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The congenitally missing upper lateral incisor. A retrospective study of orthodontic space closure versus restorative treatment

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SUMMARY Orthodontic treatment for patients with uni- or bilateral congenitally missing lateral incisors is a challenge to effective treatment planning. The two major alternatives, orthodontic space closure or space opening for prosthetic replacements, can both compromise aesthetics, periodontal health, and function.

The aim of this retrospective study was to examine treated patients who had congenitally missing lateral incisors and to compare their opinion of the aesthetic result with the dentists' opinions of occlusal function and periodontal health. In this sample, 50 patients were identified. Thirty had been treated with orthodontic space closure, and 20 by space opening and a prosthesis (porcelain bonded to gold and resin bonded bridges). The patient's opinion of the aesthetic result was evaluated using the Eastman Esthetic Index questionnaire and during a structured interview. The functional status, dental contact patterns, periodontal condition, and quality of the prosthetic replacement was evaluated.

In general, subjects treated with orthodontic space closure were more satisfied with the appearance of their teeth than those who had a prosthesis. No significant differences in the prevalence of signs and symptoms of temporomandibular dysfunction (TMD) were found. However, patients with prosthetic replacements had impaired periodontal health with accumulation of plaque and gingivitis.

The conclusion of this study is that orthodontic space closure produces results that are well accepted by patients, does not impair temporomandibular joint (TMJ) function, and encourages periodontal health in comparison with prosthetic replacements.

Introduction

The prevalence of congenitally missing teeth in people of Northwest European origin has been examined and reported by many authors. This varies between 6 and 10 per cent (Grahnén, 1956; Haavikko, 1971; Hunstadbraten, 1973; Ravn and Nielsen, 1973; Thilander and Myrberg, 1973; Bergström, 1977; Locht, 1980; Rölling, 1980; Lervik and Cowley, 1983; Bredy *et al*., 1991; Aasheim and Ögaard, 1993), with a prevalence of congenitally missing maxillary lateral incisors between 1 and 2 per cent. Approximately 20 per cent of all congenitally missing teeth are maxillary laterals, this being the third most common missing tooth after upper and lower second premolars. It has been found that agenesis of both maxillary lateral incisors is more common than agenesis of only one (Stamatiou and Symons, 1991). Sex differences in prevalence have usually been found to be small with slightly more females than males affected (Bergström, 1977; Rölling, 1980; Brook, 1984; Aasheim and Ögaard, 1993). Finally, there seems to be an association between hypodontia and malformation of the maxillary laterals, which may be reduced in size or

simplified in shape, often becoming peg-shaped (Markovic, 1982; Brook, 1984; Lai and Kim Seow, 1989).

The demand for orthodontic treatment in patients with congenitally missing upper lateral incisors is high because the condition has an obvious impact on facial aesthetics, adversely affecting an individual's self-esteem. It may even provoke an unfavourable response from others in society (Stricker, 1970; Shaw *et al*., 1980; Hobkirk *et al*., 1994).

In an experimental study of the influence of variation in the morphology of the maxillary anterior segment, using modified portrait photographs, those with a missing lateral were, among other things, more commonly associated with a higher level of aggressiveness than those showing incisors in a normal position (Shaw, 1981).

In a study of similar design (Sergl and Stodt, 1970), it was reported that well-executed orthodontic space closure in patients with missing upper laterals led to no significant deterioration in appearance. However, a midline shift, incorrect axial inclination, and large residual spaces mostly impaired the aesthetic appearance.

These findings are reflected in the weightings of several indices for the assessment of orthodontic treatment need (Grainger, 1967; Saltzman, 1968; Linder-Aronson, 1974; Cons *et al*., 1986; Brook and Shaw, 1989).

The orthodontic treatment of patients with uni- or bilaterally congenitally missing laterals presents many problems with respect to treatment planning. The two major treatment alternatives, orthodontic space closure, or opening space for prosthetic replacements or implants, are both compromises in terms of aesthetics, periodontal health, and function.

During the first half of this century, most orthodontic texts advocated an Angle's Class I canine relationship. The reason was the conviction, based on clinical experience, that no other arrangement was satisfactory from the aesthetic point of view. A mesial canine relationship, with the canine placed next to the central incisor, was thought to result in a 'carnivorous' appearance, to reduce the size of the upper arch, and to produce a loss of harmony and symmetry of the mouth (Angle, 1907; Wheeler, 1950).

More recently, on grounds of function and dysfunction, the importance of a canine protected occlusion on lateral movements has been emphasized. When canines have been advanced to replace laterals and close space, there is no opportunity for canine rise during lateral mandibular movements. Consequently, the replacement of missing laterals has been advocated by some authors (Stuart and Stallard, 1957; D'Amico, 1958; Thomas, 1967).

Since the 1950s it has become more common to advise orthodontic space closure and nowadays this is perhaps the main clinical recommendation for this condition (Hotz, 1974; Shaw, 1994). The reason for this was the poor aesthetic quality of earlier prostheses and concerns regarding periodontal health. Patients who have had orthodontic space closure have been found to be significantly healthier than those with prostheses (Nordquist and McNeill, 1975). Furthermore, the two groups did not differ significantly in respect to occlusal function and the prevalence of temporomandibular dysfunction (TMD) (Nordquist and McNeill, 1975; Senty, 1976).

However, it has been shown that reshaping maxillary canines to resemble lateral incisors more closely, greatly improves aesthetics in subjects where space closure has been carried out, at least according to the opinion of dentists (Carlson, 1952; Tuverson, 1970; McNeill and Joondeph, 1973; Zachrisson, 1978; Thordarsson *et al*., 1991). In addition, according to an evaluation using study casts, the poor aesthetic appearance of the canine eminence may have been exaggerated (Henns, 1974). Finally, a prosthetic replacement may be the treatment of choice in patients where there is a colour incompatibility between maxillary canines and central incisors, a stable Angle Class I buccal segment relationship, generalized spacing of the teeth, a tendency to a Class III malocclusion or additional congenitally missing teeth in the quadrant which also have to be replaced (McNeill and Joondeph, 1973; Zachrisson and Thilander, 1985).

What are the grounds for reconsidering these recommendations today? First, the studies are relatively old. Modern prosthetic tooth replacements (e.g. porcelain bonded to gold,

resin-bonded bridges, and single tooth implants) may give a better result in terms of periodontal health and general aesthetics. Secondly, patient satisfaction with the treatment has never been evaluated concerning aesthetics, and the patient's opinion is certainly more important than the dentists!

The aim of this retrospective study was therefore to examine and compare aesthetics (according to the opinion of the patient), occlusal function, and periodontal health in subjects with one or both upper lateral incisors congenitally missing, who had received either orthodontic space closure or space opening followed by a modern prosthetic replacement for the missing incisor. Subjects with implants were excluded from this part of the study as the follow-up periods for these individuals were considered to be too short and will be included in an ongoing prospective study.

Subjects and methods

Subjects

The sample in this study consisted of 50 patients with congenitally missing upper lateral incisors selected from the files of the Orthodontic Department, Public Dental Service, Mölndal Hospital; Sweden.

The selection criteria were:

1. Congenital absence of UR2 and/or UL2.
2. Only one tooth missing in each maxillary quadrant.
3. Subjects born before 1971.
4. Patients not treated with implants to replace the missing lateral incisors.

One-hundred-and-three patients met these criteria. This original group comprised 75 per cent females, 65 per cent of whom had been treated with orthodontic space closure. The majority of the subjects, 73 per cent, had bilaterally missing lateral incisors.

Fifty-six were randomly selected and contacted, first in writing and then by telephone and informed of the study. Six subjects could not participate as they had left the area and moved to other parts of Sweden. Fifty subjects agreed to participate and these formed the study group.

Thirty-six subjects (72 per cent) were females and 14 (28 per cent) males. The mean age of the subjects at the follow-up examination was 25.8 years, median 24.6 with a range of 18.4–54.9 years. The mean average time after completion of treatment was 7.1 years, median 6.8 with a range of 0.5–13.9 years. Thirty-nine subjects (almost 80 per cent) had absent upper left and right lateral incisors. Eleven subjects (just over 20 per cent) had just one missing lateral incisor.

When comparing sex distribution on space closure versus prosthetic replacement and bilateral/unilateral missing teeth, there was no significant difference between the original group and the randomly selected sample.

The patients who had been treated with orthodontic space closure (OSC group) and those who had been treated with prosthetic replacements (PR group) were compared with respect to age, sex, time since completion of treatment, and incidence of unilateral or bilateral absent lateral incisors. There were no statistically significant differences between the two groups. These data are set out in Table 1.

Table 1 Distribution of age, sex, uni- or bilaterally missing teeth, and post-treatment interval in the OSC (orthodontic space closure) and PR (prosthetic replacement) groups. Age and post-treatment interval presented in years and SD. Number of females/males and missing teeth.

	OSC group (n = 30)	PR group (n = 20)	Significance
Age	25.5 ± 7.5	26.1 ± 6.2	NS
Female/male	23/7	13/7	NS
Unilaterally/bilaterally missing teeth	7/23	4/16	NS
Post-treatment interval	7.1 ± 3.3	7.2 ± 3.8	NS

Methods

All interviews and clinical examinations were performed by one examiner (SR).

Aesthetic evaluation

The patient's perception of the general dental appearance was assessed using a modified version of the Eastman Esthetic Index questionnaire (Howitt *et al*., 1967; Table 2).

A structured interview was conducted in which the patients were asked their opinion of tooth shape, tooth colour, the space distribution around their upper anterior teeth, and the symmetry of their teeth, choosing one of three statements: (1) satisfied, (2) dissatisfied, or (3) no opinion.

- Dissatisfaction with tooth shape meant the tooth being too pointed, too thin, too broad, or too big.
- Dissatisfaction with tooth colour indicated that the tooth was too yellow, too grey, too dark, or too light.
- Dissatisfaction with the space distribution around their upper incisors, their teeth being too crowded or with gaps present between the teeth.
- Dissatisfaction with symmetry due to right or left side differences in shape or colour of the teeth or a midline shift.

The reproducibility of the subjects' statements of perception of aesthetics was tested. Fifteen subjects were interviewed and completed the questionnaire twice at intervals of 4–6 months. None had changed their opinion on the aesthetics of the teeth. Three subjects had changed their opinion in the comparison of the teeth and the face. The comparison with their friends showed greater variation. Five patients had changed their statements, four of these including 'no opinion'. Satisfaction with the shape of the tooth next to the central incisor remained unchanged in all subjects, whereas two individuals changed their opinion about the shape of the canine. The perception of the colour of the tooth next to the central incisor changed for two out of 27 teeth. One subject changed opinion about maxillary

Table 2 Answers to the Eastman Esthetic Index questionnaire. Female/male ratio given within brackets.

	OSC group ($n = 30$)		PR group ($n = 20$)		Significance
	n	%	*n*	%	
1. How satisfied are you with the appearance of your teeth?					$P < 0.05$
very or mildly satisfied	28 (21/7)	93	13 (9/4)	65	
very or mildly dissatisfied	2 (2/2)	7	7 (4/3)	35	
no opinion	0	0			
2. How would you consider your teeth as compared with the entire face?					NS
nicer or better than average feature	9 (6/3)	30	4 (2/2)	20	
poorer or below average feature	5 (4/1)	17	3 (2/1)	15	
no opinion	16 (13/3)	53	13 (9/4)	65	
3. Compared with your friends, how do you think your teeth look?					$P < 0.05$
nicer or better than average	14 (10/4)	47	3 (3/0)	15	
among the worst or below average	5 (5/0)	17	8 (6/2)	40	
no opinion	11 (8/3)	37	9 (4/5)	45	

crowding and one for symmetry of the maxillary arch.

Study casts and 10 standardized photographs were taken for each subject. The examiner performed an evaluation in daylight of the colour of the teeth and the prosthetic replacements.

Using this material, further studies will be possible to analyse the details of aesthetics judged by both professionals and non-professionals.

Examination of function and dysfunction

A questionnaire concerning symptoms related to TMD, parafunction, and the quality of occlusal contacts was completed by the subjects. These questions are listed in Table 3.

A clinical examination of the functional status included measurements of the maximum range of mandibular movements, deviation of the mandibular path on opening, temporomandibular joint (TMJ) sounds, TMJ locking or luxation, pain during mandibular movements and muscle, and TMJ tenderness during palpation (Helkimo, 1974; Mohlin *et al*., 1991).

Tooth contacts during various mandibular movements were recorded, if necessary using thin articulation paper.

Finally, Helkimo's index of clinical dysfunction was calculated for each subject.

Examination of the periodontal condition

All teeth from the upper right second to the upper left second premolar were examined. The presence of plaque, bleeding on probing, pocket depth, and any features which might retain plaque (Björby and Löe, 1967) were recorded at four locations on each tooth. Buccal gingival retraction was also recorded (Table 4).

Examination of prostheses

The prostheses were evaluated using methods described by Karlsson (1986). These required the examination of the marginal adaptation of the abutments and the size of the inter-proximal space. Inter-proximal space was also examined and recorded in patients who had had orthodontic space closure. The colour of the prostheses and the surrounding natural teeth were also evaluated. The findings from this examination will be presented in a separate report.

Morphology

Complete pre-treatment records were not available for all subjects in this study. Thirty-nine lateral cephalometric radiographs and 41 sets of study models were available. Lateral cephalograms

Table 3 Questionnaire for symptoms of temporomandibular disorders (TMD).

Occlusal stability:	When you put your teeth together, do they always fit together in the same way? (1)
Speech difficulties:	Do you ever have any difficulties with your speech? (2)
Pain on mouth opening:	Do you ever get pain when chewing or opening your mouth? (3)
Mouth opening:	Do you ever have any difficulties in opening your mouth? (3)
Muscle stiffness or fatigue:	Do you ever feel that your jaw gets tired or stiff? (3)
TMJ clicking:	Do you ever hear a click from the TMJ? (3)
TMJ crepitation:	Do you ever hear crepitation sounds from the TMJ? (3)
Locking/luxation:	When you open your mouth, does your jaw ever get stuck or do you ever feel that it jumps out of place? (3)
Pain around the TMJ:	Do you ever get pain around the TMJ? (3)
Pain in jaw muscles:	Do you ever get pain in the facial muscles? (3)
Headache:	Do you ever get headache? (3)
Tooth grinding:	Do you ever grind your teeth? (3)
Tooth clenching:	Do you ever clench your teeth or hold them tightly together when you are not eating? (3)
Biting habits:	Do you ever bite your tongue, lip, or inside of your cheek? (3)

(1) 0 = They seem to fit well, 1 = they do not fit comfortably.
(2) 0 = Never, 1 = sometimes.
(3) 0 = Never, 1 = once or twice a month, 2 = once per week, 3 = twice or more often per week, 4 = daily.

Table 4 Clinical recording of periodontal status.

Plaque:	Plaque/no plaque upon probing
Bleeding:	Bleeding/no bleeding after pocket depth recording
Pocket depth:	Pockets exceeding 3 mm recorded
Attachment level:	Distance cemento-enamel junction-pocket base. Distance exceeding 1 mm recorded
Retention factors:	Caries, calculus and over-contour of prosthetic replacements:
	(a) no contact with gingival margin
	(b) in contact with gingival margin
	(c) ≥1 mm apical of gingival margin
Buccal gingival	(a) cemento-enamel junction not visible
retraction:	(b) cemento-enamel junction and less than 2 mm of root surface visible
	(c) cemento-enamel junction and 2 mm or more of root surface visible

had obviously not been condidered necessary for treatment planning in some cases. Some of the original study models had not been saved due to long duration from initiation of treatment to follow-up.

The radiographs of 24 subjects with OSC and 15 with PR were assessed using the reference points of the Bergen analysis (Hasund, 1972). The soft tissue profile was analysed using four different measurements (Bishara *et al*., 1985):

1. Facial contour angle (Gl'–sn–Pog'; Burstone 1958).
2. Holdaway's soft tissue angle (LS–Pog'–NB; Bishara *et al*., 1985).
3. Ricketts' aesthetic plane to the upper lip, in millimetres (Pr–Pog':LS).
4. Ricketts' aesthetic plane to the lower lip, in millimetres (Pr–Pog':LI) (Bishara *et al*., 1985).

The use of these four measurements provided different information on the relationships and changes in the soft-tissue profile.

The pre-treatment study casts represented 48 quadrants with a congenitally missing lateral in the OSC group and 26 quadrants in the PR group. The Angle classification, overjet, and vertical relationships were analysed. Using brass wire and an electronic digital calliper, a space analysis was performed according to Björk *et al*. (1964).

Statistical methods

Continuous variables were subjected to *t*-tests to identify any systematic differences between the results. Variables using chi-squared were tested to identify differences between the categories.

Results

Subjects and treatment

Thirty subjects had been treated with space closure and 20 with space opening and a prosthesis. In 12 subjects resin-bonded bridges were used. The remaining eight patients had the missing teeth replaced with porcelain bonded to gold bridges. Seventy-seven per cent of the subjects treated with space closure were females. This percentage was slightly lower (65 per cent) in the group treated with prosthetic replacements.

Aesthetics

The answers to the questions in the Eastman Esthetic Index are shown in Table 2. The distribution of sexes for the replies is shown within brackets. In the OSC group, 93 per cent of the subjects were very or moderately satisfied with the appearance of their teeth (Question 1) compared with 65 per cent in the PR group ($P < 0.05$).

The majority of the respondents did not have any opinion on the appearance of their teeth in comparison with their entire face (Question 2). The subjects in the OSC group were significantly more satisfied ($P < 0.05$) with the appearance of their teeth compared with their friends, than subjects in the PR group (Question 3).

Table 5 presents the patients' opinions on tooth shape, tooth colour, space conditions, and symmetry of the maxillary anterior teeth. The two groups were equally satisfied with the shape of the teeth next to the maxillary central incisors.

The subjects in the two groups disagreed about whether the colour of the tooth next to the central

Table 5 The subjects' opinion of shape, colour, space conditions, and symmetry of the maxillary anterior teeth.

	OSC group		PR group		Significance
	n	%	*n*	%	
1 Opinion of the shape of the tooth next to the central maxillary incisor ($n = 89$)					
satisfied	39	74	26	72	
dissatisfied	14	26	10	28	
no opinion	0	0	0	0	NS
2 Opinion on the colour of the tooth next to the central maxillary incisor ($n = 89$)					
satisfied	24	45	29	81	
dissatisfied	29	55	7	19	
no opinion	0	0	0	0	$P < 0.001$
3 Opinion on space condition in the maxillary anterior segment ($n = 50$)					
satisfied	24	80	15	75	
dissatisfied	6	20	5	25	
no opinion	0	0	0	0	NS
4 Opinion on the symmetry of the maxillary anterior segment ($n = 50$)					
satisfied	20	67	10	50	
dissatisfied	10	33	10	50	
no opinion	0	0	0	0	NS

incisor was satisfactory and the disagreement was statistically significant ($P < 0.01$). The main complaint from those in the OSC group was that the canine replacing the missing lateral looked too yellow.

Approximately 80 per cent in both groups were satisfied with the space conditions for the upper anterior teeth.

Altogether, 40 per cent were dissatisfied with the symmetry of the upper incisor segment due to differences in shape and colour of the teeth next to the central incisor. In subjects with a unilaterally missing incisor, 73 per cent were dissatisfied with symmetry.

Mandibular function: anamnesis (Table 6)

Frequent headaches (weekly or daily) were reported by 20 per cent of the subjects. Parafunction, tooth clenching, and grinding, were common habits in 38 per cent of the respondents. TMJ sounds (clicking or crepitation) were

Table 6 Symptoms of temporomandibular disorders (TMD). Result of anamnestic questionnaire.

	OSC group ($n = 30$)		PR group ($n = 20$)		Significance
	n	%	*n*	%	
Headache					
never	15	50	9	45	
monthly	7	23	9	45	
weekly	8	27	2	10	
daily	0	0			NS
Tooth clenching and grinding					
never/very seldom	19	63	12	60	
sometimes/often	11	37	8	40	NS
TMJ sounds					
never/very seldom	24	80	15	75	
monthly/weekly	6	20	5	25	NS

reported to occur weekly or monthly in 22 per cent of the subjects. Pain or difficulties on opening, locking or luxation, and finally, a feeling of occlusal instability were either never or very seldom reported. No statistically significant differences between the OSC and PR groups were found in the anamnesis.

Temporomandibular dysfunction: clinical signs (Table 7)

The range of mandibular movement was normal in all but two subjects. Pain provoked by mandibular movement was found in 18 per cent of subjects. Deviation of the mandible during opening or closing was recorded in 38 per cent of individuals. Muscle tenderness on palpation in at least one muscle was recorded in 74 per cent of the subjects. The most commonly affected muscles were the lateral pterygoid and the insertion of the temporalis muscle. No significant differences in the prevalence of clinical signs of TMD were found between the OSC and PR groups.

Helkimo's Clinical Dysfunction Index

Most subjects (72 per cent) showed no or only mild dysfunction. Twenty-six per cent had moderate dysfunction and only one individual severe dysfunction. There were no statistically significant differences between the OSC and PR groups.

Tooth contact pattern (Table 8)

There were no statistically significant differences in sagittal or vertical separation of centric relation (CR) and centric occlusion (CO) between the two groups. Twenty-two per cent of subjects had a lateral deviation of more than 0.5 mm between CR and CO, but none were found to have an anterior forced bite. Unilateral contact in centric relation was found in 68 per cent of subjects. A canine rise on laterotrusion (up to 3 mm) was recorded in 16 per cent of all quadrants, 4 per cent in the OSC group, and 33 per cent in the PR group. The difference between the groups was statistically significant ($P < 0.01$).

Non-working side interferences during lateral movements of up to 3 mm were found in 15 per cent of quadrants and in 20 per cent of individuals. This type of interference was more frequent in the OSC group. However, the differences between the two groups were not statistically significant.

The average number of tooth contact pairs during lateral excursions of up to 3 mm was 1.47 (SD 1.17) in the OSC group and 2.03 (SD 1.44) in the PR group. The difference between the groups was statistically significant ($P < 0.05$). When quadrants with a canine rise were excluded,

Table 7 Signs of temporomandibular disorders (TMD).

	OSC group ($n = 30$)		PR group ($n = 20$)		Significance
	n	%	*n*	%	
Pain provoked by mandibular movements					
no	25	83	16	80	
yes	5	17	4	20	NS
Deviation of the mandible during opening					
no	18	60	15	75	
yes	12	40	5	25	NS
TMJ sounds					
no	20	67	11	55	
yes	10	33	9	45	NS
Muscle tenderness on palpation					
no	7	23	6	30	
yes	23	77	14	70	NS

Table 8 Prevalence of different types of recorded tooth contacts and occlusal interferences. OSC group ($n = 30$), PR group ($n = 20$). Laterotrusion up to 3 mm.

	OSC group		PR group		Significance
	n	%	*n*	%	
Distance centric relation-centric occlusion sagitally					
<0.5 mm	22	73	13	65	
≥0.5 mm	8	27	7	35	NS
Distance centric relation-centric occlusion vertically					
<0.5 mm	19	63	12	60	
≥0.5 mm	11	37	8	40	NS
Lateral deviation exceeding 0.5 mm between centric relation and centric occlusion	6	20	5	25	NS
Non-working side interferences on laterotrusion	8	27	2	10	NS
	n = 53% quadrants:		*n* = 36% quadrants:		Significance
Unilateral contacts in centric relation	22	42	12	33	NS
Canine rise on laterotrusion	2	4	12	33	$P < 0.001$
Non-working side interferences on laterotrusion	10	19	3	8	NS

this difference increased ($P < 0.01$). The number of tooth contact pairs was then 1.49 (SD 1.19) in the OSC group and 2.54 (SD 1.53) in the PR group.

Periodontology (Table 9)

There was a statistically significant difference ($P < 0.01$) in the presence of plaque and bleeding on probing in eight locations between the

Table 9 Recordings describing the periodontal condition. OSC group, $n = 53$ quadrants. PR group, $n = 36$ quadrants.

	OSC group ($n = 53$)		PR group ($n = 36$)	
	Mean	SD	Mean	SD
Number of locations with plaque. Maxillary centrals and canines	1.36	1.58	2.81	1.51 $P < 0.001$
Number of locations with bleeding after probing. Maxillary centrals and canines	1.51	1.28	2.61	1.50 $P < 0.001$
Number of locations with plaque. Maxillary premolars	2.36	1.74	2.36	2.01 NS
Number of locations with bleeding after probing. Maxillary premolars	2.67	1.45	2.92	1.65 NS
Number of locations with retention factors grade b and c. Maxillary centrals and canines	0.19	0.68	1.32	1.09 $P < 0.001$

maxillary central incisors and canines. There was no statistically significant difference in the presence of plaque and bleeding in the premolar area between the two groups.

Only a few pockets deeper than 3 mm were found. Buccal gingival retraction was found on average in 1.1 teeth in the 89 quadrants examined. There were no statistically significant differences between the OSC and PR groups.

Local factors, which encouraged plaque retention on centrals and canines, were more commonly found in the PR group. The difference was statistically significant ($P < 0.001$).

Morphology

The cephalometric analysis suggested a more retrognathic maxilla in the PR subjects. The mean ANB angle was 2.1 in the PR group compared with 3.3 in the OSC group ($P < 0.05$). The mean SNA angle was 79.2 and 81.4, respectively, while the SNB angle was 77.1 and 78.1, respectively. There was no statistically significant difference when comparing the SNB and SNA angles.

The soft tissue profile analysis showed minor differences between the two groups. The mean facial contour angle (Gl'–sn–Pog') was 14.2 in the OSC group and 12.9 in the PR group, while the mean Holdaway's soft tissue angle (LS–Pog'–NB) was 10.4 and 10.8, respectively. The mean values for Ricketts' aesthetic plane to the upper lip (Pr–Pog':LS) were 4.9 mm in the OSC group and 3.2 mm in the PR group, and the values for Ricketts' aesthetic plane to lower lip (Pr–Pog'–LI) were 3.6 in the OCS group and 1.5 in the PR group ($P < 0.05$).

According to the study casts, 65 per cent of the subjects in the OSC group and 67 per cent of subjects in the PR group had an Angle's Class I occlusion, with almost similar overjet and overbite relationships. The mean overjet in the OSC group was 2.3 mm (S.D 1.5) and in the PR group 2.1 mm (S.D 1.4), while the mean overbite was 3.0 mm (S.D 1.5) in the OSC group and, in the PR group, 2.5 mm (S.D 1.5). No statistically significant differences were found.

A space analysis showed systematic differences between the subjects in the two groups. In the mandible, the mean available space was +0.1 mm in the PR group and –2.1 mm in the OSC group ($P < 0.05$). The difference was even greater in the maxilla. When comparing maxillary quadrants, the mean value was +5.7 mm per quadrant in the PR group and +2.7 mm per quadrant in the OSC group ($P < 0.001$).

Discussion

In the original patient group as well as in the randomly selected sample there was a sex difference, females being in the majority. This difference may partly be explained by a true sex difference in the prevalence of congenitally missing teeth (Aasheim and Ögaard, 1993; Bergström, 1977; Rölling, 1980; Brook, 1984). Another explanation may be a higher demand for orthodontic treatment in females (Shaw *et al*., 1980; Salonen *et al*., 1992; Wheeler *et al*., 1994), although recent information indicates the female proportion of patients in a specialist orthodontic clinic to be no more than 55–60 per cent (Bäckström and Mohlin, 1998). The nature of the possible difference in perception of dental aesthetics is not fully understood. A study of aesthetic perception with special reference to congenitally missing teeth is under preparation.

All subjects were old enough to have an appreciation of aesthetics, according to Espeland and Stenvik (1991). Most of the subjects were still relatively young and the time since the completion of orthodontic or prosthetic treatment was comparatively short. This must be borne in mind when the functional and periodontal consequences of these two treatment regimes are compared. More differences between the OSC and PR groups may develop with time.

The reproducibility of statements on aesthetic perception appeared in most instances to be satisfactory. The major exception was the comparison of tooth appearance with friends. The difference in aesthetic satisfaction between the OSC and PR groups cannot be fully explained in this study. The stability of orthodontic space closure appears to be good; almost 95 per cent in the OSC group expressed satisfaction with their appearance (despite a fairly high dissatisfaction with the colour of the canines replacing the

laterals) and 80 per cent were satisfied with the space conditions. The reasons for the more modest satisfaction with prosthetic replacement might arise from the general impression of artificial in comparison with natural teeth, or there might be differences in colour between replacements and natural teeth, or finally, that the PR group included more asymmetric cases.

The slightly higher proportion of females in the OSC than in the PR group could be due to the higher prevalence of crowding in women than in men (Ingervall *et al*., 1978; Mohlin, 1982; Salonen *et al*., 1992). Among morphological variables, space conditions appears to have had the greatest influence on the decision of space closure versus replacement.

Although the subjects in the OSC group seemed to be fairly satisfied with the treatment results, there appeared to be dissatisfaction with the lack of colour balance between the maxillary canines and adjacent teeth. A more careful pre-treatment examination of colour compatibility and/or further treatment intended to minimize the colour imbalance seems to be indicated.

A study analysing the patients' aesthetic evaluation of various differences in alignment, symmetry, tooth colour, tooth position, and other variations in the treatment results, is being undertaken.

There were no significant differences in the prevalence of signs and symptoms of TMD, and this agrees with earlier observations that occlusal factors have only a fairly small influence on the development of dysfunction in young adults (Droukas *et al*., 1984; Pilley *et al*., 1992, 1997) and with previous studies of treatment of congenitally missing upper lateral incisors by space closure and prosthetic replacements (Nordquist and McNeill, 1975; Senty, 1976). The importance of a canine rise on lateral movement seems to have been exaggerated. This also agrees with previous results (Ingervall, 1972; Ingervall *et al*., 1980; Mohlin, 1983; Pilley *et al*., 1992, 1997). Apart from the much higher prevalence of a canine rise during laterotrusions, there were only small differences in the tooth contact patterns between the two groups. The prevalence of non-working side interferences in the OSC group (27 per cent), although the difference was not statistically significant from the PR group, exceeded the prevalence in many other studies (Droukas *et al*., 1984; Ingervall, 1972; Ingervall *et al*., 1980; Mohlin, 1983) and is comparable to figures found in a sample of adults with dysfunctional symptoms (Agerberg *et al*., 1970). Reproducibility of the functional recordings used has been discussed in a previous paper and was found to be acceptable (Mohlin *et al*., 1991).

The prostheses tended to accumulate more plaque and also gave rise to an increased number of locations with gingivitis. The subjects were too young for conclusions to be drawn on the influence that prostheses may have on long-term periodontal health. Incidentally, all prostheses examined in this study were of the modern type and most of them had been made by specialists in prosthodontics.

It might be expected that there would be systematic differences in the allocation of subjects to the two treatment groups. The choice of treatment plan may depend on factors such as colour balance, space conditions, sagittal relationship, and soft tissue profile.

Cephalometrically, subjects in the PR group seemed to have a slightly more retrognathic maxilla.

According to the cast analysis, the only clear systematic pre-treatment difference concerned the space conditions. In the OSC group, the lack of space in the mandible required, in several cases, extraction of permanent mandibular teeth. In the maxilla, the excess of space was much higher in the PR group compared with the OSC group. Thus, in this study, the amount of available space in the maxilla and the mandible seems to have been the main influence on the choice of treatment, whilst the cephalometric analysis played a minor role.

Conclusions

This study indicates that orthodontic space closure in subjects with congenitally missing lateral incisors produces treatment results that appear to be reasonably stable and better accepted by the patients than prosthetic replacements of modern design, although single implants have not been included in this study.

It is not yet known how variations in morphology and colour in the maxillary anterior segment influences a patient's aesthetic perception.

There was no difference in the prevalence of dysfunction, but there was a somewhat greater tendency to accumulate plaque and develop gingivitis in subjects with prosthetic replacements. No conclusions can be drawn at present about the long-term influence on oral health and function due to the relatively short post-treatment interval and the young average age of the patient.

Further studies, both retrospective and prospective, are in progress. There are early suggestions that patients who have received implants are more satisfied with this kind of replacement than those with orthodontic space closure, and especially those who have been treated with conventional prostheses.

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