Changes in pulp blood flow and pulp sensibility resulting from surgically assisted rapid maxillary expansion: A clinical study

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Introduction: The aim of this work was to assess and compare changes in pulp blood flow (PBF) and pulp sensibility (PS) after surgically assisted rapid maxillary expansion (SARME) and rapid orthopedic maxillary expansion (OME). **Methods:** Ten patients requiring SARME and 10 requiring OME had the pulp status of their maxillary incisors and canines assessed with the use of laser Doppler flowmetry, electric pulp testing (EPT), and CO_2 snow. The SARME group was assessed at T1-S (before surgery), T2-S (after surgery, before expansion), T3-S (after surgery, at completion of expansion), and T4-S (3 months after surgery). The OME group was assessed at T1-O (before expansion), T2-O (after rapid expansion), and T3-O (3 months after expansion commencement). Relationships between PBF/PS and the procedures, assessment times, and tooth types were evaluated. **Results:** In the SARME group, surgery did not cause significant ($P \geq 0.05$) reduction in PBF, maxillary expansion did cause significant ($P \leq 0.05$) reduction in PBF, pretreatment PBF was reestablished by T4-S, and nonresponses to both EPT and CO_2 peaked at T2-S. In the OME group, rapid expansion caused significant ($P \leq 0.05$) reduction in PBF, pretreatment PBF was reestablished by T3-O, and all teeth responded to at least 1 of EPT or CO_2 at each assessment time. **Conclusions and clinical implications:** Within the study's limitations, it can be concluded that both SARME and OME induce reduction but not elimination of PBF to maxillary anterior teeth and therefore do not cause loss of pulp vitality; surgery for SARME does not significantly reduce PBF to maxillary anterior teeth, rather it is the process of maxillary expansion that significantly reduces PBF in SARME patients; and caution when using CO_2 and EPT tests alone to assess pulp status after SARME is warranted because the capacity for CO_2 or EPT to provide negative sensibility responses despite the presence of PBF was observed. (Am J Orthod Dentofacial Orthop 2019;155:632-41)

Maxillary deficiency in the transverse dimension has long been recognized as an important component of many malocclusions. Orthopedic maxillary expansion for such deficiencies was first described as a treatment modality by Angell more than 150 years ago.[1,2] Significantly, up to one-fourth of patients who seek orthodontic treatment present with transverse deficiency of the maxilla. For individuals in mixed and deciduous dentition, the prevalence of maxillary transverse deficiency has been measured to range from 8% to 22%,[3-8] and it has been reported that up to 30% of adults who seek orthodontic treatment demonstrate maxillary transverse deficiency.[9]

Within individuals who have not reached skeletal maturity, rapid orthopedic maxillary expansion (OME) provides successful treatment of maxillary transverse deficiency.[10-14] However, in skeletally mature patients, because of maturation changes at the midpalatal and circummaxillary sutures causing resistance to expansive movements,[15-21] OME can cause undesirable sequelae. These sequelae include buccal tipping of the maxillary posterior teeth,[22-24] root resorption of the maxillary posterior teeth,[22,25-27] buccal cortex fenestration and associated predisposition to recession,[19,22] and necrosis of the palatal tissue.[28] To avoid these negative consequences in skeletally mature patients, surgical intervention to reduce resistance at the maxillary and circummaxillary sutures before maxillary expansion is widely adopted.[14,29-37] Surgically

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assisted rapid maxillary expansion (SARME), also referred to as surgically assisted rapid palatal expansion, is a treatment of maxillary transverse deficiency that includes such surgical intervention.

The surgical procedure for SARME has developed since Brown[29] first described a technique involving splitting of the midpalatal suture alone. Since the reporting of the pterygoid junctions, the zygomatic buttress, and the piriform aperture pillars as important areas of resistance to maxillary expansion,[18-21] surgical techniques involving sectioning of differing combinations of the posterior, anterior, lateral, and median articulations of the maxilla have been advocated.[25,34-37] Some authors have even suggested that a midpalatal split is unnecessary if adequate removal of posterior, lateral, and anterior resistance is completed.[31-33] In addition, variations in SARME surgical technique based on the age of the patient, the degree of arch taper, the presence of an open bite anteriorly, and the need for unilateral expansion have been reported.[36,38-40] Consequently, although the principle of removing resistance to maxillary expansion undergirds all SARME techniques reported in the literature, no consensus on a single surgical technique is apparent, with the surgeon having discretion to make cuts according to known areas of resistance to maxillary movement and individual patient characteristics.

Importantly, as with any surgical intervention, undesirable consequences can result from SARME both during surgery as well as afterward. One important risk is potential damage to tissues surrounding the surgical site. The surgery for SARME carries the risk of disrupting the neurovascular supply to the dental pulps of the maxillary teeth.[18,21,41-43] Significantly, should the blood supply to the pulp of a tooth be reduced through damage to its neurovascular bundle, there is a risk that the pulp may become necrotic. In the absence of pulp recovery, the loss of pulp blood supply (and therefore vitality) would necessitate root canal therapy or tooth extraction.[44-46]

However, despite the potential risk of SARME to maxillary tooth pulp health, only 1 previous study (limited to a 1-week period before expansion) has examined the effect of SARME on pulp blood flow (PBF).[47] Therefore the aim of the present study was to assess changes in PBF and pulp sensibility resulting from SARME, and to compare those changes with those in resulting from rapid OME.

MATERIAL AND METHODS

The present study was a single center prospective study conducted at the Oral Health Center of Western Australia, Perth, Australia. Ethical approval for the study was attained from the Human Research Ethics Committee at the University of Western Australia (RA/4/1/7516). Full consent was received from every study participant, and additional consents were obtained from parents/guardians when the patients were <18 years of age.

Patients in the SARME group were 10 consecutive patients eligible for orthodontic treatment at the Oral Health Center of Western Australia who required SARME treatment. All patients exhibited transverse maxillary deficiency and adult skeletal maturity, rendering OME inappropriate. The SARME group included 2 men (mean age 17 years, range 17-17 years) and 8 women (mean age 19.5 years, range 16-26 years). The surgery for all patients was conducted from August 2015 to March 2016.

Patients in the OME group were 10 patients eligible for orthodontic treatment at the Oral Health Center of Western Australia who required rapid OME. All patients exhibited transverse maxillary deficiency and skeletal maturity rendering PME appropriate. The OME group included 2 male patients (mean age 12.5 years, range 12-13 years) and 8 female patients (mean age 11.5 years, range 9-15 years).

Within both groups, all subjects had noncontributory medical histories.

Patients in the SARME group underwent surgery at either Fiona Stanley Hospital, Western Australia, or Royal Perth Hospital, Western Australia. At both hospitals, the following surgical technique was used. A horizontal incision was made through the mucoperiosteum of the maxilla at ~5 mm above the dental roots extending forward from the mesial of the first molar bilaterally. This incision allowed subsequent use of a microsaw or osteotome to enable maxillary disarticulation at the pterygoid plates, zygomatic buttress, lateral nasal wall, anterior maxillary sinus wall, and midpalatine suture. The position of the incision at 5 mm from the apices of the dentition was to ensure that pulp blood supply did not completely cease.[41] No surgical complications, including iatrogenic damage of the root apices of the maxillary canines and incisors, were reported by the surgeons after surgery.

The SARME group commenced expansion 3-5 days after surgery. Expansion was completed at a rate of 0.5 mm/day until the desired amount of expansion was achieved.

The OME group completed expansion according to the following protocol: days 1-3: 0.5 mm/day; days 4-10: 0.25 mm/day; day 11 onward: 0.25 mm/3.5 days as required until the desired amount of expansion was achieved. Days 1-10 therefore constitute the period of rapid expansion.

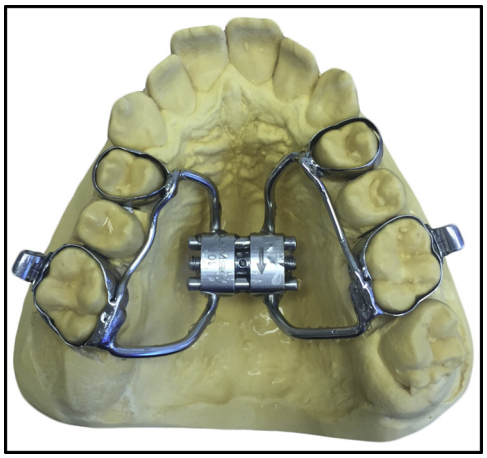

Fig 1. SARME appliance.

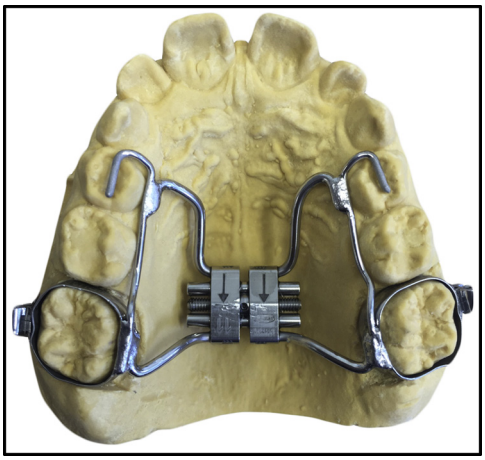

Fig 2. OME appliance.

Both groups were fitted with a hyrax expansion appliance to enable maxillary expansion. For the SARME group this was done before surgery. The design of the appliance was identical for both groups with the exception of the attachment to the premolars: The SARME group appliance used premolar bands (Fig 1), and the OME group appliance used extension tags (Fig 2).

The teeth assessed in this study were the maxillary central incisors, the maxillary lateral incisors, and the maxillary canines. Three patients in the OME group possessed primary canines, and the readings from these teeth were included in the final results. Before study commencement, all teeth to be assessed were deemed to be healthy, exhibiting no history of trauma and no evidence of caries, previous restorations, or periodontal disease.

To minimize error associated with operator differences, only 2 investigators were used to complete the dental pulp assessments for both groups. Three dental pulp tests were used at each assessment time in both groups. The tests were conducted in the following order at each assessment time.

1. A laser Doppler flowmeter (LDF; Moorlab/Flolab; Moor Instruments, Axminster, U.K.), zeroed against a static reflector and calibrated with the use of a Brownian motion medium, was used to measure PBF. The laser source exhibited a wavelength of 780 nm and a primary band width frequency of 3.1 kHz set to a 0.1 second time output constant. Probe fiber separation was 0.5 mm. Individual customized soft-lined acrylic splints were prepared for each tested tooth to allow for changes in tooth position with maxillary expansion (Fig 3). Holes were placed in the buccal surface of each splint

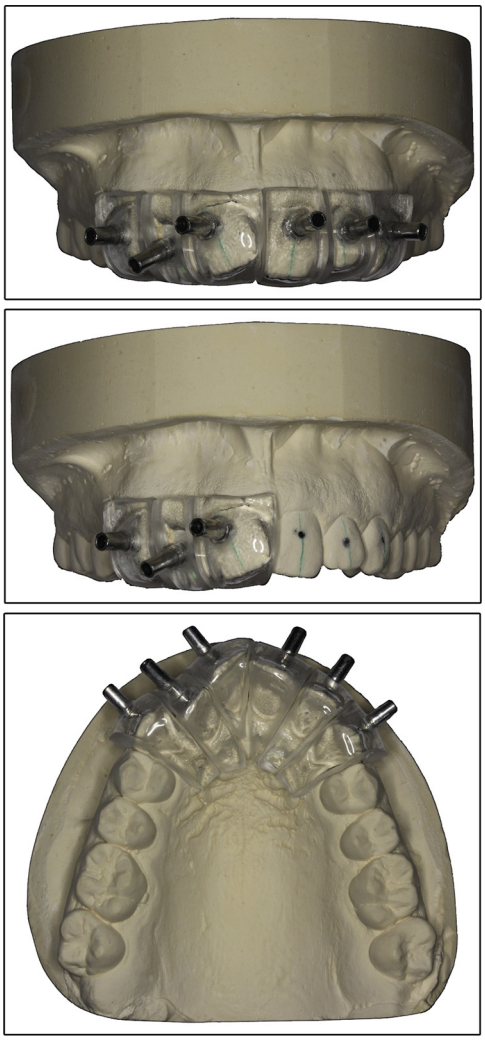

Fig 3. Customized acrylic splints.

into which a metal cylinder of diameter 0.05 mm greater than that of the flowmeter probe was secured. The center of the cylinder was positioned 3 mm from the gingival margin of each tooth. During PBF measurement, the LDF probe was inserted into the metal cylinder of each splint to make contact with the buccal surface of the tooth being assessed. The splint design ensured the necessary accuracy, stability, and reproducibility of probe position at the tooth surface at each assessment time.[48] Patients were rested in a supine position for 1-3 minutes before testing commenced. Testing was continued until a stable reading for >20 seconds was recorded. Customized software (Labsoft; Moor Instruments) was used to record the raw data from each tooth and to determine a flux reading in perfusion units (PU); 1.0 V of blood flow was taken to be equivalent to 100 PU.[49]

2. The probe of an electric pulp tester (Vitality Scanner 2006; Kerr Endodontics, Orange, Calif) was placed on the center of the buccal surface of each assessed tooth until the patient indicated feeling a tingling sensation. A measurement in the range of 1-80 was recorded, with an increasing number corresponding to an increased voltage being delivered. A recording of 80 was made if the patient did not respond to the maximum stimulus provided by the electric pulp tester during 2 consecutive tests in a single assessment appointment. A recording of 80 correlated to a negative (−) response being recorded. A recording of 1-79 correlated to a positive (+) response being recorded.
3. Carbon dioxide attained from a pressurized cylinder containing liquid carbon dioxide (Odontotest; Fricar, Zurich, Switzerland) was collected in a thin plexiglass tube of 3.5 mm diameter as CO_2 snow. The CO_2 snow was applied to the center of the buccal surface of each assessed tooth for up to 10 seconds, unless a patient response to the stimulus was attained. Responses to the CO_2 test were recorded as either positive (+) or negative (−); a negative response was recorded if the patient did not respond to the stimulus during 2 consecutive tests in the single assessment appointment.

For the SARME group, dental pulp assessment was carried out at the following times: T1-S before surgery (1-7 days before surgery); T2-S after surgery, before hyrax expansion (3-5 days after surgery); T3-S after surgery, at completion of hyrax expansion (14-20 days after surgery); and T4-S after surgery, immediately before full fixed appliances being placed (3 months after surgery).

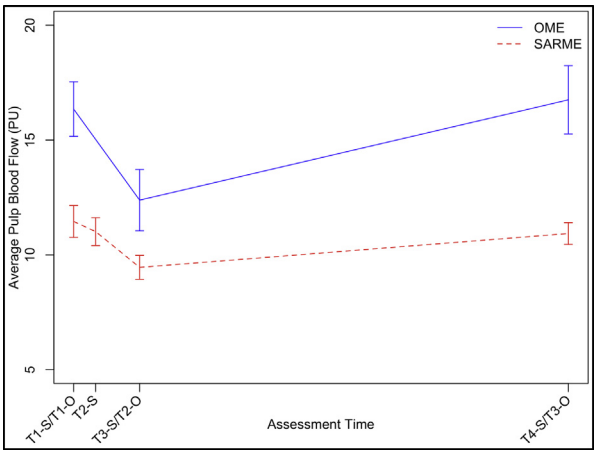

Fig 4. Average pulp blood flow (±SE) at each assessment time for the SARME and OME groups.

For the OME group, dental pulp assessment was carried out at the following times: T1-O before hyrax expansion (day of hyrax insertion); T2-O after rapid expansion, at completion of daily hyrax expansion (10 days after hyrax insertion); and T3-O 3 months after expansion commencement (3 months after hyrax insertion).

The extent of the monitoring period (3 months) was defined by the inability to continue PBF monitoring after placement of orthodontic brackets, 3 months after surgery being the routine time at which brackets are placed for patients treated with the use of SARME at the Oral Health Center of Western Australia.

Statistical analysis

The raw data from the laser Doppler flowmetry pulp tests were processed with the use of software developed by Moor Instruments (Moorsoft for Windows). Linear mixed models were conducted to investigate the relationships between average PBF (PU) and time, tooth type, age, sex, and responsiveness to electric pulp testing (EPT) and CO_2 for each group. All effects were included in the full models, and variables that were significant at a 5% significance level were retained in the final models. All analyses were conducted using the R environment for statistical computing (R Core Team 2016).

RESULTS

Figure 4 displays the average total PBF within the maxillary anterior teeth for the SARME and OME groups over the duration of the study. In the SARME group, the difference in average total PBF from baseline (T1-S) to T2-S was not statistically significant (3.8% decrease; $P \geq 0.05$), but average total PBF significantly decreased

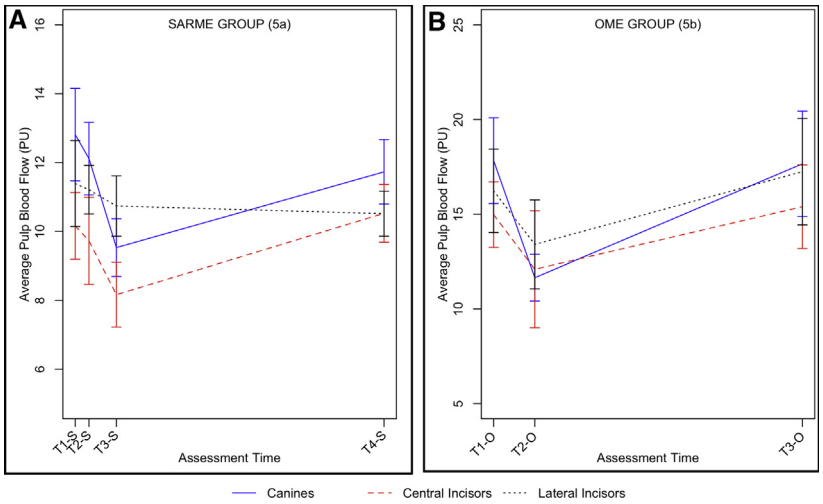

Fig 5. Average pulp blood flow (SE) at each assessment time by tooth type in **(a)** the SARME group and **(b)** the OME group.

over the period of expansion (T2-S to T3-S; 14.1% decrease; $P \leq 0.05$). A significant increase in average total PBF was observed after expansion (T3-S to T4-S; 15.6% increase; $P \leq 0.05$), with the average total PBF at 3 months after surgery not being significantly different from the average total PBF at baseline (T4-S to T1-S; 4.6% decrease; $P \geq 0.05$). In the OME group, the average total PBF at the completion of rapid expansion had significantly decreased compared to the preexpansion values (T2-O to T1-O; 24.2% decrease; $P \leq 0.05$). A significant increase in average total PBF was observed from T2-O to T3-O (35.3% increase; $P \leq 0.05$). The average total PBF measured at T3-O was not significantly different than at T1-O (2.5% increase; $P \geq 0.05$).

Figure 5 displays the average PBFs for each of the tooth types by assessment time for each group. In the SARME group, the maxillary central incisor and maxillary canine average PBFs followed the pattern of the average total PBF (Fig 4); the average PBF within the maxillary central incisors and canines significantly decreased from T2-S to T3-S (by 27.2% and 21.3%, respectively; $P \leq 0.05$) before increasing from T3-S to T4-S (by 28.9% and 23.1%, respectively; $P \leq 0.05$). In contrast, the lateral incisors maintained a relatively stable average PBF over the study duration. In the OME group, all 3 tooth types followed the pattern of the average total PBF (Fig 4): The average PBF for all 3 tooth types significantly decreased from T1-O to T2-O (central incisors 19.2%, canines 38.2%, lateral incisors 17.4%; $P \leq 0.05$) before significantly increasing from T2-O to T3-O (central incisors 27.3%, canines 52.2%, lateral incisors 28.6%; $P \leq 0.05$). An analysis of PBF results in which primary canines were excluded was completed and no difference (measurably or statistically) to the results was identified.

Figure 6 displays the percentage of teeth that responded positively to EPT at each assessment time. All teeth in the SARME group responded positively to the stimulus provided by the electric pulp tester prior to surgery (T1-S). In the SARME group, the percentage of teeth failing to respond to EPT peaked at the first measurement after surgery (T2-S). As time progressed from T2-S, the number of teeth failing to respond to EPT declined (T3-S negative responses > T4-S negative responses). The number of teeth that did not respond to EPT in the SARME group were as follows: maxillary central incisors (T1-S: 0; T2-S: 3; T3-S: 4; T4-S: 3), maxillary lateral incisors (T1-S: 0; T2-S: 3; T3-S: 4; T4-S: 4), and maxillary canines (T1-S: 0; T2-S: 13; T3-S: 10; T4-S: 6). In the OME group, all negative responses to EPT were from a single patient, with the exception of a single lateral incisor at the completion of rapid expansion in another patient. The number of teeth that did not respond to EPT for the OME group were as follows: maxillary central incisors (T1-O: 0; T2-O: 0; T3-O: 0), maxillary lateral incisors (T1-O: 1; T2-O: 3; T3-O: 0), and maxillary canines (T1-O: 0; T2-O: 1; T3-O: 0).

Figure 7 displays the percentage of teeth that responded positively to CO_2 snow at each assessment time. All teeth in both the SARME group and the OME group responded positively to CO_2 before surgery and OME, respectively (T1-S and T1-O). In the SARME group, the pattern of nonresponse to CO_2 was similar to that for EPT: The percentage of teeth failing to respond to CO_2 peaked at the first measurement after surgery (T2-S)

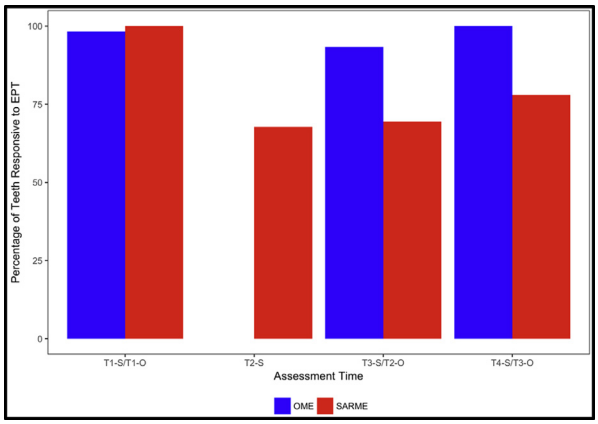

Fig 6. Percentage of teeth responsive to electric pulp testing (EPT) at each assessment time.

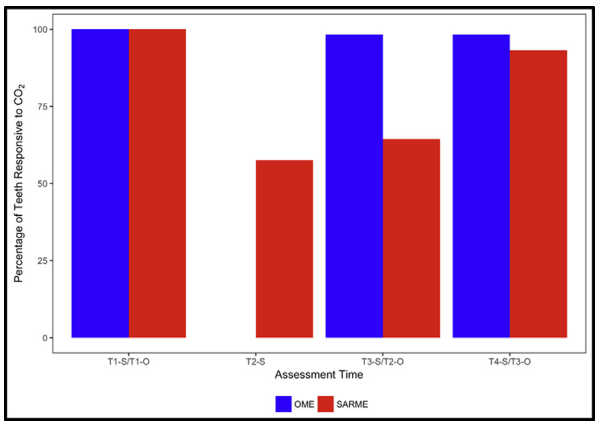

Fig 7. Percentage of teeth responsive to CO_2 snow at each assessment time.

and declined from this observation point (T3-S negative responses > T4-S negative responses). In the SARME group, the number of teeth that did not respond were as follows: maxillary central incisors (T1-S: 0; T2-S: 10; T3-S: 10; T4-S: 2), maxillary lateral incisors (T1-S: 0; T2-S: 4; T3-S: 3; T4-S: 0), and maxillary canines (T1-S: 0; T2-S: 11; T3-S: 8; T4-S: 2). In the OME group, the 2 negative responses were from primary canine teeth nearing exfoliation in 1 patient.

Figure 8 displays the average PBFs (±SE) in the SARME group for both the positive and negative responses to either CO_2 snow or EPT at each assessment. There was no significant difference ($P \geq 0.05$) in average PBF observed at any assessment time between positive and negative responses to either sensibility test (CO_2 or EPT); PBF and pulp sensibility results were independent at each time point.

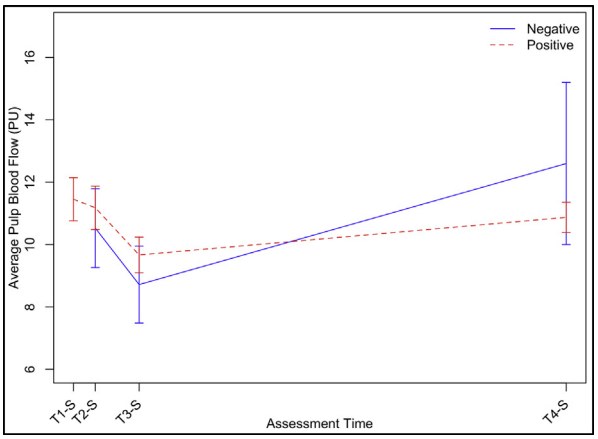

Fig 8. Average pulp blood flows (±SE) and assessment times for both negative and positive responsiveness to either CO_2 snow or EPT in the SARME group.

DISCUSSION

This study indicates that SARME and rapid OME induce reduction but not elimination of PBF to maxillary anterior teeth and therefore do not cause loss of pulp vitality. Notably, surgery for SARME did not significantly reduce PBF to maxillary anterior teeth. Rather, the greatest reduction in PBF in the SARME group was observed at the completion of maxillary expansion. PBF for both groups increased from its minimum level at the completion of expansion to reestablish itself to presurgery levels by 3 months after treatment commenced.

The absence of a statistically significant difference in PBF when comparing readings before surgery (T1-S) and immediately after surgery (T2-S) can be attributed to an inflammatory-mediated increase in blood flow to the maxillary mucogingiva initiated by the SARME surgical procedure.[50-55] The surgical procedure for SARME used in this study results in severing of the infraorbital and nasopalatine arteries, thus reducing arterial blood supply to the dentition of the anterior maxilla. Consequently, a reduction in maxillary PBF immediately after surgery for SARME could be expected, as has been reported previously[47] and suggested by Tonder's theory of "Stealing of dental pulp perfusion pressure."[56] However such a reduction did not manifest in the present study until the second postsurgical assessment, 14-21 days after surgical intervention. Therefore, although the surgical cuts affected the main arterial supply to the neurovascular bundles of maxillary anterior teeth, the effect on PBF seems initially masked by an inflammatory-mediated hypervascular period. This finding is consistent with observations over the first 1-3 weeks after Le Fort 1 osteotomy.[50-55,57,58]

The significant reduction in PBF recorded at the completion of expansion in the SARME group (T3-S) compared with both presurgery and initial postsurgery measures, may be a consequence of the tension on the mucogingiva induced by the expansion process. Because the mucogingiva of the anterior maxilla is stretched during maxillary expansion, compression of the microvasculature within the palatal and buccal pedicles occurs, causing a reduction in blood supply to the pulps of the anterior maxilla.[59-61] This blood flow reduction within the palatal and buccal pedicles, potentially in combination with reduced blood flow from the nasopalatine and infraorbital arteries, therefore functions to decrease PBF within the anterior maxilla during the expansion process of SARME. In addition, bending of the maxillary alveolar bone[62-64] and periodontal ligament compression[65] during maxillary expansion can contribute to the observed PBF reduction. Although these phenomena will induce greater microvasculature compression around maxillary posterior teeth relative to anterior teeth, anterior tooth PBF has the capacity to be reduced through these processes.

Alveolar bone bending, periodontal ligament compression, and tension on the mucogingiva of the anterior maxilla may also be the cause of PBF reduction after rapid expansion in the OME group. This finding, however, differs from that reported by Babacana et al,[66] who observed an increase in PBF within maxillary canines and incisors during rapid OME, attributing it to inflammatory changes caused by the applied forces. Notably, though, at 3 months after expansion commenced, both in the present study and that conducted by Babacana et al,[66] PBF reestablished at pretreatment values. This suggests that changes in PBF induced by rapid orthopedic maxillary expansion are reversible, which is consistent with previous histologic evaluation of pulp tissue after rapid OME.[67,68]

In both the SARME group and the OME group, recovery of PBF after rapid expansion ceasing (T3-S/T2-O) can be attributed to a reduction in mucogingival tension, periodontal ligament compression, and alveolar bone bending.[59-65] In addition, for the SARME group, maturation of vessels that supply the maxillary dentition during surgical wound healing can lead to an increase in postexpansion PBF.[69] This trend toward PBF recovery with increased time after surgery for SARME was also reported by Ozturk et al, although Ozturk et al limited observation to the preexpansion period. A similar pattern of PBF recovery within the maxilla after Le Fort 1 osteotomies also has been reported.[70,71]

The recorded stable PBF of the lateral incisors in the SARME group may be a result of the lateral incisors possessing a narrower pulp chamber (mesiodistally) compared with central incisors and canines. Consequently, when using the LDF method in the present study, changes in PBF within lateral incisors may be less detectable than within canines and central incisors exhibiting broader pulp chambers. The lateral incisors in the OME group would not have been as susceptible to this phenomenon owing to the greater pulp chamber widths of teeth within younger individuals.[72,73] The small sample size may also be a reason for the lateral incisors in the SARME group not following the pattern of the total PBF.

The trend of increasing pulp sensibility recovery with increasing time after surgery for the SARME group (T2-S negative responses > T3-S negative responses > T4-S negative responses) correlates to that reported after SARME[74,75] and Le Fort 1 oestotomy.[70,71,76-79] Furthermore, the proportion of teeth in the SARME group responding positively to CO_2 and EPT after 3 months in the present study is similar to previously reported results after SARME[74] and is within the range of reported positive results to both thermal tests (after 12 months)[80-82] and EPT (after 6-64 months)[71,77,78,83-86] for teeth within osteotomized segments after Le Fort 1 osteotomy. The observation in the SARME group that the canine teeth exhibited the greatest prevalence of nonresponse to sensibility testing can be attributed to canine teeth possessing the greatest root length of the teeth investigated, causing canine apices to be closest to the surgical incisions.[87]

The observation in the OME group that more teeth responded negatively to EPT than to CO_2 (both before expansion and at the completion of expansion) is consistent with previous studies reporting that EPT is a less reliable measure of pulp sensibility than CO_2 for teeth with immature apicies.[88-90] However, the findings of the present study suggest that CO_2 snow testing is potentially unreliable for primary teeth nearing exfoliation: The single negative response to CO_2 at T2-O was from a primary canine that exfoliated before T3-O, and the single negative response to CO_2 at T3-O was from a primary canine that exfoliated soon after the study was completed.

To minimize the effects of contamination "noise" caused by light back-scattered from periodontal tissues,[91] individualized tooth splints were used for LDF readings to center the flowmeter probe 3 mm from the gingival margin. Although because of greater pulp volume a stronger signal is attained when positioning the flowmeter probe closer to the gingival margin,[92] that stronger signal is more affected by gingival blood flow ("gingival backscatter").[48] Consequently, placement of a LDF probe at a distance 2-3 mm from the gingival

margin has been suggested because that position enables a suitable signal volume to be recorded when LDF is used while minimizing signal "noise."[93,94]

A limitation of the present study was the inability to generate prestudy equivalence between the 2 groups owing to the necessary differences in skeletal maturity between them. As alluded to previously, a clear difference in skeletal maturity was required to ensure appropriate treatment selection for each participant. As a consequence, a comparison of 2 groups with differing age profiles was unavoidable. In addition, although the sample size used in the present study was similar to previous PBF assessments following SARME and OME,[47,66] the sample size was restricted.

A further limitation of the present study is the time period over which it was conducted. Ideally, a period of observation extending beyond 3 months should be used so that longer-term evaluation of pulp status could be attained. Practically, however, this is difficult to achieve owing to the significant midline diastema at the completion of SARME. Consequently, patients who undergo SARME commonly desire fixed appliance therapy as soon as is practical after expansion, and the placement of fixed appliances then renders the customized tooth splints for LDF readings unusable, and EPT can not be readily used when archwires are placed unless they are removed every time the teeth are tested. In addition, the effect of tooth movement on PBF would act as a significant confounder after placement of fixed appliances.[95]

In the context of these limitations, further studies evaluating larger SARME and OME cohorts over longer time periods are warranted. Future studies assessing PBF and pulp sensibility changes within cohorts undergoing maxillary expansion via temporary anchorage device–supported expansion appliances are also merited, especially as this procedure is increasing in popularity. In addition, future studies assessing PBF and pulp sensibility changes for cohorts reporting a history of pulp damage before SARME and OME is required. It is well accepted that previous trauma experience and/or restorative therapy can result in pulp respiration and pulp health being compromised.[96-98] Consequently, should the completion of a maxillary expansion procedure (SARME or OME) lead to a transient reduction in PBF, as in the present study, potential exists for pulp damage to progress beyond a critical level, leading to pulp chamber calcification or loss of vitality.

CONCLUSIONS AND CLINICAL IMPLICATIONS

Within the limitations of the present study the following can be concluded:

1. SARME and rapid OME for skeletally immature patients induces reduction but not elimination of PBF to maxillary anterior teeth and therefore does not cause loss of pulp vitality. In this study, pretreatment PBF was reestablished by 3 months.
2. Surgery for SARME does not significantly reduce PBF to maxillary anterior teeth; rather it is the process of maxillary expansion itself that significantly reduces PBF in SARME patients.
3. Caution when using CO_2 and EPT tests alone to assess pulp status after SARME is warranted; the capacity for CO_2 and EPT to provide negative sensibility responses despite the presence of PBF was observed.

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