dentition. There was no difference in the changes between cases having and not having had a TPA during treatment. Therefore, no differentiation with regard to the use of a TPA was made. The change in width between the first permanent molars during the treatment varied widely from a decrease of 2 mm to an increase of 7.5 mm. The median change during treatment was small and not significant, and nor was any significant difference found in relation to the reference sample. The widths between the second premolars or the second deciduous molars, as well as between the first premolars, increased significantly during treatment and developed significantly differently to the corresponding dimensions in the reference sample. The change in width in the individual cases treated with the lip bumper is shown in Figure 4. All subjects of the treatment group had an increase of the dimensions mentioned. The widths between

Table 1 Median and range (in mm) of changes in the dimensions of the maxillary dental arch during treatment. The table also gives the median annual changes in the matched reference sample (Moyers *et al.*, 1976). The varying number of observations is due to varying development of the dentition.

Width between	n	Median	Range	Median in reference sample	Significance of difference in test-reference
First molars	22	0.3	–2.0–7.5	0.5	NS
Second premolars	6	2.2*	0.1–4.6	–0.1	*
Second deciduous molars	7	1.5*	0.2–3.3	0.2	*
First premolars	11	2.2*	0.6–4.7	–0.1	**
First deciduous molars	3	0.9	0.8–1.0	0	NS
Canines	6	0.8	–0.6–1.7	–0.3	NS
Deciduous canines	3	1.1	0.9–2.6	0	NS
Arch length	22	1.9**	0.1–4.0	–0.3	***

*$0.01 < P < 0.05$; **$0.001 < P < 0.01$; ***$P < 0.001$; NS, non-significant.

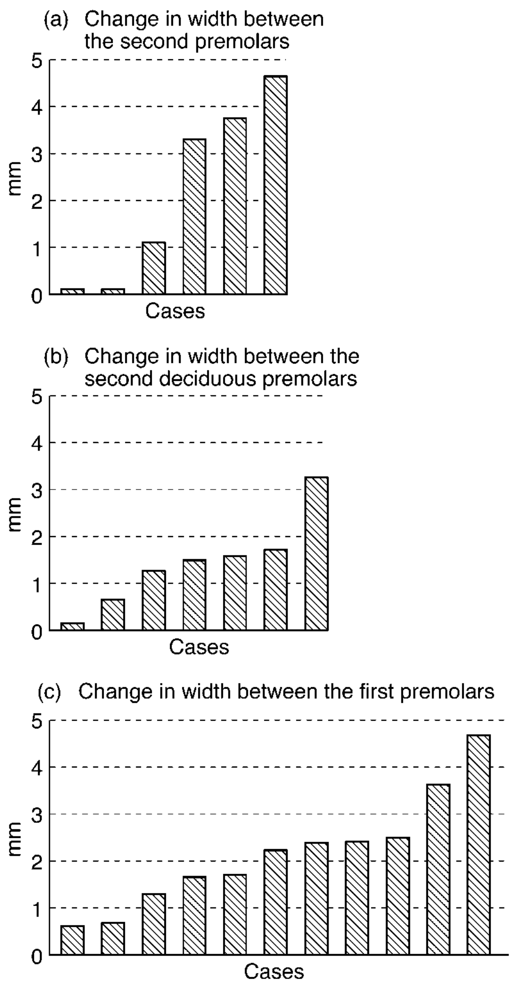

Figure 4 Change in width in the individual cases between the second premolars (a), between the second deciduous molars (b), and between the first premolars (c) during the treatment.

the first deciduous molars and between the canines also showed a numerical increase, but the number of observations was too small to allow statistical analysis. The length of the dental arch increased significantly during treatment and also when compared with the reference sample. All subjects showed an increase in arch length (Figure 5). For the reference sample, in contrast, the arch length decreased in 20 cases (up to 0.7 mm).

The changes of the variables measured on the profile cephalogram are given in Table 2. There was no significant difference in the change of first molar position between patients who had or had not worn a TPA. Therefore, no differentiation of the sample with regard to the use of a TPA was undertaken. During the period of treatment the maxilla (point ss) and the maxillary incisors (point is) moved anteriorly by 1.0 and 1.5 mm (median), respectively. Only one patient showed a distal movement of the maxilla or incisors. The anterior movement of the molars was less and not significant. The movement of the molars varied from an anterior movement of 1.5 mm to a posterior movement of 2.8 mm. The next largest posterior movements were 1.4 and 0.65 mm. The crowns of the first molars tipped posteriorly by 5.8 degrees (median). The molars tipped anteriorly in only one case.

The maxilla increased in length (distances ss–pm, pr–pm, is–pm) by 1.0–1.3 mm (median) and the incisors proclined 1.4 degrees. The proclination of the incisors was, however, not significant and none of these changes were significant compared with the changes in the reference material.

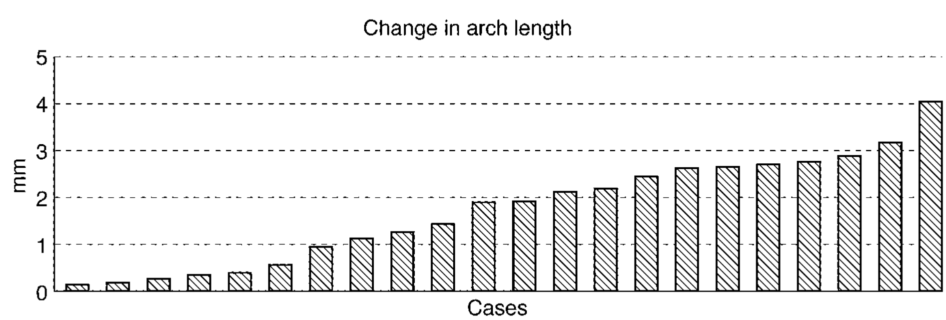

Figure 5 Change in arch length in the individual cases during treatment.

Table 2 Median and range (in mm and degrees) of changes in antero-posterior position of points ss, is, and m, as well as dimensions of the maxilla and inclination of the maxillary central incisors and maxillary molars during treatment. The table also gives the median annual changes in maxillary dimensions and in the inclination of the incisors in the matched reference sample (Bahtia and Leighton, 1993) $n = 18$.

	Median	Range	Median in reference sample	Significance of difference in test-reference
Antero-posterior position of points				
ss	1.0**	–0.3–1.8		
is	1.5**	–1.7–3.8		
m	0.4	–2.8–1.5		
Inclination of first molars (degree)	–5.8**	–18.2–3.8		
Distance ss–pm	1.0**	–0.3–3.4	0.8	NS
Distance pr–pm	1.2**	–0.3–3.6	1.0	NS
Distance is–pm	1.3**	–0.3–4.0	1.1	NS
IL_s/NL (degree)	1.4	–2.8–7.7	–0.1	NS

A positive sign means anterior movement or change in inclination in an anterior direction. NS, not significant.
**0.001 > P > 0.01.

Discussion

For this study, a lip bumper with vestibular shields was chosen. The force from the lip on a bumper with shields has in the mandible been found to be greater than on a wire lip bumper (Hodge *et al.*, 1997) and this may also be assumed to be true for the maxilla. The difference in force is thought to be due to the larger surface area of contact between the lip and the appliance when shields are used. The upper lip is much weaker than the lower. The mean pressure at rest from the lower lip on the lower incisors amounts to 9–12 g/cm^2 against 2–5 g/cm^2 from the upper lip on the upper incisors (Thüer *et al.*, 1985; Thüer and Ingervall, 1986, 1990). Therefore, a bumper with shields is necessary if the distally-directed force from the lip bumper on the molars is to be of any appreciable magnitude.

The changes of most of the variables during the period of treatment were compared with the changes of the same dimensions in samples of children followed for the study of normal growth and development. These samples (Moyers *et al.*, 1976; Bahtia and Leighton, 1993) comprise children with normal occlusion and varying types of malocclusions. It cannot be taken for granted that the changes with growth and development of these children are quite comparable with those of the children of the present study, who had a Class III or a tendency to Class III intermaxillary skeletal relationship. Furthermore, the children of the reference samples were from different populations than those of this investigation. The data in the reference samples were collected several decades ago. It is therefore possible that secular changes may influence a comparison with the present results. A control group of children with the same characteristics as the group of treated children would have been preferable for the comparison. The collection of such material was, however, impossible for ethical reasons and also because of the scarcity of children with Class III morphology. When comparing the treated children and the reference samples the limitations mentioned should be kept in mind.

The median increase in width between the first permanent molars during treatment was negligible. This may be due to the fact that the lip bumper was used passively, i.e. a change in width between the first molars was hindered by the rigid lip bumper and that, in many cases, the inter-molar width was controlled by a TPA. In one subject, however, the width between the first molars was purposely expanded 7.5 mm. In the premolar area, on the other hand, there was a considerable widening of the dental arch, which was significant when compared with the reference sample. There was also an increase in inter-canine width, which, however, was not significant. The number of inter-canine width observations was, however, small. The increase in maxillary inter-premolar widths achieved by the lip bumper treatment was much the same as the increase in mandibular inter-premolar widths achieved by the use of a lower lip bumper (Osborn *et al.*, 1991; Nevant *et al.*, 1991; Werner *et al.*, 1994; Grossen and Ingervall, 1995; Davidovitch *et al.*, 1997; O'Donnell *et al.*, 1998).

In contrast to the situation in the mandible, there is possibly more than one explanation for the increase in arch width from a lip bumper used in the maxilla. One explanation, which would hold true for both the maxilla and the mandible, is that the lip bumper changes the oral environment by holding the lips and cheeks away from the dental arches, thus altering the equilibrium between the forces from the circumoral soft tissues and from the tongue acting on the teeth. The effect of the lip bumper would then be similar to that of the vestibular shields of a Fränkel appliance (Fränkel, 1974). The other explanation is that a maxillary lip bumper increases the growth in the mid-palatal suture. This has been shown to be the case with the use of vestibular shields in growing rabbits (Kalogirou *et al.*, 1996). In that animal experiment, however, the shields were extended to create tension in the buccinator insertions. The authors suggested that the increased sutural growth was due to relief of the buccal pressure and continued tongue pressure against the dento-alveolar bone, leading to separation of the adjoining bone and sutural growth as a passive filling process. In the present study, the increase in width between the first molars, as well as between the second premolars/second deciduous molars and between the first premolars/first deciduous molars, and between the canines was the same in subjects with and without a TPA during treatment. A TPA holds the two maxillary halves together, thereby decreasing the possibility of mid-palatal sutural growth expressing itself. Therefore, the explanation for the increase in maxillary dental arch width produced by the lip bumper treatment is most likely the change in equilibrium of the forces acting on the surfaces of the teeth.

The growth in length of the maxilla was not affected by the lip bumper treatment as the distance ss–pm increased similarly in the treated group and the reference sample. The same is true for the distances pr–pm and is–pm. In relation to the reference line OLP, the maxilla (point ss) in the treated group moved 1 mm (median) anteriorly during the period of observation. Unfortunately, the literature contains no such measurement for untreated samples. The median anterior movement of is was 1.5 mm, i.e. somewhat more than for point ss. This may be due to eruption of the incisor and/or to a slight increase in its inclination, which changed more in the treated group than in the reference sample. The anterior movement of the first molar (point m) was only half that of the maxilla (point ss) and signifies a slight holding effect (median about half a millimetre) from the lip bumper on the molar. In single cases the molars may move distally but this rarely exceeds 1 mm. The small effect of the lip bumper on the molars in terms of holding or distalization may be due to the small force produced by the upper lip but, as mentioned in the introduction, in many studies a similar small effect was also found in the mandible. In a previous study of the effect of a lip bumper in the mandible (Grossen and Ingervall, 1995), the state of development and eruption of the second molars was found not to influence the effect of the bumper on the first molars. A similar analysis could not be carried out in the present study because we refrained from taking additional radiograms, and because one or both second molars were only erupted in four cases as judged from the dental casts.

The increase in arch length from molar holding/distalization and from incisor eruption/proclination was limited, and quite comparable with that found with the use of a lip bumper in the mandible (Osborn *et al.*, 1991; Grossen and Ingervall, 1995; Davidovitch *et al.*, 1997; O'Donnell *et al.*, 1998). The main effect of a maxillary lip bumper seems to be a widening of the dental arch across the premolars. This is, of course, beneficial, but it is not the ultimate solution to the space deficiency problem in a retrognathic maxilla. On the other hand, no negative effects of the use of a maxillary lip bumper were found.

It is an open question whether the expansive effect of a lip bumper and the proclination of the incisors are stable in the long term. The results of Soo and Moore (1991) indicated an adaptation of the lower lip to the tooth position achieved with lower lip bumper treatment. In their study, the pressure from the lower lip both at rest and during speech first increased (at 1 month), but then (at 8 months) decreased below baseline. These observations are at variance with the results of recent studies. O'Donnell *et al.* (1998) found no decrease of the pressure from a lower lip bumper on the first molars after one year of uninterrupted use. Ingervall and Thüer (1998) found the pressure from the lower lip on the lower incisors to be the same after 8 months of lower lip bumper treatment as at the start. The lip had not adapted to the changed position of the incisors, nor had it reacted to the extension by the lip bumper. Therefore, the conclusion of Houston and Edler (1990) may be correct, namely, 'with a few exceptions, the initial position of the lower incisors provides the best guide to their position of stability'.

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