Factors Affecting Decision-Making For Congenitally Missing Permanent Maxillary Lateral Incisors: A Retrospective Study

Keywords

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ABSTRACT

The aims of this study were as follows: 1) to retrospectively evaluate clinical situations of patients with congenitally missing permanent maxillary lateral incisors (CMPMLI) who were referred to three dental clinics specialised in prosthodontics over a 14-year period and 2) to investigate the factors affecting decision-making for patients with CMPMLI. The records of 46 patients with CMPMLI who were treated over a period of 14 years were examined to determine the mechanism of decision-making for treatment planning and factors affecting the decision. Descriptive statistics were used in the initial analysis of the entire data set. In addition, a correlation coefficient—the nonparametric Spearman's rho coefficient—was calculated to trace any possible relation between variables or rank orders. The significance level was set at 0.05 for the analysis. The results of this study revealed that decision-making for treatment of CMPMLI is directly dependent mainly on the following four factors:

1. Patient's age at treatment commencement

2. Individual characteristics of each clinical situation, which play a crucial but not an exclusive role in the treatment approach

3. Synthesis of the participating specialists in the treating team, which plays a crucial role in the decision-making

4. Use of pin-retained resin-bonded bridges (RBBs), either bilaterally attached or cantilevered, proved to be a reliable solution in terms of aesthetics, function and soft tissue response during the study period.

Clinical implication: The rationale in the decision-making process for patients with congenitally missing permanent maxillary lateral incisors was investigated in this study to determine whether specific treatment options are superior to others.

INTRODUCTION

Permanent teeth that are most commonly congenitally missing are the permanent maxillary lateral incisors. The condition may be unilateral or bilateral. It may be an individual anomaly or one of several orofacial symptoms of certain genetic syndromes.[1]

Congenital absence of teeth usually has a genetic/hereditary basis, and many affected individuals have a family history of developmental dental anomalies.[2] Congenital absence of teeth typically has a complex and poorly defined genetic background, with >200 genes involved in tooth formation.[1,3] Among these genes, the paired box 9 gene (PAX9) codes for a transcription factor expressed in the tooth mesenchyme during tooth morphogenesis. Mutations in this gene have been implicated in arresting tooth development at the bud stage.4 Furthermore, in a large case-controlled study on 306 unrelated Portuguese individuals, it was found that single nucleotide polymorphisms in the PAX9 gene were associated with a high risk of maxillary lateral incisor agenesis.[5]

According to the theory of species evolution, the craniofacial structure in humans tends to decrease in the anterior–posterior direction. This tendency has led to the disappearance of the last tooth from each group of teeth (T2, P2 and M3).[1,6]

Despite the fact that genetic/hereditary factors account for the absence of teeth from the dental arch in majority of the cases, environmental factors such as trauma (fractures and extractions of primary teeth),[5] radiotherapy,[7,8] chemical substances or drugs[9] and disturbances in jaw innervations can also account for missing teeth.[10,11]

Congenital absence of one or more teeth is the most common genetic abnormality of the human dentition.[12] Regarding prevalence, CMPMLI has been reported to occur in 3.5%–6.5% of individuals of the Caucasian race, with females outnumbering males by a ratio of 3:2.[13-15] In one study, this ratio was reported to be 2:1.[16] Additionally, bilateral agenesis of maxillary permanent lateral incisors occurred more often than unilateral agenesis.[17]

In a recent multicentric epidemiological study of 4006 Italian orthodontic patients, it was found that the tooth types that were missing most often were the mandibular second premolars (20.3%), followed by the maxillary lateral incisors (17.8%) and maxillary second premolars (7.4%).18 The prevalence of dental agenesis was 9%, and the most common bilateral missing teeth were the mandibular second premolars (1.9%) and maxillary lateral incisors (1.6%).[18]

In the Caucasian population, CMPMLI accounts for approximately 20% of all missing teeth.[17] In the Chinese and Japanese populations, the absence of mandibular incisors was found to be more prevalent than that of maxillary lateral incisors.[19] In Malaysian children, the mandibular incisors were the most commonly missing teeth.[19,20]

The treatment choices for CMPMLI include the following:

orthodontic space closure, in which the missing lateral incisor are substituted with reshaped canines; orthodontic space opening, in which the missing teeth are replaced with either teeth or implant-supported fixed partial dentures (FPDs), such as a conventional FPD, resin-bonded bridge (RBB) or implant-supported crown (ISC); and autotransplantation of one or both developing maxillary premolars in place of CMPMLI.[21]

To the best of our knowledge, the present retrospective clinical study is the first to describe the involvement of dental specialists and evaluate the factors affecting decision-making for the treatment of Greek patients with CMPMLI for 14 years. The treatment choice of space closure versus space opening (which is the preferred approach to achieve long-term success in terms of function, aesthetics and periodontal health) is still controversial among orthodontists and prosthodontists.[22-24] An interdisciplinary approach and interactions between orthodontists and prosthodontists are essential for optimal treatment planning.[25]

However, certain factors and clinical characteristics favour one treatment option over the other.

1. Space closure with a reshaped canine substitution is favoured in the following situations:[26-30]

a) Unilateral CMPMLI

b) Balanced profile, normal inclination of the anterior teeth and a tendency toward crowding

c) Canines and premolars of similar size and colour

d) Bi-maxillary dentoalveolar protrusion

e) Class II malocclusion

2. Space opening is favoured in the following situations:[31, 32]

a) Well-aligned Class I malocclusion with normal intercuspation of posterior teeth

b) Pronounced spacing of the maxillary dentition and normal mandibular dentition

c) Class III malocclusion with retrognathic profile

d) Large size differences between canines and first premolars

e) Considerable differences in size between the canine and the contralateral incisor.

3. Criteria and recommendations for autotransplantation are as follows:[33-38]

a) Timing of root development of the donor premolar (roots of the donor premolar should be <75% formed)

b) Adequate space in the arch

c) No jiggling contacts between donor tooth and opposing teeth during post-surgery healing

d) Performance of the procedure by skilled surgeons

e) Restoration of the auto-transplanted teeth by veneers or full crowns.

The differences and challenges lie in the application of these factors in treatment planning and long-term management of patients with CMPMLI. Absence of lateral incisors, whether unilateral or bilateral, may cause a variety of aesthetic, functional, social and psychological complications and may affect an individual's oral health-related quality of life.[39,40]

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In a retrospective study of 451 patients with dental agenesis, the most common patient complaints included spacing in the dental arches, poor aesthetics and awareness of the missing teeth.[41] It is suggested that delayed referral of the patient has negative educational and social consequences for these patients.[41] Furthermore, therapy for CMPMLI may be a severe financial burden for orthodontic or prosthodontic patients and their families.[42] Treatment plans needed to manage the missing teeth in patients with CMPMLI are complex and require an interdisciplinary approach and interactions between orthodontists, prosthodontists and other specialists to ensure an optimal therapeutic outcome. However, the decision-making process regarding the best treatment plan for CMPMLI continues to cause controversy among orthodontists, prosthodontists and other specialists.

The aims of this study were as follows: 1) to retrospectively evaluate clinical situations of patients with CMPMLI who were referred to three dental clinics specialised in prosthodontics over a 14-year period and 2) to investigate the factors affecting decision-making for patients with CMPMLI. The null hypothesis was that the process of deciding the treatment approach for CMPMLI is related to the individual characteristics of each clinical situation rather than to the synthesis of the participating specialists in the treating team.

MATERIAL AND METHODS

Forty-six patients with CMPMLI belonging to the Caucasian race were treated over a 14-year period (2003–2016) at three clinics specialised in prosthodontics. Patients 1–32 and patients 43–46 were treated at dental clinic 1 (by NMK and SNK); patients 33–37 were treated at dental clinic 2 (by ALP) and patients 38–42 were treated at dental clinic 3 (by DT).

The data were obtained from the electronic files of the archive systems of the three clinics. Of the 46 patients, 43 had been referred to these clinics mostly by general practitioners or pedodontists, and the other three patients (patients 30, 31 and 32) were self-referred.

Male and female patients with unilateral or bilateral CMPMLI were eligible for inclusion in the study. The exclusion criterion was the presence of unilateral or bilateral CMPMLI that was part of an orofacial genetic syndrome. Therefore, four patients (patients 43–46 from dental clinic 1) were excluded from the study. Details of the patients' sex and age are presented in Table 1.

The following data were recorded from patient's files: full mouth periapical, panoramic and cephalometric radiographs; diagnostic casts; and facial photographs (frontal and lateral).

Clinical examination and data collection were followed by consultation with an orthodontist to discuss the appropriate treatment plan. Alternatives of the treatment plan were discussed with patients or with patients along with their parents, and all factors associated with each treatment option, such as advantages and disadvantages, were explained. For patients interested in implant placement, an oral surgeon was also included in the treatment group. Because of the earlier skeletal maturation in females, the age limit for implant placement was set to >17 years of age for female patients and >25 years of age for male patients.[43,44] Possible complications in case of implant placement were discussed. Factors such as the cost and duration of the treatment were analysed. The long-term success rates of RBBs were also presented because RBBs would serve as permanent or interim restorations if implants were to be the treatment of choice.

Table 1. Details of patient gender and age.

Patients	n= 42
Gender	F : n= 31 (cases: 2-5,9-23, 25-27, 29, 31, 32, 35-37, 40-42)
	M: n= 11 (cases: 1, 6-8, 24, 28, 30, 33, 34, 38, 39)
Age	F >17 : n= 10 (cases: 12, 19, 22, 23, 26, 27, 29, 31, 32, 40)
	M >18: n= 7 (cases: 1, 30, 33, 34, 37, 38, 39)

On agreement of the appropriate treatment plan, patients were referred to the orthodontist for orthodontic interventions, which was followed by prosthodontic treatment. On treatment completion, patients' level of satisfaction was recorded.

All patients were enrolled in a yearly follow-up recall programme for monitoring the functionality, soft tissue response (periodontal and peri-implantation status), aesthetic outcome and technical condition. For the functional condition regarding the temporomandibular joint, the Helkimo dysfunction index was used. For the periodontal and peri-implant status, plaque index, bleeding index (BI), probing depth and gingival index were used. In patients with pin-retained RBBs, pulp vitality was monitored. Technical complications of the restorations and implants were also monitored.

STATISTICAL ANALYSIS

Descriptive statistics were used in the initial analysis of the whole data set. Descriptive statyistics were used in the initial analysis of the whole data set *(Table 2*). Frequency tables and medians were estimated. In addition, a correlation coefficient—the nonparametric Spearman's rho coefficient—was calculated to trace any possible relation between variables or rank orders. The significance level was set at 0.05 for the analysis. Moreover, nonparametric tests were conducted to evaluate whether several independent samples belonged to the same population. The Kruskal–Wallis H test was used to detect differences in the distribution of the sample population (at a significance level of 0.05). The distribution of certain characteristics favouring space opening or closing, as listed in Tables 3 and 4, was explored using the Z test for column proportions (adjusted by the Bonferroni method at a significance level of

Table 2. Details of clinical characteristics.

	Class I	Class II Divis1	Class III	Bilateral CMPMLI	Unilateral CMPMLI	Smile line HIGH	Smile Line LOW*	Canine & premolar different in size & color	Canine & premolar similar in size & color	Tendency towards crowding	Pronounced spacing of maxillary dentition and normal mandibular dentition.	Considerable difference in size between canine and contralateral incisor
Clinical characteristics favoring space opening	n= 40		n= 1 (case: 32)	n=24 (cases: 1, 2, 3, 5, 6, 8, 9, 11, 15, 17, 18, 19, 20, 21, 22, 23, 26, 27, 32, 35, 36 38,39,40)		n =22 (cases: 2, 4, 8, 9, 10, 12, 13, 14, 15, 17, 18, 19, 22, 23, 28, 31, 32, 33, 36, 37, 40, 41)		n = 25 (cases: 2, 3, 6, 7, 8, 10, 12, 13, 14, 15, 16, 17, 24, 27, 28, 30, 31, 32, 34, 36, 37, 38, 40, 41. 42)		NO n= 39	NO n=40	YES : n= 8 (cases: 7, 12, 16, 24, 25, 32, 33, 42)
Clinical characteristics favoring space closing		n= 1 (case 28)			n=18 (cases: 4, 7, 10, 12, 13, 14, 16, 24, 25, 28, 29, 30, 31, 33, 34, 37, 41, 42)		n = 20 (cases: 1, 3, 5, 6, 7, 11, 16, 20, 21, 24, 25, 26, 27, 29, 30, 34, 35, 38, 39, 42)		n = 17 (cases: 1, 4, 5, 9, 11, 18, 19, 20, 21, 22, 23, 25, 26, 29, 33, 35, 39)	YES n= 3 (cases: 12, 13, 28)	YES n=2 (cases: 6, 8)	NO : n= 10 (cases: 4, 10, 13, 14, 28, 29, 30, 31, 34, 37, 41)

***** : gingival margin is not visible at maximum lip opening.

Table 3. Cases and characteristics favoring space closing.

Cases with 4 characteristics favoring space closing	
N=1	Case: 28
Cases with 3 characteristics favoring space closing	
N=4	Cases: 4, 29, 30, 34
Cases with 2 characteristics favoring space closing	
N=10	Cases: 7, 10, 13, 14, 24, 25, 31, 33, 41, 42

Table 4. Cases and characteristics favoring space opening.

Cases with 6 characteristics favoring space opening	
N=1	Case: 32
Cases with 5 characteristics favoring space opening	
N=4	Cases: 2, 15, 17, 40
Cases with 4 characteristics favoring space opening	
N=8	Cases: 3, 9, 18, 19, 22, 23, 36, 38
Cases with 3 characteristics favoring space opening	
N=11	Cases: 1, 5, 6, 8, 11, 20, 21, 26, 27, 35, 39
Cases with 2 characteristics favoring space opening	
N=0	Case: -

0.05). Details of the treatment provided, specialists involved and type of missing CMPMLI replacements are listed in Table 5. The correlations involving treatment provided, specialist involved and type of CMPMLI replacement are listed in Table 6.

All statistical analyses were conducted using the SPSS v25 statistical software (IBM, Armonk, N.Y).

RESULTS

The data obtained in this retrospective study disproved the stated null hypothesis. The results showed that the decision-making process of the treatment approach of CMPMLI seems to be related to the participation of the specialists in the treating team rather than to the individual characteristics of each case.

Three patients treated for space closure when they were teenagers (patients 30, 32) self-referred as adults to the prosthodontic dental clinics mainly for "smile improvement." Their records revealed that these were cases of a Class I molar relationship without malocclusion, which is a major

Table 5. Details of treatment provided, specialists involved and type of missing CMPMLI replacement

Treatment provided	Space closed : n= 3 (cases: 30, 31, 32)
	Spaced opened: n= 39
Specialist involved*	O : n= 3 (cases: 30, 31, 32)
	O + P : n= 30 (cases: 1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 35, 36, 41, 42)
	O + P + S : n= 9 (cases: 3, 28, 29, 33, 34, 37, 38, 39, 40)
Type of CMPMLI replacement	RBB (conventional) bilaterally attached: n=15 (cases: 1, 2, 16, 28, 29, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42)
	RBB pin retained bilaterally attached: n= 17 (cases: 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 23, 27)
	RBB pin retained cantilever: n= 7 (cases: 19, 20, 21, 22, 24, 25, 26)

* O = Orthodontist, P = Prosthodontist, S = Oral Surgeon

Table 6. Spearman's rho correlation coefficient for specialist involved, treatment provided and type of CMPMLI replacement.

Factor	Specialist involved	Treatment provided	Type of CMPMLI replacement
Specialist involved		0,564**	0,843**
Treatment provided	0,564**		0,470**
Type of CMPMLI replacement	0,843**	0,470**	

**p = 0.05 (two-tailed).

clinical characteristic favouring space opening. In these patients, the clinical characteristics in favour of space opening outnumbered those in favour of space closing.[30] These patients desired smile improvement, which was accomplished using all-ceramic FPDs *(Figure 1)*. For these cases, no information on the temporomandibular joint functionality, soft tissue response and possible technical complications was available because these patients failed to attend the follow-up recall programme.

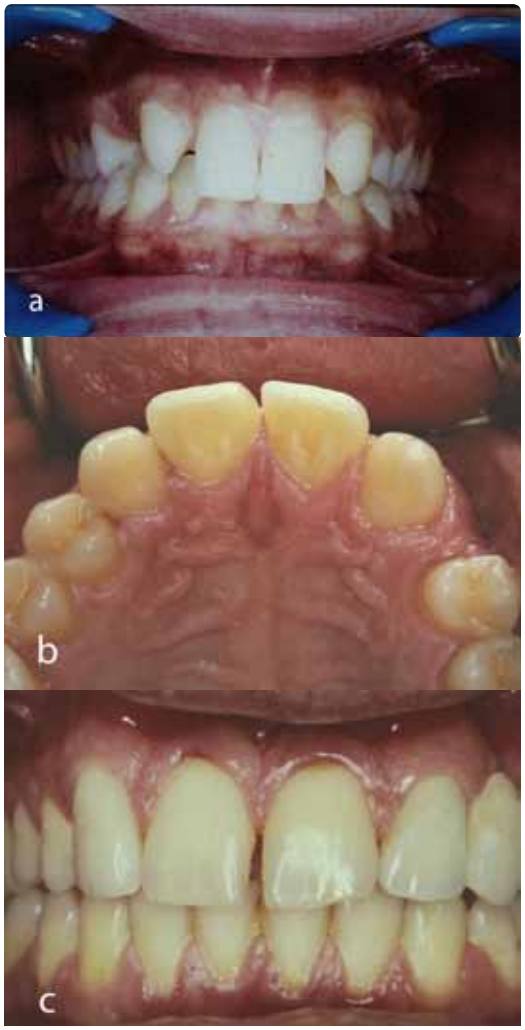

Figure 1a-c: Smile improvent in a patient treated for space closure, using all-ceramic FPDs

One female who received an implant at the age of 18 years (patient 29) self-referred 4 years later for aesthetic improvement (because of Infraocclusion of the ISC).

A new ISC was fabricated to compensate for the aesthetic problem, at least partially, because the gingival zenith of the new ISC was higher than those of the central incisors and canines *(Figure 2*). No statistically significant difference in was recorded in the temporomandibular joint functionality or soft tissue status.

A man who received an implant at the age of 25 years (patient 28) self-referred 10 years later with complaints of sensitive and bleeding gingiva around the all-ceramic ISC as well as mobility of the ISC.

Clinical and radiographic examination revealed peri-implant soft and hard tissue deficiency (peri-implantiitis, stage IV grade C; Figure 3). Surgical intervention (implant extraction and bone augmentation at the extraction site) was done to manage the peri-implatitis.

Fifteen patients (patients 1, 2, 26, 28, 29 and 33–42) had RBBs of earlier types (base metal frame, intaglio surface acid-etched and cemented with adhesive resin cement). In eight

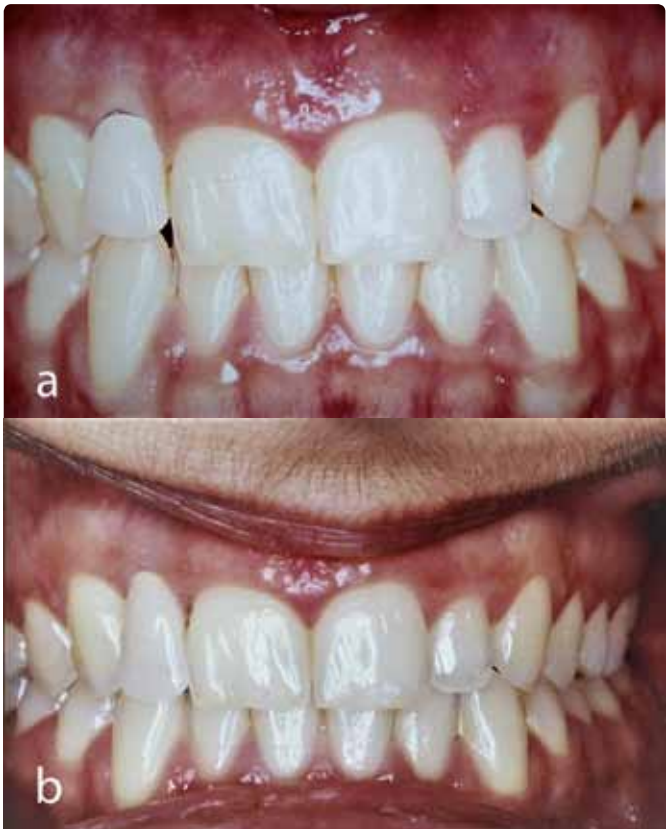

Figure 2a & b: Infraocclusion of the ISC 4 years after implant placement

patients (patients 28, 29, 33, 34 and 37–40), the RBBs served as interim restorations prior to implant placement. No problems were recorded during that time (3–5 years). In seven patients (patients 1–3, 35, 36, 38 and 42), the RBBs served as permanent restorations. Those seven patients failed to attend the follow-up recall programme beyond that time, and therefore, no further data were recorded for them.

Eighteen patients (patients 3–18, 23 and 27) had pin-retained RBBs with two retainers *(Figure 4*), whereas six patients (patients 19–22, 24 and 25) had pin-retained cantilever RBBs *(Figure 5*). In these eighteen patients, no technical (debonding) or aesthetic problems were recorded (survival rate, 100% over a mean time of 12 years [range, 10–14 years]). Moreover, no statistically significant differences were recorded in the function of the temporomandibular joint or soft tissue status, and pulp vitality of the abutment teeth was found to be normal.

DISCUSSION

Among the patients, females outnumbered males (33 and 13, respectively). This difference is higher than those reported by Stamatiou and Symons[16] and Polder *et al.*[17] and may be explained by the higher demand for orthodontic treatment by female patients.[22,45,46]

Because all patients in this study were aged >12 years, which is the minimum age for autotransplantation of premolars for replacement of CMPMLI, the remaining alternatives were either space closure or space opening.

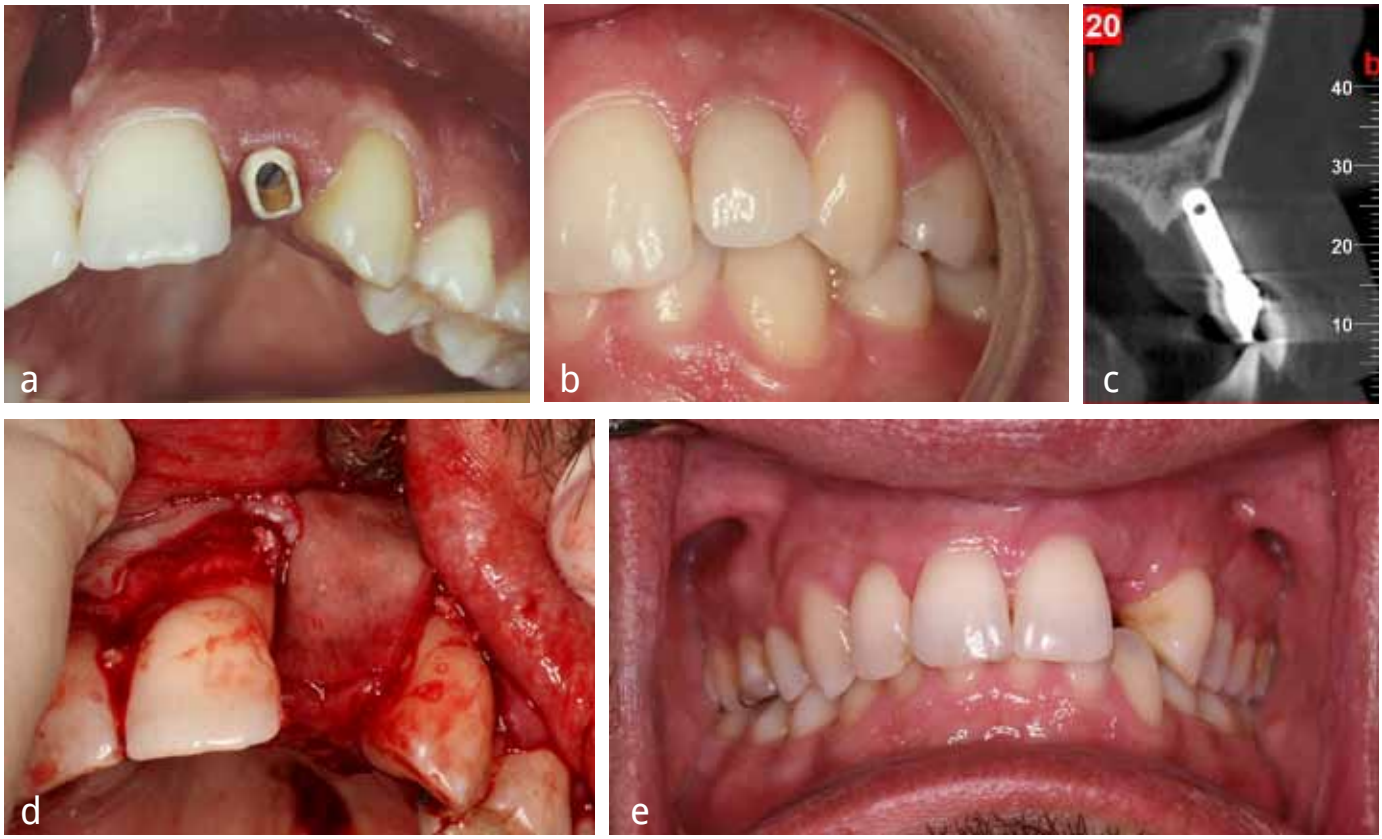

Figure 3a-e: Implant failure 10 years after implant placement

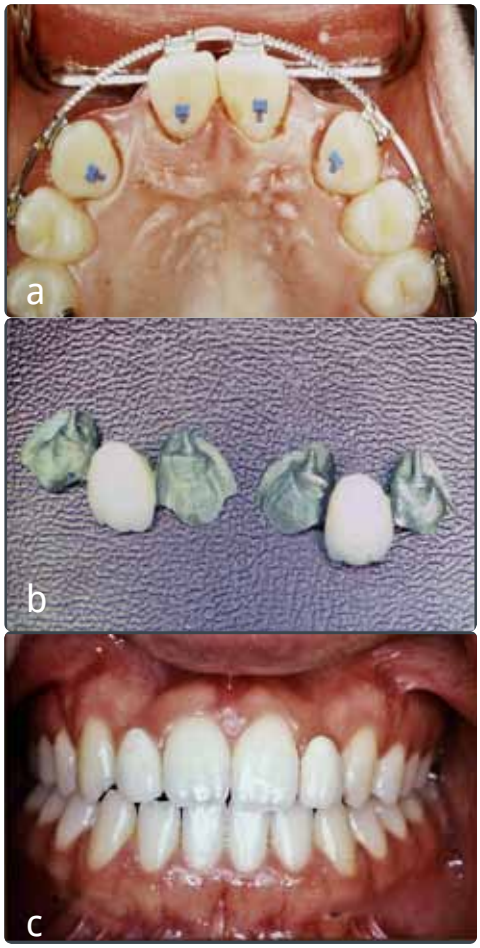

Figure 4a-c: Pin-retained RBBs with two retainers

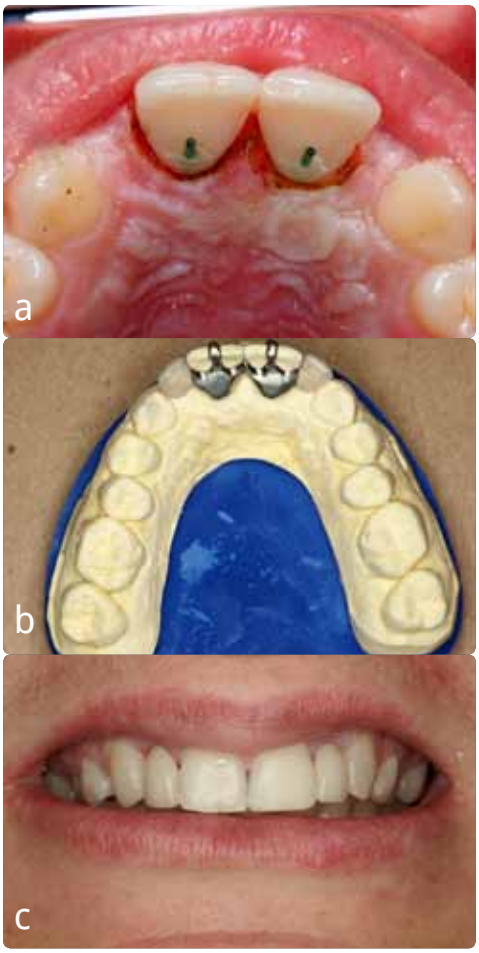

Figure 5a-c: Pin-retained RBBs with one retainer (cantilever)

Three patients (patients 30–32) had been treated with space closure when they were teenagers in provincial cities of northern Greece. In these patients, the decision of performing space closure had been made solely by the treating orthodontist (a prosthodontist was not involved in decision-making), despite the fact that these patients exhibited major clinical characteristics in favour of for space opening.[28] All patients had Class I molar relationships without malocclusion, which is a major clinical characteristic in favour of space opening; all patients exhibited many other clinical characteristics in favour of space opening instead of space closure.[30] This observation is in agreement with the findings of Louw *et al*.[47] who reported that orthodontists who do not communicate with or seek the opinion of prosthodontists mostly prefer space closure. These three patients and six others (1, 2, 35, 36, 38 and 42) failed to attend the follow-up recall programme, and therefore, it was impossible to monitor the functional, periodontal and aesthetic outcomes of the treatment. Of note, the three patients mentioned first resided out of town, having to travel >100 km to reach the dental clinics, which did not facilitate recall visits.

For the remaining 39 patients, space opening was selected, and the decision was made by the orthodontist after consultation with a prosthodontist. In nine of these 39 patients, an oral surgeon was also involved in the decision-making process.

The time of implant placement is crucial; if implants are placed before the completion of facial growth, the risk of infraocclusion of the implant crown increases. According to Oesterle and Croning,[44] facial growth is completed by 17 years of age in females, whereas it may not be completed until as late as 25 years of age in males. Age was relied upon in this study because it is safe (no need for exposure to accumulative radiation), simple and inexpensive compared with other methods of determining bone maturity, such as hand–wrist radiography[48,49] or the cervical vertebral maturation method, involving superimposition of serial lateral cephalometric radiographs obtained 6 months–1 year apart.[49,50]

None of the aforementioned methods can ensure that infraocclusion of the implant crown will not occur; it has been shown that the facial dimensions change even in mature adulthood.[51]

This implies that at consultation, patients have to be informed that the implant crown may need to be replaced in the future.

Of the eight patients with implants in this study, one presented with aesthetic problems caused by changes in facial dimensions and another presented with stage IV grade C periimplantitis. For the period until implant placement, RBBs of earlier types were chosen as interim restorations. Of these nine patients, eight returned for implant treatment. The remaining patient (patient 3) postponed the implant placement because he was satisfied with the RBB restoration.

The remaining 31 patients, for whom a prosthodontist was involved with the orthodontist in the treatment planning for space opening, CMPMLIs were replaced by RBBs. Of these bridges, eight were of the earlier types, and the other 24 (treated in dental clinic 1) had a pin or pins as a feature in the lingual cusp of the abutment teeth for increased bridge retention because of parallel tooth walls produced during pinhole preparation.[52] Of the RBBs in these 24 patients, 17 were bilaterally attached and seven were cantilevered; in these patients, pin-retained RBBs proved to be a reliable solution in terms of aesthetics, function and soft tissue responses for the time frame of this study. Finally, statistical analysis provided strong evidence that the involvement of specialists is a statistically important parameter in treatment selection. No statistical differences were observed concerning the distribution of the characteristics between treatments. A positive significant correlation was detected among the following pairs: the specialist involved and treatment provided, the specialist involved and type of CMPMLI replacement as well as the treatment provided and type of CMPMLI replacement.

CONCLUSIONS

The results of this study revealed that decision-making for treating CMPMLI is directly dependent mainly on the following four factors:

1. Patient's age at treatment commencement
2. Individual characteristics of each clinical situation, which play a crucial but not an exclusive role in the treatment approach
3. Synthesis of the participating specialists in the treating team, which plays a crucial role in the decision-making. When the orthodontists did not communicate with or seek the opinion of prosthodontists, the preferred solution appeared to be space closure. Conversely, when a prosthodontist was a member of the treating team, the space opening and restoration of the CMPMLI by RBBs seemed to be the preferred solution for adolescent patients. When a surgeon participated in the treatment group, the preferred solution seemed to be space opening and replacement of the CMPMLI with implant-supported restorations.
4. 4. Use of pin-retained RBBs, either bilaterally attached or cantilevered, proved to be a reliable solution in terms of aesthetics, function and soft tissue response during the study period.

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