European Journal of Orthodontics 20 (1998) 525–534

No effect of lip bumper therapy on the pressure from the lower lip on the lower incisors

Bengt Ingervall and Urs Thüer
Department of Orthodontics, University of Bern, Switzerland

SUMMARY The pressures from the lower lip on the lower incisors were measured at the midline between the central incisors and between the left lateral incisor and canine. The measurements were made with the lip at rest and during swallowing of water in 24 boys and 40 girls aged 9–15 years. The children were divided into four groups, two treated with a lip bumper with and without an oral shield, and two with a lingual arch with and without springs for proclination of the lower incisors. Recordings of the pressures were made before the start of the treatment, and 3 and 8 months after the use of the appliance, as well as 4 months after the removal of the lip bumper or lingual arch.

The treatment with a lip bumper did not change the pressure from the lip on the lower incisors at rest. The pressure at the midline during swallowing was also unaffected by the lip bumper therapy, but the pressure between the lateral incisor and canine increased. Thus, lip bumper therapy did not lead to decreased pressure from the lip on the incisors.

Proclination of the lower incisors with a lingual arch resulted in an increase of the pressure from the lip at rest. Thus, no adaptation of the lower lip to the proclination occurred. After relapse of the proclination the pressure from the lip decreased to a value no different from that before the start of the treatment.

Introduction

The lower lip bumper has gained much popularity as a means of increasing the perimeter of the dental arch. It has been advocated as an important and simple adjunct in non-extraction therapy (Cetlin and Ten Hoeve, 1983). A lower lip bumper results in an increase of the transverse arch dimensions and a moderate proclination of the lower incisors (Bjerregaard *et al.*, 1980; Nevant *et al.*, 1991; Osborn *et al.*, 1991; Grossen and Ingervall, 1995). Whether these effects are stable is, however, unknown. Mechanical expansion of the lower dental arch, especially an increase of the intercanine width, and proclination of the lower incisors is known to be unstable with a great tendency to relapse. It is, however, possible that the use of a lip bumper for a relatively long period during the growth of the soft tissues would result in an extension of the lower lip. The lip bumper stretches the lower lip, which might lead to an increased soft tissue 'manchette' with resulting decreased pressure on the teeth at the end of the lip bumper therapy. If this were the case the 'natural', passive expansion of the dental arch would have a chance to remain stable, in contrast to the mechanical, active expansion achieved with conventional orthodontic appliances.

Soo and Moore (1991) reported a decrease of the pressure from the lower lip on the incisors after the use of a lip bumper for up to 8 months. A decrease of both resting and functional (phonetic) pressures was found. Simulated expansion of the lower dental arch by the wearing of a stent for 1 week has also recently been shown to decrease the resting pressure from the lower lip in the midline but not at the canine (Moawad *et al.*, 1996). In an experiment of longer duration where the stent was used during 6 months, both the pressure in the midline and that at the canine at 1 month were no greater than before the insertion of the stent (Shellhart *et al.*, 1997). McNulty *et al.* (1968) studied the adaptive

potential of the upper lip at rest to labial positioning of a prosthetic incisor for 1 week. The authors found that some subjects reacted to the incisor protrusion by muscle accommodation. Unexpected results with regard to the pressures from the lips on the teeth were reported by Proffit and Phillips (1988). These authors found the pressures at rest on the maxillary incisors to have markedly decreased 2 years post-surgically after maxillary advancement. The same was true for the pressures on the mandibular incisors after mandibular advancement. In contrast to the above results, Nanda *et al.* (1997) found no effect of a 1-year lip bumper therapy on the resting forces from the lower lip transferred by the lip bumper to the first molars.

If a lip bumper extends the lip with a resulting decrease of the pressure on the lower incisors, an important question is whether this effect is permanent or will disappear some time after the end of the lip bumper therapy. The present study was undertaken to evaluate the effect of passive expansion of the lower dental arch with a lip bumper with regard to the pressure from the lower lip on the lower incisors. The pressures recorded after the passive expansion with a lip bumper were compared with those from active proclination of the incisors and in a control group with relatively unchanged lower dental arch morphology. These comparisons were made during and after lip bumper therapy and at a follow-up observation in order to reveal whether any differences were permanent or temporary.

Subjects and methods

Altogether 64 children participated in the study. They were divided into four groups. The sex and age of the children in the groups are given in Table 1.

The children were included in one of the following groups after treatment.

Group I consisted of 20 children who were treated with a mandibular lip bumper. The lip bumper was of the type shown in Figure 1a. It was made of 1.1 mm stainless steel wire which was covered with plastic tubing. It was anchored in buccal tubes on the mandibular first molars and adjusted to be positioned 6 mm below the edges of the mandibular incisors, and to lie 3 mm away from the labial surfaces of the incisors and canines and from the buccal surfaces of the premolars.

Group II contained 19 children who also had a lip bumper in the mandible. It was made of the same type of wire and anchored similarly as the lip bumper of group I. It was, however, not covered with plastic tubing, but had a custom-made acrylic shield in the labial fold below the canines and incisors (Figure 1b). The lip bumper lay away from the incisors, canines and premolars and from the alveolar process in a similar way as the bumper used in group I.

In both groups the children were instructed to wear their lip bumper day and night, and to remove it only for meals and for tooth-brushing.

Group III contained 16 children who were treated with a lingual arch. The lingual arch was

Table 1 Sex and age of the subjects included in the study.

	n	Sex		Age	
		Male	Female	Median	Range
Group I, Lip bumper	20	6	14	10 years 9 months	8 years 9 months–13 years 5 months
Group II, Lip bumper with shield	19	6	13	10 years 8 months	9 years 3 months–11 years 10 months
Group III, Lingual arch with proclination	16	9	7	10 years 9 months	9 years 7 months–14 years 10 months
Group IV, Lingual arch	9	3	6	11 years 6 months	8 years 6 months–14 years 5 months

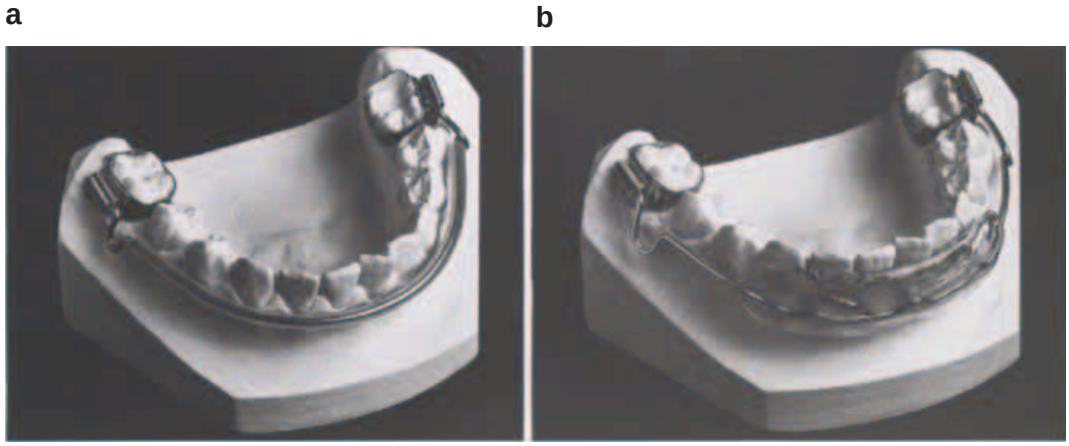

Figure 1 The lip bumper used in group I (a), and in group II (b).

anchored to first molar bands and had a spring for the proclination of the incisors.

Group IV consisted of nine children who wore a lingual arch, but without proclination of the incisors.

The lip bumpers and lingual arches were used for 8 months. Control visits were scheduled every month, at which the position of the lip bumper or arch was checked and adjusted if necessary, or the proclination spring activated.

Measurements of the pressure from the lower lip on the labial surfaces of the mandibular incisors were made on two different occasions before the insertion of the lip bumper or lingual arch. The means of these two recordings were used as baseline values. Three further recordings were made: 3, 8, and 12 months after the start of treatment. The recordings at 3 and 8 months were made during the ongoing or at the end of the treatment, respectively, and the recording at 12 months was made 4 months after removal of the lip bumper or lingual arch.

At each recording, the pressure from the lower lip on the labial surfaces was measured at the midline (MP1), and between the left lateral incisor and canine (MP2). In these two locations mouthpieces included in the measuring system of Thüer *et al.* (1985) were mounted. The system consists of an extra-oral pressure transducer incorporated in a water-filled system with an intra-oral mouthpiece at the position where the lip pressure is recorded. The mouthpiece is bonded to the teeth at the level of the tip of the gingival papilla and projects at most 2 mm from the labial surfaces of the teeth. In group II a mouthpiece was also incorporated in the oral shield of the lip bumper opposite the contact between the right central and lateral incisors. Recordings of the pressure from the lip on this point of the oral shield were made, in addition to the other recordings, at the second recording before the start of treatment and at the subsequent occasions.

The recordings of the pressure from the lip were made in the rest position of the mandible and during swallowing of 6 ml of water. The muscle function of the lips (relaxation in the rest position) was monitored electromyographically with the method of Thüer *et al.* (1985). Surface electrodes were used on the upper and lower lips.

For the recording, the child was seated in a dental chair, in an upright position, with a headrest. The Camper line was kept horizontal. The recordings were made separately for the MP1 and MP2, and in group II for the oral shield in the following order:

1. Rest position.
2. During two swallowings of water.
3. New recording of rest position.

4. New recording of 2 swallowings of water.
5. New recording of rest position.

Thus, at each session, three recordings of the pressure in the rest position and four of the (maximum) swallowing pressure were made for each measuring point. The means of the three and four recordings, respectively, were used in the analysis.

Before the insertion of the lip bumper or lingual arch and at the removal of these appliances (8 months), as well as at the examination at 12 months, profile cephalograms and dental casts were made. The cephalograms were used to measure the change in antero-posterior position of the mandibular incisor at the most prominent point of the labial surface and at the incisal edge. These measurements were made parallel to the lower border of the mandible with the use of fiducial reference points that were transferred from the first to the second cephalogram by superimposition on the natural reference structures of the mandible (Björk and Skieller, 1983). The measurements were made with sliding calipers to a tenth of a millimetre and included 3 per cent linear enlargement. The inclination of the mandibular incisor to the mandibular line (ILi/ML) was measured to half a degree. The overjet was measured to half a millimetre.

On the mandibular dental casts the width of the dental arch was measured at the canines, premolars (deciduous molars), and first molars. In addition, the length of the dental arch to the central incisors was measured perpendicular to a line connecting the first molars. These measurements were made as described by Grossen and Ingervall (1995).

Errors of the method and statistical analysis

The errors of the method for the recordings of the pressures from the lip on the teeth were evaluated for all 64 cases from the two recordings made before the start of treatment. These recordings were made 0–50 days apart (median 7 days). Systematic differences between the two recordings were tested with the Wilcoxon matched-pairs, signed-ranks test and accidental errors with the formula

$$si = \sqrt{\frac{\sum d^2}{2n}}$$

where d is the difference between the two recordings.

No significant systematic differences were found for the recordings of the pressures at rest or for the recording of the swallowing pressure at the midline (MP1). The value of the swallowing pressure between the lateral incisor and canine (MP2) was in median 12.3 g/cm^2 larger at the second than at the first recording. The accidental errors were 3.3 g/cm^2 and 2.2 g/cm^2 for the recordings of the pressures at rest at MP1 and MP2, respectively. The corresponding values for the recordings of the pressures during swallowing were 71.4 g/cm^2 and 42.1 g/cm^2.

Differences were tested with the Wilcoxon matched-pairs, signed-ranks test.

Results

Morphological changes

The changes during the period of use of a lip bumper or lingual arch (8 months) of parameters describing the morphology of the lower dental arch are given in Table 2.

In the two groups treated with a lip bumper (I and II), the position of the lower incisors changed in a similar way, i.e. on average the incisors proclined moderately. In the group treated with a lingual arch with proclination springs (III), the proclination of the lower incisors was in general more marked than in the two lip bumper groups. In the group treated with a lingual arch without proclination springs (IV) a moderate proclination of the incisors was found, but no linear change of the lower incisor position was noted. In the two lip bumper groups the widths at the canines and premolars increased in a similar way, while no or only a small increase was found in the lingual arch groups. There was an increase in arch length in the lip bumper groups and in the group treated with proclination

Table 2 Median and range of changes in position of the lower incisor, arch length, and overjet in the four groups in the interval from start of treatment to the observation at 8 months.

	Group I Lip bumper			Group II Lip bumper with shield			Group III Lingual arch with proclination			Group IV Lingual arch		
	n	Median	Range	*n*	Median	Range	*n*	Median	Range	*n*	Median	Range
Lower incisor												
Labial surface (+)	20	0.5***	–0.5–1.4	19	0.4***	–0.1–2.0	16	0.9***	0.2–2.2	9	–0.1	–0.5–0.9
Incisal edge	20	0.8***	–0.3–2.3	19	0.7***	–0.5–2.7	16	1.9***	0.5–4.5	9	0.1	–0.6–1.7
Inclination	20	2.0***	–1.0–5.5	19	3.0***	–2.0–6.5	16	7.0***	3.5–12.0	9	3.0*	–1.0–7.0
Arch length	20	1.3***	–1.0–3.1	19	2.2***	0.3–5.4	15	2.5***	1.4–3.9	9	0.1	–2.3–0.7
Overjet	20	–1.5***	–6.5–1.0	19	–1.0**	–5.5–1.2	16	–1.0*	–5.0–2.0	9	–0.5	–4.0–0.5

(+) a positive sign means anterior movement of the incisor, increase in proclination, arch length or overjet.
*$0.01 < P < 0.05$; **$0.001 < P < 0.01$; ***$P < 0.001$.

springs, but not in the group treated with a lingual arch without proclination springs.

After the removal of the lingual arch with proclination springs in group III at 8 months, there was a relapse of the incisor proclination to the final examination at 12 months. The labial surface of the incisor moved backwards in median 0.9 mm (range –0.6–2.3 mm), the incisal edge by 1.4 mm (range –0.2–3.4 mm) and the incisor uprighted in median 3.0 degrees (range 1.5–9.0 degrees). These changes were significant ($P < 0.001$).

Pressures from the lip

The pressures from the lower lip on the lower incisors in the rest position are given in Table 3 and Figures 2 and 3. The median pressure at the midline (MP1) at the start of treatment for all cases combined was 6.5 g/cm^2 (range –1.0–32.8 g/cm^2) and between the left lateral incisor and canine 5.2 g/cm^2 (range –2.6–13.4 g/cm^2). The difference in pressure at the two points of measurement was significant ($0.001 < P < 0.01$). Some individuals had a negative pressure

Table 3 Median and range (in g/cm^2) of the pressures at rest from the lower lip at the midline between the lower central incisors (MP1) and between the left lateral incisor and canine (MP2) at the start of treatment and median of the recordings at 3, 8, and 12 months.

	Start of treatment		3 months	8 months	12 months	Difference
MP1						
Group I	9.9	0.1–32.8	8.6	10.3	10.4	
Group II	5.0	0.3–24.2	8.4	5.4	5.2	
Group III	5.2	–0.4–18.1	9.3	11.4	8.6	Start—3, 8 months*
Group IV	6.9	–1.0–13.1	10.2	9.5	9.0	
MP2						
Group I	6.9	–0.1–11.3	8.6	6.6	6.3	
Group II	5.4	1.4–11.5	5.9	5.6	4.7	
Group III	3.4	–2.6–10.9	5.2	6.4	3.3	
Group IV	4.8	0.2–13.4	5.6	7.1	6.2	

*$0.01 < P < 0.05$.

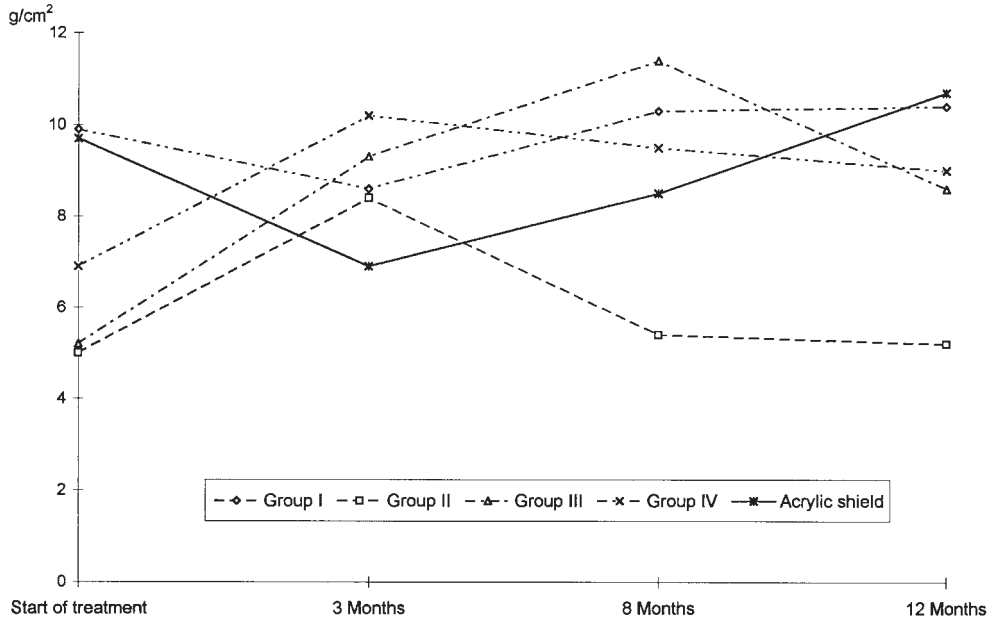

Figure 2 The median resting pressures at the midline between the lower central incisors (MP1) in groups I–IV and on the acrylic shield of the lip bumper in group II.

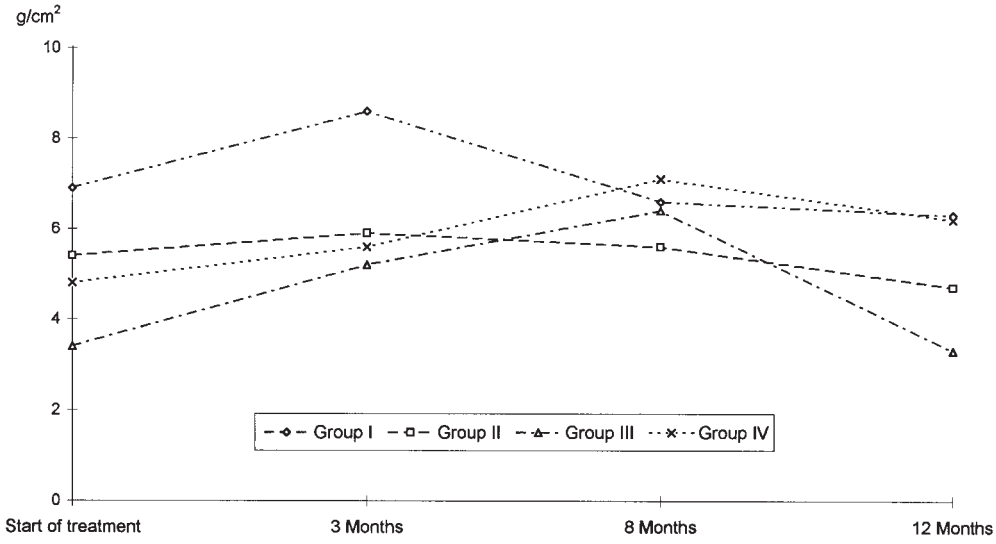

Figure 3 The median resting pressures between the left lower lateral incisor and canine (MP2) in groups I–IV.

(– sign), i.e. in these individuals (four of 64 subjects at point MP1 and three at point MP2) a vacuum was recorded. In groups I, II and IV the pressure at rest recorded at 3, 8, and 12 months did not differ significantly from the pressure recorded before the start of the treatment. Thus, no effect on the pressure was discernible as a result of treatment or time. In group III (lingual arch with proclination), on the other hand, the pressures recorded in the midline (MP1) at 3 and

8 months were significantly greater than those at the start of treatment while the pressure at 12 months did not differ significantly from the value at the start.

The pressures recorded during swallowing are presented in Table 4. Like the pressures at rest, higher pressures were recorded at the midline (MP1, median for all 64 cases 131.3 g/cm^2, range 34.1–498.2 g/cm^2) than between the lateral incisor and canine (MP2, median 88.0 g/cm^2, range 22.3–284.3 g/cm^2; $P < 0.001$). During the period of observation the pressures at the midline did not change significantly except in group IV, where higher values were found at 8 and 12 months than before treatment. At the measuring point between the lateral incisor and canine an increase was noted in group I from the start to the recording at 3 months, in group II from the start to the recording at 8 months, and in group IV from the start to all subsequent recordings.

The pressures recorded on the oral shield in the subjects of group II (Table 5, Figure 2) at rest and during swallowing did not differ significantly from the start to the subsequent recordings. The pressure recorded at rest on the shield was significantly higher than the pressure recorded on the incisors at the midline ($0.01 < P < 0.05$) and between the lateral incisor and canine ($0.001 < P < 0.01$). The pressure recorded on the shield during swallowing was lower than that on the incisors in the midline ($0.001 < P < 0.01$), while no significant difference from the pressure between the lateral incisor and canine was found.

Discussion

The subjects of this investigation were children enrolled in orthodontic treatment in whom a lower lip bumper or lingual arch was part of the treatment plan. The lip bumper is a frequently

Table 4 Median and range (in g/cm^2) of the pressures during swallowing from the lower lip at the midline between the lower central incisors (MP1) and between the left lateral incisor and canine (MP2) at the start of treatment and median of the recordings at 3, 8, and 12 months.

	Start of treatment		3 months	8 months	12 months	Difference
MP1						
Group I	169.7	102.3–498.2	159.3	164.2	179.2	
Group II	121.5	40.3–352.5	159.7	136.7	116.8	
Group III	113.4	38.1–258.7	149.5	127.0	99.9	
Group IV	79.0	34.1–229.3	126.2	146.5	140.4	Start—8 months**, 12 months*
MP2						
Group I	115.1	35.6–284.4	146.7	112.1	111.9	Start—3 months*
Group II	69.2	30.0–198.6	105.8	99.2	95.9	Start—8 months*
Group III	72.0	26.8–185.8	72.4	86.1	81.0	
Group IV	71.1	22.3–180.2	126.2	146.5	140.4	Start—3, 8, 12 months*

*$0.01 < P < 0.05$; **$0.01 < P < 0.01$.

Table 5 Median and range (in g/cm^2) of the pressure recorded on the oral shield of the lip bumper in group II at the start of treatment and median of the observations at 3, 8, and 12 months.

	Start of treatment		3 months Median	8 months Median	12 months Median
	Median	Range			
Rest	9.7	0.9–16.5	6.9	8.5	10.7
Swallowing	96.9	26.0–198.5	90.1	102.3	117.5

used appliance, whereas a lingual arch for proclination of the incisors is used only infrequently. Alignment of the mandibular incisors is as a rule undertaken with a labial arch and brackets. It was therefore not possible to include as many lingual arch as lip bumper cases in the sample during the period covered by the investigation. The use of the appliance was restricted to 8 months in order to standardize the conditions of the investigation. The 8 months of treatment were followed by a period of 4 months without the use of a lower appliance. After the final recording at 12 months the lip bumper or lingual arch was again inserted in a number of children or the treatment was continued with other measures.

The lip bumpers had an effect very similar to that in a previous study where the same type of lip bumper as in group I was used, also for 8 months (Grossen and Ingervall, 1995). This is important as proof that the bumpers were actually used by the children and therefore could influence the soft tissues and the lower lip muscle. The typical effect of the lip bumper in both groups was a moderate anterior movement and proclination of the incisors and a marked widening of the arch at the canines and premolars. The use of the lip bumpers had thus resulted in a passive expansion of the dental arch.

In addition to the measurements on the cephalograms and dental casts, the casts were inspected by two examiners for changes typically resulting from lip bumper therapy. Cases where no clear effect of the lip bumper therapy was seen were excluded. Again, this was carried out to ensure that only children who had actually used their lip bumper as prescribed were analysed with respect to lip pressure. In the group treated with a lingual arch with proclination springs, the incisors had been moved anteriorly and proclined about twice as much as in the lip bumper groups. No or very little expansion of the dental arch at the canines and premolars had, however, occurred. In the group treated with a lingual arch without proclination springs, a moderate change in inclination of the incisors had taken place, but the incisors had not moved forward. Only a moderate or no increase in width at the canines and premolars was noted in this group.

The measurements of the pressures from the lip were made with the method developed in our laboratory which has been used in many previous studies (Thüer *et al.*, 1985; Thüer and Ingervall, 1986, 1990; Fuhrimann *et al.*, 1987; Ingervall and Thüer, 1988). The system has many advantages. It is rigidly linear and fast (response for 50 per cent deflection in the most frequently used measuring range 5 milliseconds); it is independent of temperature differences between the oral cavity and the surroundings; is easy to calibrate and non-fragile. Another advantage is that it is possible to record negative pressure. The combination with electromyographic recordings of lip muscle activity ensures that the state of activity of the lips can be monitored.

The accidental errors of the method for the recording of the pressures at rest were smaller in this study than in a previous study of children where the same method was used (Thüer *et al.*, 1985). The errors for the recording during swallowing, on the other hand, were larger.

The pressure recorded in the midline at rest in this study (6.5 g/cm^2 for all cases) was smaller than in previous studies of children (9–12 g/cm^2) where the same method was used (Thüer *et al.*, 1985; Thüer and Ingervall, 1986, 1990). The resting pressures in this study, both at the midline and between the lateral incisor and canine, were, however, very close to the values recently recorded by Shellhart *et al.* (1996, 1997) in young adults with the use of a diaphragm transducer. Also, the proportion of subjects with a negative pressure at rest (6 per cent in the recording at the midline) was in this investigation lower than in the previous studies from our laboratory, where a prevalence of 11–15 per cent was found. The resting pressure was found to be lower at the point between the lateral incisor and canine than at the midline. This is in agreement with the results of Shellhart *et al.* (1996, 1997) in adults, but in contrast to the findings of Soo and Moore (1991) in children.

The swallowing pressure at the midline in the present investigation (131 g/cm^2) was higher than previously found in children (85 g/cm^2) (Thüer *et al.*, 1985). The previous value corresponds to the value between the lateral incisor and canine (88 g/cm^2) in this study.

We were unable to detect any influence of lip bumper therapy on the resting pressures at either of the two measuring points. Two different designs of lip bumper were used. The one with a shield is believed to stretch the lower lip more than the plain lip bumper used in group I. With both types of bumpers, the resting pressures remained very constant over the period of observation. A slight numerical increase in pressure at the midline was seen with the lip bumper with a shield at the recording at 3 months, and with the plain lip bumper at the measuring point between the lateral incisor and canine, likewise at 3 months. No significant differences were found, however. Our results are therefore at variance with those of Soo and Moore (1991). The reasons for this discrepancy are unknown. The size of the sample in the study by Soo and Moore was, however, small and the resting pressures recorded were much higher than those of the present investigation and in our previous studies, as well as in comparison with those of Shellhart *et al.* (1996, 1997). Longitudinal data on the development of the pressure from the lips on the teeth are lacking. Cross-sectional comparisons show, however, that the pressure is lower in adults than in children (Thüer *et al.*, 1985, 1986; Fuhrimann *et al.*, 1987). There is thus no reason to believe that the pressure from the lip would have increased if the lip bumper had not been used.

The resting pressures in the control group (lingual arch) remained constant. This was also the case for the resting pressure recorded between the lateral incisor and canine in the lingual arch proclination group. Only the pressure at the midline increased in the proclination group so that it was significantly higher at 3 and 8 months than at the start of the treatment. The increase was, however, temporary as the pressure at 12 months was lower than at 8 months. During the active treatment the lower incisors had been markedly proclined in the proclination group. This may explain the increase in pressure at the midline and strongly suggests that the lower lip is unable to adapt to such proclination even after several months of changed tooth position. Interestingly, the resting pressure at the midline decreased during the period between 8 and 12 months, when most of the forward movement and proclination of the incisors relapsed. The finding of Proffit and Phillips (1988) of a decreased pressure from the lips after maxillary and mandibular surgical advancement is interesting, but may not be comparable to proclination of the incisors. It is possible that retention of the proclination over a long period could have resulted in normalization of the pressure from the lip. This question cannot be answered by the design of the present investigation. The positioning of the mandibular incisors is, however, a complex problem. Houston and Edler (1990) studied cases where the lower incisors had been moved to the A–Pog line, which is thought to be an ideal incisor position. In most cases, after retention, the incisors to a varying extent moved back to their original position. Their results support the view that the initial position of the mandibular incisors is the best guide to their position of stability.

Soo and Moore (1991) found a decrease of the pressures on the lower incisors during function, i.e. at the pronunciation of four different phonetic sounds, after lip bumper therapy. A decrease of the pressure from the lower lip on the lower incisors during the function of swallowing was not noted in this study. In the midline, the swallowing pressures remained constant in the two lip bumper and in the lingual arch proclination groups. Only in the control group did the swallowing pressure at the midline increase over time. At the measuring point between the lateral incisor and canine, there was an increase in the group of plain lip bumper wearers at 3 months and in the shield lip bumper group at 8 months compared with the values recorded before the treatment. In no group was there a decrease of the pressure during swallowing with treatment or time.

Conclusions

The present study has revealed that pressure from the lower lip on the lower incisors at rest is unaffected by lip bumper therapy. The pressures during the function of swallowing are either unaffected or increase. The hypothesis that a lip bumper, by extension of the lip, leads to lower pressures from the lip is thus not substantiated

by the results of the present investigation. It is therefore unlikely that passive, 'natural' expansion of the dental arch is more stable than active expansion.

The study also revealed that proclination of the lower incisors does not seem to result in an adaptation of the lower lip. The pressure from the lower lip at the incisors increased after proclination, a fact which may be responsible for the noted relapse of the incisors. Active proclination of the incisors resulted in an increased resting pressure from the lip on the incisors, but passive proclination with the use of a lip bumper did not. It may therefore be argued that passive proclination is superior to active and would have a chance to remain stable. This may be so, but it must be remembered that the amount of proclination was different in the groups. In the lingual arch proclination group the amount of proclination was approximately twice that of the lip bumper groups. Further studies are obviously needed to reveal how much proclination of the incisors is tolerated before an increase in pressure occurs.

Address for correspondence

Professor Bengt Ingervall
Klinik für Kieferorthopädie
Freiburgstrasse 7
CH-3010 Bern
Switzerland

Acknowledgement

We are grateful for the technical assistance of Mrs Margrit Stucki during the recordings.

References

Bjerregaard J, Bundgaard A M, Melsen B 1980 The effect of the mandibular lip bumper and maxillary bite plate on tooth movement, occlusion and space conditions in the lower dental arch. European Journal of Orthodontics 2: 257–265

Björk A, Skieller V 1983 Normal and abnormal growth of the mandible. A synthesis of longitudinal cephalometric implant studies over a period of 25 years. European Journal of Orthodontics 5: 1–46

Cetlin N A, Ten Hoeve A 1983 Nonextraction treatment. Journal of Clinical Orthodontics 17: 396–413

Houston W J B, Edler R 1990 Long-term stability of the lower labial segment relative to the A–Pog line. European Journal of Orthodontics 12: 302–310

Fuhrimann S, Schüpbach A, Thüer U, Ingervall B 1987 Natural lip function in wind instrument players. European Journal of Orthodontics 9: 216–223

Grossen J, Ingervall B 1995 The effect of a lip bumper on lower dental arch dimensions and tooth positions. European Journal of Orthodontics 17: 129–134

Ingervall B, Thüer U 1988 Cheek pressure and head posture. Angle Orthodontist 58: 47–57

McNulty E C, Lear S C, Moorrees C F A 1968 Variability in lip adaptation to changes in incisor position. Journal of Dental Research 47: 537–547

Moawad M I, Shellhart W C, Matheny J, Paterson R L, Hicks E P 1996 Lip adaptation to simulated dental arch expansion. Part 2: One week of simulated expansion. Angle Orthodontist 66: 255–260

Nanda R S, O'Donnell S A, Ghosh J 1997 Perioral forces and dental changes with mandibular lip bumper treatment. European Journal of Orthodontics 19: 457–458 (Abstract)

Nevant C T, Buschang P H, Alexander R G, Steffen J M 1991 Lip bumper therapy for gaining arch length. American Journal of Orthodontics and Dentofacial Orthopedics 100: 330–336

Osborn W S, Nanda R S, Currier G F 1991 Mandibular arch perimeter changes with lip bumper treatment. American Journal of Orthodontics and Dentofacial Orthopedics 99: 527–532

Proffit W R, Phillips C 1988 Adaptations in lip posture and pressure following orthognathic surgery. American Journal of Orthodontics and Dentofacial Orthopedics 93: 294–302

Shellhart W C, Moawad M I, Paterson R L, Matheny J 1996 Lip adaptation to simulated dental arch expansion. Part 1: Reliability and precision of two lip pressure measurement mechanisms. Angle Orthodontist 66: 249–254

Shellhart W C, Moawad M I, Mathney J, Paterson R L, Hicks E P 1997 A prospective study of lip adaptation during six months of simulated mandibular dental arch expansion. Angle Orthodontist 67: 47–54

Soo N D, Moore R 1991 A technique for measurement of intra-oral lip pressures with lip bumper therapy. American Journal of Orthodontics and Dentofacial Orthopedics 99: 409–417

Thüer U, Ingervall B 1986 Pressure from the lips on the teeth and malocclusion. American Journal of Orthodontics and Dentofacial Orthopedics 90: 234–242

Thüer U, Ingervall B 1990 Effect of muscle exercise with an oral screen on lip function. European Journal of Orthodontics 12: 198–208

Thüer U, Janson T, Ingervall B 1985 Application in children of a new method for the measurement of forces from the lips on the teeth. European Journal of Orthodontics 7: 63–78