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Periodontal effects of surgically assisted rapid palatal expansion evaluated clinically and with cone-beam computerized tomography: 6-month preliminary results

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Introduction: Transverse maxillary deficiency is frequently observed in patients who seek orthodontic treatment. In skeletally mature patients, transverse maxillary deficiency can be treated with surgically assisted rapid palatal expansion (SARPE). Forces delivered by the expander produce areas of compression in the periodontal ligament, which could lead to alveolar bone resorption and possible changes in the attachment level. The aim of this prospective clinical study was to evaluate the periodontal effects of SARPE by means of a complete clinical evaluation and cone-beam computerized tomography (CBCT) evaluation. **Methods:** The sample included 14 patients (5 males, 9 females), with a mean age of 23.0 ± 1.9 years (range: 16.4 to 39.7 years). All patients were treated using a bonded Hyrax-type expander, and the mean expansion was 9.82 mm (7.5 to 12.0 mm). All patients had a 1-year retention period. CBCT scans were taken, and periodontal charts were completed at time points T0 (initial) and T1 (6 months after expansion). **Results and Discussion:** SARPE seemed to have little detrimental clinical effects on the periodontium. Radiographic data demonstrated statistically significant changes: a significant decrease in the buccal alveolar bone thickness on most teeth, a significant increase in the palatal alveolar bone thickness on most teeth, a decrease in the buccal alveolar crest level of all canines and posterior teeth, and a tendency toward a decrease in the interproximal alveolar crest level on the mesial aspect of both central incisors. **Conclusions:** SARPE seems to have little detrimental effects on the periodontium clinically. However, radiographic data demonstrated some statistically significant changes, which could eventually have a significant clinical impact on the periodontium. (Am J Orthod Dentofacial Orthop 2011;139:S117-28)

Transverse maxillary deficiency is frequently observed in patients who seek orthodontic treatment[1,2] and is often characterized by unilateral or bilateral crossbite as well as anterior crowding.[2,3] There are different treatment approaches, depending on the skeletal maturity,[4,5] the amount of desired expansion,[6-8] and the presence of a concomitant sagittal or vertical problem.[9]

In skeletally immature patients, rapid orthopedic palatal expansion (RPE) is a common method of treatment.[2,10] However, as the patient matures and circummaxillary sutures[7] offer more and more resistance to expansion, this procedure produces predominantly dentoalveolar expansion[11,12] and may cause periodontal complications.

In skeletally mature patients, the deficiency can be corrected by segmental LeFort I osteotomy or surgically assisted rapid palatal expansion (SARPE).[6-9,13-16] When compared with RPE, SARPE is believed to limit the amount of tooth movement from dentoalveolar expansion, as it eliminates the sutural resistance to expansion and therefore produces few periodontal side effects.[14,16-19] Nevertheless, forces delivered by the expander still produce areas of compression in the

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Table I. Sample pretreatment characteristics

			Dental characteristics				*Skeletal characteristics*			
			Molar Relation							
	Sex	*Age*	*Right*	*Left*	*OJ*	*OB*	*SNA*	*SNB*	*ANB*	*FMA*
1	M	17.9 years	II (6)	II (5)	10.0	7.0	82.0	76.0	6.0	28.0
2	F	16.9 years	I	II (5)	4.0	3.0	78.0	79.0	−1.0	27.0
3	M	25.3 years	III (1)	III (3.5)	1.0	−1.0	82.5	81.0	1.5	29.0
4	F	16.9 years	I	II (4.5)	3.0	2.0	82.5	77.0	5.5	34.0
5	F	26.7 years	I	I	0.5	0.5	84.0	82.5	1.5	35.0
6	F	39.7 years	I	II (3)	3.0	2.0	77.5	73.0	4.5	32.0
7	F	20.4 years	II (3)	II (3)	6.5	6.0	85.0	76.5	8.5	31.0
8	M	20.7 years	I	I	5.0	0.0	86.0	78.5	7.5	33.0
9	F	27.1 years	II (3.5)	II (3)	1.5	7.5	81.5	73.0	8.5	35.0
10	M	18.2 years	II (4.5)	II (2)	2.5	2.5	77.5	76.0	1.5	28.0
11	F	16.4 years	I	I	3.0	4.0	81.5	78.5	3.0	22.0
12	F	25.2 years	II (5.5)	I	3.0	4.0	78.5	76.0	2.5	19.0
13	F	34.11 years	II (4)	II (7)	6.5	0.0	79.0	74.0	5.0	41.0
14	M	17.4 years	III (5)	III (5)	0.0	0.0	83.5	86.5	-3.0	24.0

periodontal ligament, which could lead to alveolar bone resorption and possible changes at the attachment level.[20-24]

Some studies have evaluated periodontal effects of orthopedic RPE,[21,25,26] yet limited information exists concerning SARPE.[27-29] The protocols used in past studies have been highly variable: clinical measurements,[21,29,30] radiographic measurements,[25,26,29] and measurements on models and/or pictures.[27,31,32] To date, no study has employed complete clinical and 3D radiographic evaluation of posterior teeth as well as central incisors. Only 2 published studies used tomography,[26,33] which is known to provide better quantitative 3D images of osseous changes.[34-36] Developed 2 decades ago, cone-beam computerized tomography (CBCT) is a multiplanar imaging technique that allows visualization of slices as well as 3D reconstructions like medical CT scanning does, with a better resolution and a far lower ionizing radiation dose.[36-44]

The purpose of this prospective and comparative clinical study was to evaluate the periodontal effects of SARPE by means of a complete clinical evaluation and a CBCT evaluation. The working hypothesis was that SARPE has no detrimental effect on the periodontium.

MATERIAL AND METHODS

This study was approved by the ethics committee of the Hôpital du Sacré-Coeur de Montréal. The sample included 14 patients (5 males, 9 females), with a mean age of 23.0 years ± 1.9 years (range: 16.4 to 39.7 years). Subjects were selected from among the patients who sought orthodontic treatment at the Faculté de médecine dentaire, Université de Montréal. The inclusion criteria were severe transverse maxillary deficiency (> 7 mm)[6]; advanced skeletal maturity as assessed by chronological age, cervical vertebral maturation,[45] and sexual secondary characteristics; no missing maxillary teeth (except lateral incisors); good general health; good periodontal health; good oral hygiene; nonsmoking status during the study period; and acceptance and signature of the consent form. The only exclusion criterion was any health problem that presented a contraindication to the surgery. Pretreatment and treatment characteristics of the sample are presented in Tables I and II.

All orthodontic clinical manipulations were performed by C.G. (resident in orthodontics) and supervised by A.P. (orthodontist). All patients were treated using a Hyrax-type expander, which was bonded to both first and second premolars as well as first molars with a metal extension on the mesial-occusal surface of the second molar to prevent supraeruption during the expansion and retention. The mean expansion was 9.82 mm (7.5 to 12.0 mm). All had a 1-year retention period (4 months with the Hyrax-type appliance and 8 months with a Hawley-type appliance) before fixed orthodontic treatment began. All surgeries were performed by the same oral and maxillofacial surgeon (N.P.). The surgery included osteotomies of the lateral walls of the maxilla, midpalatal suture, and pterygoid plates, as well as release of the nasal septum.

At this time, 2 time points were considered: T0 (initial) and T1 (6 months after expansion) for all patients. A periodontal chart was completed at each time point by a periodontist (R.V.). The collected data included probing depth, width of keratinized tissue, attachment level using the enamocemental junction, gingival recession, tooth mobility, bleeding on probing, and assessment of the furcations.

Table II. Sample treatment characteristics

	Screw	*Extraction*		*Surgery*	
	Expansion	*Without*	*With*	*One maxilla*	*Two maxillae*
1	7.50	X		X	
2	10.25	X			
3	9.75	X			
4	9.00		X		
5	10.50	X			
6	10.00	X			
7	9.00	X			
8	11.50	X			
9	10.50	X			
10	9.00		X		
11	9.00		X		
12	8.25		X		
13	11.25		X		X
14	12.00	X		X	

A CBCT (i-CAT, Imaging Sciences International, Hatfield, Pa) was taken at each time point, and scanning parameters were a visualization field of 22 cm (enlarged field), an acquiring time of 22 seconds, and a voxel size of 0.2 mm. During image acquisition, subjects were seated with the head stabilized, occlusal plane parallel to the floor, and teeth in maximal intercuspidation. The Digital Imaging and Communications in Medicine (DICOM) images were assessed with Dolphin 3D software, 10.5 version (Dolphin Imaging and Management Solutions, Chatsworth, Calif). All measurements were done by a blinded examiner (O.Q., resident in orthodontics, under the supervision of M.P. (oral and maxillofacial radiologist). The following parameters were recorded: buccal alveolar bone thickness (BABT) (Fig 1), palatal alveolar bone thickness (PABT) (Fig 2), buccal alveolar crest level (BACL) (Fig 3), and interproximal alveolar crest level (IACL) (Fig 4). From an axial section parallel to the occlusal plane (Fig 5), a curved planar reconstruction was made in which the imaging plane passed through the center of each maxillary tooth. A serial transplanar reconstruction was then made, giving 0.2-mm-thick and 0.5-mm-spaced orthogonal slices. The first 3 parameters were evaluated on slices that passed through each cusp, from the canine to the second molar on both sides. Palatal and buccal bone thicknesses were measured at a level 2 mm apical to the furcation of the right first molar. The fourth parameter was measured on a coronal slice passing through the long axis of each central incisor.

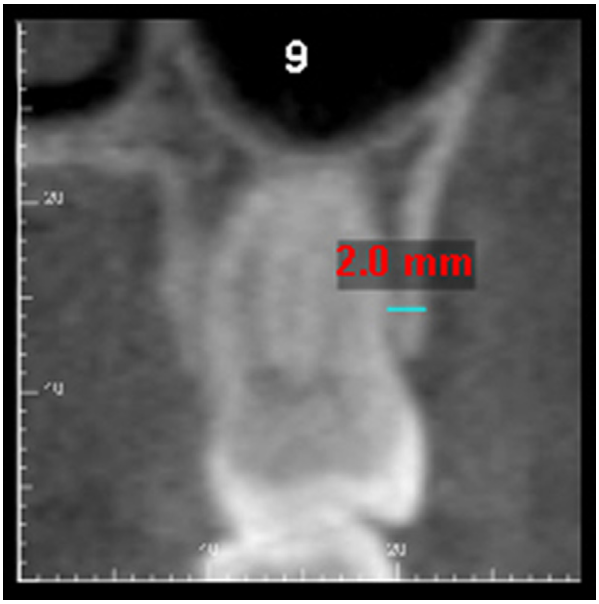

Fig 1. Radiographic image showing BABT.

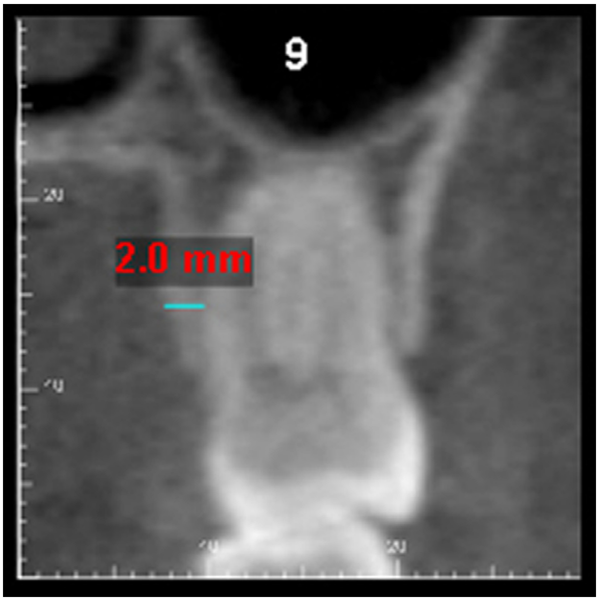

Fig 2. Radiographic image showing PABT.

Statistical analyses

The median, mean, and standard deviation of each variable were determined at T0 and T1, as well as changes between T0 and T1. Dependent *t* tests were calculated to compare all radiographic parameters, as well as the width of the attached gingiva. Wilcoxon tests were used to compare the level of attachment and mobility as well as the attached gingiva for control teeth, since data distribution did not follow normal law. All clinical measurements were taken twice within a 2-week interval for 5 teeth at T0 to establish intraexaminer reliability. As for

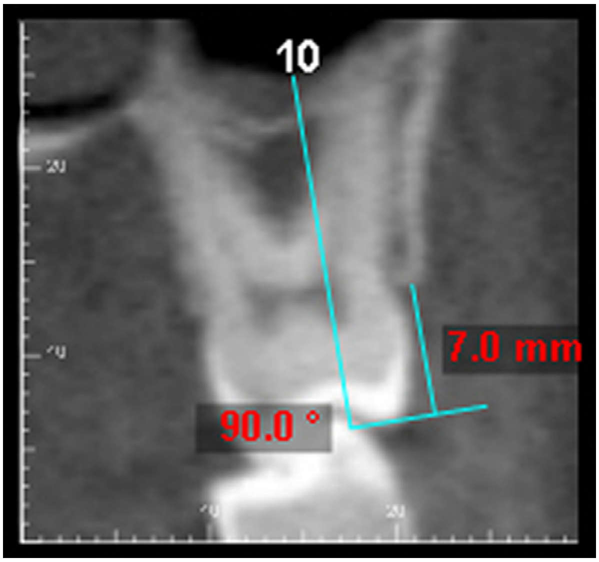

Fig 3. Radiographic image showing BACL.

Fig 4. Radiographic image showing IACL.

the radiographic measurements, 2 assessments of each parameter at T0 were taken for the right teeth at least 2 weeks apart. Both were expressed as the intraclass correlation coefficient, and it ranged from $r = 0.852$ to 1.000 for clinical measurements and from $r = 0.966$ to 0.996 for radiographic measurements. All results were regarded as significant for $P < 0.05$.

RESULTS

Evaluation of clinical data showed no significant change in the attachment levels between T0 and T1. The palatal aspect of maxillary teeth showed no change in attachment level between T0 and T1, with median 0.0 both at T0 and T1, all $P > 0.3173$. Changes in attachment level for the buccal aspect of maxillary teeth are presented in Table III. The first molars presented a tendency toward a loss of attachment at its buccal central aspect, which was not statistically significant ($P = .0656$). Changes in attachment level for both buccal and palatal aspects of central incisors are presented in Table IV. One patient who already had gingival recession on 5 teeth at T0 showed 5 new recession sites (0.5 to 1.0 mm) and worsening of the previous recessions of up to 1 mm. Two patients showed gingival recession (1 mm) at T1 on the mesial aspect of the central incisors. Eleven of the 14 patients lost the interdental papilla between the central incisors. The patients who showed evidence of a papilla at T1 had had a complete spontaneous closure of the interdental space that had been opened during the expansion phase.

The width of attached gingiva (Table V) showed statistically significant changes for the first molar on the right side and the second molar on both sides. The most significant decrease was observed on the second molar, with a mean of 0.8 ± 1.0 mm ($P = 0.0088$) and 0.9 ± 0.7 mm ($P = 0.0004$) on the right and left side, respectively.

There was a statistically significant increase in tooth mobility (Table VI) between T0 and T1 for all teeth, with the exception of the second molars, for which mobility changes were not statistically significant. Between T0 and T1, all central incisors had a grade I or grade II mobility according to the Miller Classification[46]; 6 of the 14 patients presented with grade II mobility. At T1, many teeth exhibited some mobility, but not more than a grade I mobility.

Radiographic analyses showed a significant decrease in the thickness of the alveolar bone on the buccal aspect (Table VII) of all premolars and molars and a significant increase on the palatal aspect (Table VIII) of most canines, premolars, and first molars. Second molars showed a slight decrease in the PABT. The most important changes of BABT were observed on the mesial aspect of the left first molar, with a mean of 0.6 ± 0.5 mm ($P = 0.0036$), which represents a loss of 55% of the initial thickness.

The height of the alveolar bone crest (Table IX) decreased on the buccal aspect of all canines and posterior teeth, but this decrease was not statistically significant for all teeth. The changes were more considerable clinically and statistically on the mesial aspect of the first molars and on the canines, with means of −3.3 ± 4.3 mm ($P = 0.0126$) and −2.4 ± 4.0 mm ($P = 0.0407$) for the right and left first molars, and −2.8 ± 4.5 mm ($P = 0.0385$) and −2.5 ± 3.4 mm ($P = 0.0166$) for the right and left canines. The height of alveolar bone crest between the central incisors (Table X) decreased as well, but the changes were not statistically significantly ($P = 0.0695$ and $P = 0.0590$).

Clinical data for the mandibular teeth (canine to second molar on the left side for all patients) were recorded

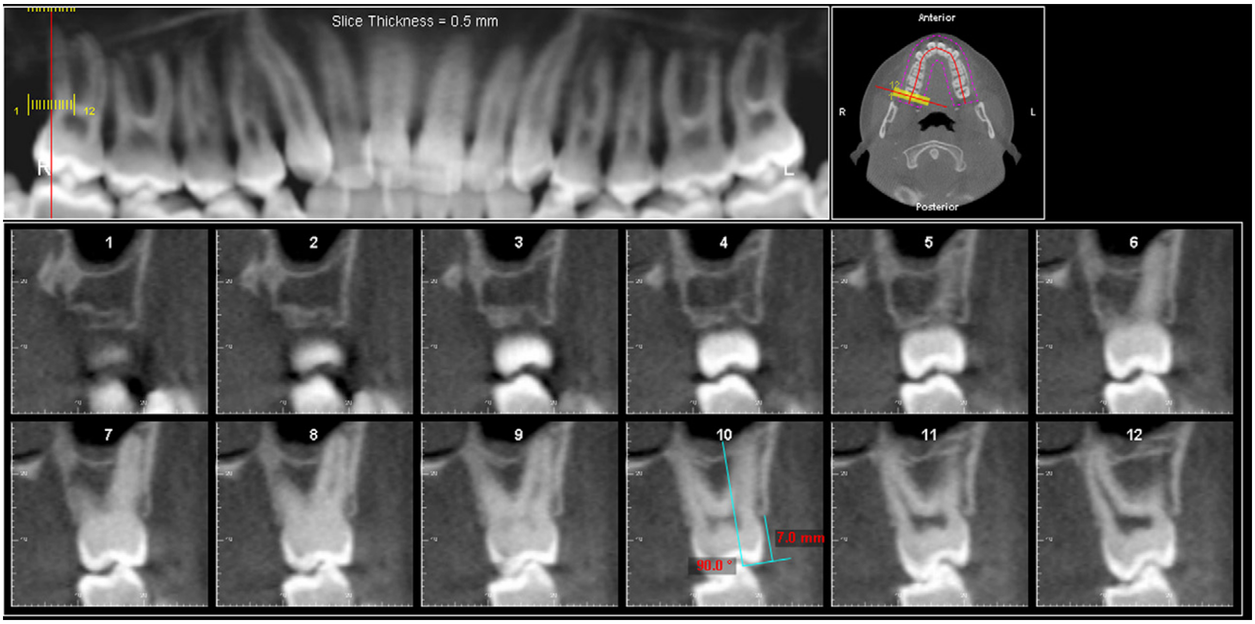

Fig 5. Images showing curved planar reconstruction and serial transplanar reconstruction made from an axial section

as controls of periodontal health maintenance. Tooth mobility as well as attachment level on both buccal and lingual aspects showed no change between T0 and T1, with median of 0.0 both at T0 and T1. Also, the attached gingiva (Tables XI and XII) showed no statistically significant changes. All P values range from 0.3173 to 1.0000, with the exception of the buccal width of attached gingiva of the lower canine ($P = 0.0833$).

Spearman correlations were calculated between changes in the height of alveolar bone and the initial thickness of buccal alveolar bone, the initial width of attached gingiva and the amount of expansion done. Only the amount of expansion showed a statistically significant correlation ($P = 0.0200$).

DISCUSSION

The novelty of this research project lies in the fact that it is the first reported study that has a stringent protocol to evaluate the periodontal effects of SARPE on posterior teeth, as well as canines and central incisors, by means of a complete periodontal evaluation and a 3D evaluation with CBCT. Since SARPE allows palatal expansion after releasing resistance coming from circummaxillary sutures, it is thought to produce little tooth movement and have few detrimental effects on the periodontium. The results of this present study seem to be partly in agreement with the current beliefs. Few statistically significant clinical changes were observed. However radiographic results showed many statistically significant changes that could eventually have a clinical impact on the periodontium.

Periodontal status is of particular interest in orthodontics, especially when expansion movements are involved. Alterations in the thickness of the surrounding bone and gingiva are observed, depending on the direction of the orthodontic forces. As a tooth is moved buccally, its buccal alveolar bone and its buccal gingiva get thinner, these teeth are then more prone to bone dehiscences and gingival recessions.[20,22,23,47-53] Some experimental animal studies have demonstrated dehiscences and fenestrations when teeth or apices of teeth were moved through thin periodontal tissues.[23,24]

At 6 months after expansion, clinical data showed few statistically significant changes. There was no significant change in the attachment level and recession, with a tendency toward an attachment loss on the buccal aspect of the first molars. This is in accordance with the results of recent studies and common clinical observations[17,27] showing that SARPE seems to have few adverse periodontal effects on posterior teeth. This is also in accordance with Greenbaum and Zachrisson[21] who observed an attachment loss of 0.5 mm on first molars after RPE. Most patients did not show any recession sites at T1. In our study, interestingly, one patient who already had gingival recession on 5 teeth at T0 showed 5 new recession sites (0.5 to 1.0 mm) and worsening of the previous recessions of up to 1 mm. Müller and Eger[54,55] and Müller et al[56] brought

Table III. Attachment level changes between T0 and T1 (Wilcoxon test) – buccal aspect of maxillary teeth, except incisors

	T0 Median (min–max)	T1 Median (min–max)	Number of subjects T0>T1	Number of subjects T0<T1	P
Right Molar - D	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
2nd Right Molar – C	0.0 (0.0-4.0)	0.0 (0.0-3.5)		1	0.2850
2nd Right Molar – M	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
Right Molar – D	0.0 (0.0-3.0)	0.0 (0.0-4.0)		1	0.3173
1st Right Molar – C	0.0 (0.0-4.0)	0.0 (0.0-4.0)	4		0.0656
1st Right Molar – M	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
2nd Right Premolar – D	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
2nd Right Premolar – C	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
2nd Right Premolar – M	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
1st Right Premolar – D	0.0 (0.0-2.5)	0.0 (0.0-0.0)	1		0.3173
1st Right Premolar – C	0.0 (0.0-0.0)	0.0 (0.0-3.0)		1	0.3173
1st Right Premolar – M	0.0 (0.0-2.5)	0.0 (0.0-0.0)	1		0.3173
Right Canine – D	0.0 (0.0-0.0)	0.0 (0.0-4.0)		1	0.3173
Right Canine – C	0.0 (0.0-4.0)	0.0 (0.0-4.0)	1		0.3173
Right Canine – M	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
Left Canine – M	0.0 (0.0-0.0)	0.0 (0.0-3.0)		1	0.3173
Left Canine – C	0.0 (0.0-4.0)	0.0 (0.0-3.0)	1		0.3173
Left Canine – D	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
1st Left Premolar – M	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
1st Left Premolar – C	0.0 (0.0-0.0)	0.0 (0.0-3.0)		2	0.1797
1st Left Premolar – D	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
2nd Left Premolar – M	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
2nd Left Premolar – C	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
2nd Left Premolar – D	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
1st Left Molar – M	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
1st Left Molar – C	0.0 (0.0-3.0)	0.0 (0.0-3.0)	1	2	0.5637
1st Left Molar – D	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
2nd Left Molar – M	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
2nd Left Molar – C	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
2nd Left Molar – D	0.0 (0.0-0.0)	0.0 (0.0-0.0)			

Since data did not follow normal law, median (min-max) are presented for these variables and Wilcoxon tests were used.

out the concept of periodontal biotype, which stipulates that a thin and delicate gingiva might be predisposed to recession after an inflammatory process. There was a statistically significant decrease (0.7 to 0.9 mm) in the width of the attached gingiva for the first molar on the right side and second molars on both sides. As the mucogingival junction does not move throughout life,[46] it is probably related to some attachment loss.

As described by Atherton[57], it was possible to appreciate gingival changes between the central incisors during the expansion period and the opening of the diastema. Most patients in the study lost the interdental papilla between the central incisors from T0 to T1, while the space between these teeth remained open. Carmen et al[27] reported the same for 6 of their 35 patients, in whom the alignment and the closure of the diastema allowed for new papilla formation. Tarnow et al[61] reported that when the measurement from the contact point to the crest of bone was 5 mm or less, the papilla was present almost 100% of the time.

The orthodontic effect of expansion—RPE or SARPE—with a tooth-borne anchorage device seems to be an increase in bone thickness on the palatal side and a decrease on the buccal side, as Garib et al.[25] already showed for RPE with a medical CT scan. This present study demonstrated the same changes: a significant decrease in the BABT of all premolars and molars and a significant increase in the PABT of most canines, premolars, and first molars. Changes in BABT ranged from 0.26 mm to 0.89 mm between T0 and T1, which represented one fourth to one half of the initial alveolar bone thickness. The most considerable clinical and statistical changes were observed on the distal aspect of the first molars. Furthermore, a decrease in the BACL was observed for all canines and posterior teeth, but this decrease was not statistically significant for all teeth. This is in

Table IV. Attachment level changes between T0 and T1 (Wilcoxon test) – buccal and palatal aspect of maxillary incisors

	T0 Median (min-max)	T1 Median (min-max)	Number of subjects		P
			T0>T1	T0<T1	
BUCCAL ASPECT					
Right Central Incisor – D	0.0 (0.0-0.0)	0.0 (0.0-3.0)		2	0.1573
Right Central Incisor – C	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
Right Central Incisor – M	0.0 (0.0-0.0)	0.0 (0.0-3.0)		2	0.1573
Left Central Incisor – M	0.0 (0.0-0.0)	0.0 (0.0-3.0)		2	0.1573
Left Central Incisor – C	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
Left Central Incisor – D	0.0 (0.0-3.0)	0.0 (0.0-4.0)		1	0.3173
PALATAL ASPECT					
Right Central Incisor – D	0.0 (0.0-0.0)	0.0 (0.0-2.5)		1	0.3173
Right Central Incisor – C	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
Right Central Incisor – M	0.0 (0.0-0.0)	0.0 (0.0-2.0)		1	0.3173
Left Central Incisor – M	0.0 (0.0-0.0)	0.0 (0.0-3.0)		1	0.3173
Left Central Incisor – C	0.0 (0.0-0.0)	0.0 (0.0-0.0)			
Left Central Incisor – D	0.0 (0.0-0.0)	0.0 (0.0-3.0)		1	0.3173

Since data did not follow normal law, median (min-max) are presented for these variables and Wilcoxon tests were used.

Table V. Attached gingiva changes between T0 and T1 (paired *t* test) – maxillary teeth

	T0	T1	T0-T1	P	P >0.05
2nd Right Molar	1.9 ± 0.3	1.1 ± 0.3	0.8 ± 1.0	0.0088	*
1st Right Molar	3.4 ± 0.5	2.7 ± 0.3	0.7 ± 1.0	0.0285	*
2nd Right Premolar	3.6 ± 0.4	3.5 ± 0.4	0.1 ± 0.7	0.4346	
1st Right Premolar	2.5 ± 0.4	2.1 ± 0.3	0.4 ± 0.8	0.0537	
Right Canine	2.5 ± 0.4	2.5 ± 0.4	0.0 ± 0.9	1.0000	
Right Central Incisor	3.2 ± 0.4	2.7 ± 0.4	0.5 ± 1.0	0.0893	
Left Central Incisor	3.1 ± 0.3	2.6 ± 0.3	0.5 ± 0.9	0.0682	
Left Canine	2.4 ± 0.4	2.3 ± 0.4	0.1 ± 0.5	0.4257	
1st Left Premolar	2.2 ± 0.3	1.8 ± 0.3	0.4 ± 1.0	0.1667	
2nd Left Premolar	3.1 ± 0.3	3.0 ± 0.3	0.1 ± 0.7	0.4346	
1st Left Molar	3.4 ± 0.3	2.8 ± 0.3	0.6 ± 1.0	0.0554	
2nd Left Molar	2.3 ± 0.3	1.4 ± 0.3	0.9 ± 0.7	0.0004	*

accordance with the findings of Garib et al[25] and Rungcharassaeng et al[26] for RPE. The changes were more considerable clinically and statistically on the mesial aspect of the first molars and on the canines. Looking at both clinical and radiographic results, it seems that first molars are the most affected teeth during SARPE using a bonded Hyrax-type appliance.

Ramieri et al[29] suggested that a bone-anchored appliance has fewer detrimental effects on the periodontium than a tooth-borne anchorage device. They documented adverse periodontal effects of SARPE as they used a bone-borne appliance and stated that these effects were predominantly between the central incisors. They reported mobility of no more than grade I for 11 of the 34 central incisors at the removal of the bone-anchored expander and on 4 of the 24 incisors evaluated 1 year after expansion. This suggests that there is a reduction in the mobility during the 1-year observation period. No premolar or molar presented any mobility. In our study, tooth mobility increased statistically for almost all teeth. All central incisors exhibited grade I or grade II mobility 6 months after expansion, 6 of the 14 patients having grade II mobility. Furthermore, many of the other teeth exhibited some mobility, but not more than a grade I mobility. It is essential to mention that the tooth-borne appliance was removed 4 months after expansion. All patients then received a Hawley-type appliance for the remainder of the retention period. Thus, mobility recorded at T1 cannot be entirely attributed to the recent removal of the expander. As the teeth were still bonded during the first 4 months

Table VI. Mobility changes between T0 and T1 (Wilcoxon test) — maxillary teeth

	T0 Median (min–max)	*T1* Median (min–max)	*Number of subjects* *T0>T1*	*T0<T1*	P	P >*0.05*
2nd Right Molar	0.0 (0-0)	0.0 (0-1)		2	0.1573	
1st Right Molar	0.0 (0-0)	1.0 (0-1)		8	0.0047	*
2nd Right Premolar	0.0 (0-0)	1.0 (0-1)		10	0.0016	*
1st Right Premolar	0.0 (0-0)	1.0 (0-1)		10	0.0016	*
Right Canine	0.0 (0-0)	0.0 (0-1)		3	0.0833	
Right Central Incisor	0.0 (0-1)	1.0 (1-2)		12	0.0017	*
Left Central Incisor	0.0 (0-1)	1.5 (1-2)		11	0.0024	*
Left Canine	0.0 (0-0)	0.0 (0-1)		4	0.0455	
1st Left Premolar	0.0 (0-0)	1.0 (0-1)		12	0.0005	*
2nd Left Premolar	0.0 (0-0)	1.0 (0-1)		9	0.0027	*
1st Left Molar	0.0 (0-0)	0.0 (0-1)		4	0.0455	*
2nd Left Molar	0.0 (0-0)	0.0 (0-1)		1	0.3173	

Since data did not follow normal law, median (min-max) are presented for these variables and Wilcoxon tests were used.

Table VII. BABT (Buccal alveolar bone thickness) changes between T0 and T1 (paired *t* test)

	T0	*T1*	*T0-T1*	P	P >*0.05*
2nd Right Molar – D	1.7 ± 0.2	1.1 ± 0.2	0.6 ± 0.7	0.0064	*
2nd Right Molar – M	1.8 ± 0.2	1.3 ± 0.2	0.5 ± 0.4	0.0009	*
1st Right Molar – D	1.6 ± 0.2	0.8 ± 0.2	0.8 ± 0.5	0.0000	*
1st Right Molar – M	0.8 ± 0.2	0.5 ± 0.2	0.4 ± 0.4	0.0043	*
2nd Right Premolar – B	2.0 ± 0.3	1.7 ± 0.3	0.4 ± 0.6	0.0483	*
1st Right Premolar – B	1.0 ± 0.1	0.7 ± 0.2	0.3 ± 0.4	0.0386	*
Right Canine – B	0.3 ± 0.1	0.3 ± 0.1	0.1 ± 0.2	0.3969	
Left Canine – B	0.4 ± 0.1	0.3 ± 0.1	0.0 ± 0.3	0.6663	
1st Left Premolar – B	1.2 ± 0.2	0.8 ± 0.2	0.4 ± 0.4	0.0023	*
2nd Left Premolar – B	2.3 ± 0.2	1.9 ± 0.2	0.5 ± 0.5	0.0036	*
1st Left Molar – M	1.0 ± 0.2	0.5 ± 0.2	0.6 ± 0.5	0.0013	*
1st Left Molar – D	1.8 ± 0.2	1.0 ± 0.2	0.9 ± 0.6	0.0001	*
2nd Left Molar – M	2.0 ± 0.2	1.4 ± 0.2	0.6 ± 0.5	0.0010	*
2nd Left Molar – D	2.1 ± 0.1	1.5 ± 0.2	0.6 ± 0.8	0.0083	*

Table VIII. PABT (Palatal alveolar bone thickness) changes between T0 and T1 (paired *t* test)

	T0	*T1*	*T0-T1*	P	P >*0.05*
2nd Right Molar – P	1.0 ± 0.1	0.8 ± 0.1	0.2 ± 0.3	0.0328	*
1st Right Molar – P	0.7 ± 0.2	2.0 ± 0.2	−1.2 ± 0.5	0.0000	*
2nd Right Premolar – P	1.7 ± 0.2	2.6 ± 0.2	−0.9 ± 0.4	0.0000	*
1st Right Premolar – P	1.1 ± 0.3	2.2 ± 0.2	−1.1 ± 0.8	0.0002	*
Right Canine – P	1.4 ± 0.3	1.7 ± 0.3	−0.4 ± 0.5	0.0311	*
Left Canine – P	1.9 ± 0.4	2.1 ± 0.4	−0.2 ± 0.8	0.3807	
1st Left Premolar – P	1.3 ± 0.3	2.3 ± 0.3	−1.0 ± 0.6	0.0001	*
2nd Left Premolar – P	1.8 ± 0.2	2.8 ± 0.2	−1.0 ± 0.5	0.0000	*
1st Left Molar – P	0.7 ± 0.2	2.1 ± 0.1	−1.4 ± 0.6	0.0000	*
2nd Left Molar – P	0.9 ± 0.2	0.9 ± 0.2	0.0 ± 0.5	0.9553	

of retention, some movement was possible even if activation was completed, as the appliance is still holding the teeth while the 2 halves of the maxilla have a relapse movement toward the midline.[58] Periodontal ligament could then be in a similar state as during orthodontic treatment and when brackets are removed.[46,59,60] Goldenberg et al[18] mentioned the same transient dental mobility in 13.3% of their cases.

Table IX. BACL (Buccal alveolar crest level) changes between T0 and T1 (paired *t* test)

	T0	*T1*	*T0-T1*	P	P > *0.05*
2nd Right Molar – D	8.3 ± 0.2	9.3 ± 0.5	−1.0 ± 1.5	0.0264	*
2nd Right Molar – M	8.8 ± 0.5	9.2 ± 0.5	−0.4 ± 0.8	0.1198	
1st Right Molar – D	8.5 ± 0.2	10.4 ± 1.0	−1.9 ± 3.5	0.0647	
1st Right Molar – M	9.5 ± 0.6	12.8 ± 1.4	−3.3 ± 4.3	0.0126	*
2nd Right Premolar – B	9.1 ± 0.3	9.2 ± 0.3	−0.1 ± 0.2	0.2382	
1st Right Premolar – B	9.5 ± 0.3	12.0 ± 1.3	−2.5 ± 4.4	0.0531	
Right Canine – B	13.0 ± 0.8	15.8 ± 1.3	−2.8 ± 4.5	0.0385	*
Left Canine – B	12.8 ± 0.7	15.3 ± 1.2	−2.5 ± 3.4	0.0166	*
1st Left Premolar – B	9.7 ± 0.3	11.3 ± 0.9	−1.5 ± 2.9	0.0711	
2nd Left Premolar – B	8.4 ± 0.3	9.0 ± 0.3	−0.6 ± 0.6	0.0021	*
1st Left Molar – M	9.4 ± 0.6	11.8 ± 1.3	−2.4 ± 4.0	0.0407	*
1st Left Molar – D	8.3 ± 0.2	10.0 ± 1.1	−1.7 ± 4.1	0.1319	
2nd Left Molar – M	8.8 ± 0.2	9.0 ± 0.3	−0.2 ± 0.5	0.0756	
2nd Left Molar – D	7.9 ± 0.2	8.0 ± 0.3	−0.5 ± 1.2	0.1539	

Table X. IACL (Interproximal alveolar crest level) changes between T0 and T1 (paired *t* test)

	T0	*T1*	*T0-T1*	P
Right Central Incisor – M	10.5 ± 0.3	10.7 ± 0.3	−0.1 ± 0.2	0.0695
Left Central Incisor – M	10.6 ± 0.2	11.0 ± 0.3	−0.3 ± 0.6	0.0590

This present study showed a tendency toward a decrease in the IACL on the mesial aspect of both central incisors. Clinically, 2 patients showed gingival recession of 1 mm at T1 on the mesial aspect of the central incisors. Ramieri et al[29] reported that 22 of 136 central incisors had gingival recession 4 months after expansion, and 5 of them had some recession 1 year after expansion. Interestingly, this same author also noted new recession sites on 7 of the 128 premolars or molars observed, which could not have been predicted, as no force was applied to these teeth. It would definitely be interesting to repeat our protocol to evaluate the periodontal effects of SARPE using a bone-anchored appliance in order to accurately compare the appliances.

Spearman correlations were calculated between buccal alveolar crest level and other parameters, and only the amount of expansion showed a statistically significant correlation, as did the Rungcharassaeng et al study.[26] However, Rungcharassaeng et al[26] and Garib et al[25] also established a correlation with the initial alveolar bone thickness, which was not statistically significant in our study.

All patients tolerated the surgery well, and no immediate postoperative complications were noted. The only complication encountered during the study was the decalcification of a molar in 1 patient. This patient presented at the initial examination with many restorations and carious lesions, and thus the type of appliance used and the patient predisposition to decay may have been factors in the observed decalcification.

There were some limitations to this study. First, there was no control group. As it was a comparative study, data obtained were valuable, since it compared periodontal effects before and after a surgical procedure. Clinical evaluation of the mandibular teeth ensured the maintenance of the periodontal health status of each subject between the different time points. Second, a quantitative record of the gingival thickness was not recorded and it would have been of interest, as suggested by Müller et al.[54-56] Third, it would have been interesting to have a time point immediately after the expansion period. CBCT images and results between the different time points could have been quite revealing, but this presented an unacceptable increased radiation dose. Furthermore, a periodontal follow-up of the patients after completion of fixed orthodontic treatment as well as in the long-term could be valuable. As some overcorrection during expansion was done and as fixed orthodontics will correct the buccolingual inclination of the posterior teeth, it may be possible to see some remodeling. Some experimental studies have observed the healing potential of alveolar bone after buccal movement of teeth and the appearance of fenestrations and dehiscences. Fenestrations seemed to heal completely as apices were brought back in the alveolar bone, whereas dehiscences have the potential to only partially heal.[62-64] Fourth, no correction for multiple comparisons was used in the present study. It is possible that some statistically significant differences occurred by chance. However, few statistically significant changes were detected in the study. Furthermore, these statistically significant changes

Table XI. Attached gingiva changes between T0 and T1 (Wilcoxon test) — buccal aspect of mandibular teeth

	T0 Median (min-max)	*T1* Median (min-max)	*Number of subjects* T0>T1	T0<T1	P
Canine – B	1.0 (0.0-2.0)	1.0 (0.0-2.0)		3	0.0833
1st Premolar – B	0.5 (0.0-2.0)	0.5 (0.0-2.0)	3	1	0.3173
2nd Premolar – B	1.0 (0.0-3.0)	1.0 (0.0-3.0)	2	2	1.0000
1st Molar – B	2.0 (0.0-3.0)	1.5 (0.0-2.0)	3	2	0.6547
2nd Molar – B	0.5 (0.0-2.0)	1.0 (0.0-2.0)		1	0.3173

Since data did not follow normal law, median (min-max) are presented for these variables and Wilcoxon tests were used.

Table XII. Attached gingiva changes between T0 and T1 (Wilcoxon test) — lingual aspect of mandibular teeth

	T0 Median (min-max)	*T1* Median (min-max)	*Number of subjects* T0>T1	T0<T1	P
Canine – L	2.0 (1.0-4.0)	2.0 (1.0-3.0)	2	6	0.1573
1st Premolar – L	2.0 (1.0-4.0)	2.0 (1.0-3.0)	5	3	0.7630
2nd Premolar – L	3.0 (1.0-4.0)	2.0 (1.0-5.0)	6	4	0.2222
1st Molar – L	3.0 (1.0-4.0)	3.0 (1.0-5.0)	4	4	0.5580
2nd Molar – L	2.5 (0.0-4.0)	3.0 (1.0-5.0)	4	7	0.4773

Since data did not follow normal law, median (min-max) are presented for these variables and Wilcoxon tests were used.

were also compared to the clinical importance of the results.

CONCLUSIONS

In conclusion, after 6 months of follow-up, SARPE-seems to have little detrimental effect on the periodontium when measured clinically. However, radiographic data demonstrated some statistically significant changes:

- A significant decrease in the BABT on most teeth, with the most clinically and statistically important changes on the distal aspect of the first molars
- A significant increase in the palatal alveolar bone thickness on most teeth
- A decrease in the buccal alveolar crest level of all canines and posterior teeth, which was not statistically significant for all teeth, and the changes were more considerable clinically and statistically on the mesial aspect of the first molars and on the canines
- A tendency toward a decrease in the interproximal alveolar crest level on the mesial aspect of both central incisors

These changes could eventually have a clinically significant impact on the periodontium.

Both clinical and radiographic 1-year data will be available shortly, and may show remodeling changes in the thickness and height of the alveolar bone, as well as changes in the attachment levels.

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