Literature reviews

These reviews have been prepared by the orthodontic postgraduate students of The University of Melbourne, Melbourne, Australia.

The cervical vertebrae maturation (CVM) method cannot predict craniofacial growth in girls with Class II malocclusion

Engel TP, Renkema AM, Katsaros C, Pazera P, Pandis N and Fudalej PS
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Background: It is suggested that the treatment of some Class II malocclusions may be most successful when timed to coincide with the period of peak mandibular growth velocity. A reliable predictor of this event would therefore be of value to the orthodontist. The cervical vertebral maturation (CVM) method relates the skeletal maturation of these structures to the growth velocity of the facial skeleton, using information available from a diagnostic lateral cephalogram. This index is of value if it demonstrates validity and reliability, both of which have been simultaneously supported and discredited in the literature. The predictive accuracy of the CVM method in Class II subjects has been previously unreported.

Aim: To assess both the inter-examiner reliability and predictive accuracy of the CVM method in a sample of untreated Class II adolescent female subjects.

Materials and methods: The records of 29 Angle Class II female subjects from the Nijmegen Growth Study were selected from a total of 254. As the study of subjects’ growth was terminated at 14, males were excluded due to their later completion of the pubertal growth spurt. Cephalograms taken at nine years of age were cropped to show only the cervical vertebrae and staged by five calibrated senior orthodontic residents. Cephalograms taken at six-month intervals were analysed for several measures of mandibular and maxillary length between the ages of nine and 14. Kappa statistics were used to determine associations between the observers’ average CVM stage and cephalometric evidence of maxillary and mandibular growth.

Results: The mean CVM stage at 9.3 years of age was 2.4 (SD = 1.4). Kappa statistics for both intra- and inter-examiner reliability indicated fair agreement (0.36 and 0.30 respectively). A regression analysis demonstrated that the only parameter associated with facial growth was chronological age. The CVM stage was not a significant predictor of cephalometric changes.

Conclusion: While several studies have reported an association between facial growth and cervical vertebral morphological characteristics, the results of this study support others which have demonstrated that the predictive value of this association is limited. It was determined that chronological age was of greater predictive value for the timing of peak facial growth velocity. The standard deviations for the observed CVM stages represented periods of several years, yielding little information of clinical benefit. The main weaknesses of the technique are therefore lack of both reliability and specificity.

Aiden McKeever

The reliability of clinical decisions based on the cervical vertebrae maturation staging method

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Background: The cervical vertebrae maturation staging (CVMS) method is one of several techniques to determine the optimum timing for growth modification. It is considered to be as accurate as a hand and wrist radiograph in assessing skeletal maturity.
without the need for additional radiation exposure. However, its reproducibility has been questioned and the method has not been recommended as a strict clinical guideline.

**Aim:** The aim of this study was to investigate the cause of poor reproducibility and to assess the reproducibility of the clinical decisions made based on cervical vertebral maturation.

**Materials and methods:** Seventy lateral cephalograms of Iranian children aged 9–15 years were rated by five experienced orthodontists. The process was repeated two weeks later. The observers were blinded to the patients’ developmental stage, chronological age and dentition phase (blocked out on cephalogram). Observers were asked to analyse the lower border of C2, C3 and C4, and the morphology of C3 and C4. Observers were then asked to rate the cephalograms according to the CVMS method. Clinical application regarding treatment timing was related to the staging: CVMS I and II (phase 1 – before optimum timing); CVMS III (phase 2 – during optimum timing); CVMS IV and V (phase 3 – after optimum timing). Fleiss’ kappa statistical test was used to assess intra-observer agreement; Cohen’s kappa statistical test was used to assess inter-observer agreement.

**Results:** Inter-observer agreement was 48% and intra-observer agreement was 59–85% across the five CVMS stages. Considering the clinical application of the CVMS method across three phases, inter-observer agreement was 61%, which is considered in the substantial range. Inter-observer reproducibility regarding the morphology of C3 and C4 was considered to be in moderate agreement. Inter-observer reproducibility regarding the lower border of C2, C3 and C4 was considered to be in substantial agreement.

**Conclusions:** Inter-observer reproducibility of the CVMS method was low to moderate, and intra-observer reproducibility was substantial. When considering the clinical application of the CVMS method in determining optimum timing for Class II growth modification using three phases, the reproducibility was substantial. Difficulty in determining the morphology of C3 and C4 led to the poor reproducibility of the CVMS method.

Adam Chen

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**Comparisons of two protocols for the early treatment of Class III dentoskeletal disharmony**

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**Background:** There are several methods to treat Class III dentoskeletal discrepancy at an early age, which often involve both intra-oral and extra-oral appliances. Examples are rapid maxillary expansion with face-mask (RME/FM) and two occlusal splints combined with Class III elastics and chin cup (SEC III). Currently, there are no studies comparing the effects of the SEC III with alternative methods or with the changes observed in untreated Class III patients.

**Aim:** To compare the short-term treatment effects produced by SEC III protocol and RME/FM therapy in patients with a Class III dentoskeletal discrepancy compared with growth changes in an untreated Class III control group.

**Materials and methods:** Twenty-five patients with a Class III dento-skeletal discrepancy treated with an SEC III protocol (wear the splints and elastics for a minimum of 16 hours per day and chincup for a minimum of 14 hours a day for one year) were evaluated and compared to a matched sample of 32 Class III patients who were treated with the RME/FM protocol (after over-expansion, wear the facemask for a minimum of 14 hours per day for six months, then only at night for another six months) and to a matched control group (untreated Class III individuals) consisting of 23 subjects.

**Results:** In the short term, the SEC III and RME/FM groups produced significantly greater forward sagittal displacement of the maxilla (SNA +1.2 and +1.4 degrees, respectively), significant reduction of mandibular projection (SNB -1.3 and -1.4 degrees, respectively) and significant improvements in the intermaxillary sagittal relationships (ANB +2.6 and +2.9 degrees, respectively; Wits +3.7 and +2.6 mm, respectively), when compared with the control group. In addition, the RME/FM group showed a significant increase in the palatal plane to mandibular plane angle when compared with the control group (+2.0 degrees). There was no significant difference between the two treated groups, except the small vertical change in the
RME/FM group. The amount of compliance was also similar in both treated groups.

**Conclusion:** Similar to previous studies, both SEC III and RME/FM protocols produced favourable, short-term maxillary and mandibular skeletal changes in the early treatment of Class III patients. The SEC III group appeared to have slightly better control on the vertical relationship when compared to the RME/FM protocol.

Michael Zhao

**Lower first permanent molars: developing better predictors of spontaneous space closure**

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**Background:** First permanent molars (FPM) are susceptible to post-eruptive breakdown due to caries and hypomineralisation. The extraction of affected teeth may be indicated, often with increased need for subsequent orthodontic treatment due to incomplete space closure. To improve the occurrence of spontaneous space closure following the extraction of FPMs, it has previously been advised that extraction should occur at an ‘ideal time’ when calcification of the second permanent molar (SPM) bifurcation is evident radiographically between ages 8–10 years. However, space closure does not always occur. Other radiographic factors that may contribute to spontaneous space closure following FPM extraction include the development of the second premolar in the bifurcation of the second primary molar, mesial angulation of the developing SPM and the presence of the permanent third molar. More precise predictors of space closure are required when treatment planning for the extraction of FPMs.

**Aims:** The primary aim of this study was to investigate if one or more radiographic findings affected spontaneous space closure following lower FPM extraction. A secondary aim was to evaluate the interaction between three other radiographic findings with the conventional parameter of the SPM development stage to enable improved predictors of success for space closure following FPM extraction.

**Materials and methods:** This retrospective study involved a sample of 66 patients aged 11–17 years who had one or two lower FPMs extracted five years earlier without subsequent FPMs extracted five years earlier without subsequent orthodontic treatment. Panoramic radiographs taken at the time of extraction of the 127 FPMs were used to assess the stage of SPM development using Demirjian’s dental development stages, the presence of the second premolar engagement in the bifurcation of the second primary molar, the mesial angulation of the SPM and the presence of the permanent third molar. The patients were recalled for grading by clinical examination to assess the amount of space closure in the posterior segments. The mean age of the patients at the time of extraction was 9.2 years and the mean age at clinical assessment was 13.8 years. Ordered logistic regression was used to analyse the data.

**Results:** 56% of the sample underwent extraction at the ‘ideal time’. Of the spaces created by first molar extraction, 58% achieved grade 1 closure with contact point displacements less than 1 mm and 16% had displacements greater than 4 mm. Grade 1 space closure occurred in 83% of the cases with all three other radiographic factors. Conversely, none of those with unfavourable space closure had all three factors combined. Favourable space closure occurred when the SPM was between the stages of crown calcification and early root formation and in the presence of the other radiographic factors. This suggests that timing of FPM extraction is not as critical as previously accepted. However, unfavourable space closure was more likely to occur when the SPM was in the late root formation stage.

**Conclusion:** The findings of this study may be applied clinically when attempting to predict the chance of spontaneous space closure following lower FPM extraction. The most favourable parameters for spontaneous closure in the lower arch include the SPM in a development stage prior to late root formation, SPM mesially angulated and the presence of the third molar. A limitation of this study was the small sample size of patients in each group of SPM development stage and space closure grade. Furthermore, the inclusion criteria of patients who did not receive orthodontic treatment possibly excluded those with less favourable space closure.

Shiva Senathirajah
Three-Dimensional digital cast analysis of the effects produced by a passive self-ligating system

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Background: The desire to minimise orthodontic extractions has resulted in the need to create space through alternate means including increasing arch perimeter through expansion, interproximal reduction and distalisation. Many techniques and appliances have been designed to deliver expansive forces. The proponents of the passive self-ligating Damon System® of brackets have claimed their system is capable of expanding arches and their supporting tissues. The balance of existing evidence would suggest the Damon System® has similar expansion capabilities as other fixed appliance systems. No study has evaluated transverse maxillary and mandibular arch changes produced by a passive self-ligating system compared with untreated controls using digital casts.

Aim: To evaluate maxillary and mandibular arch changes induced by a passive self-ligating appliance by using digital dental casts versus a matched untreated control group.

Materials and methods: A retrospective study was conducted on patients treated by a single practitioner experienced in the use of the Damon System®. Pretreatment (T1) and post-treatment (T2) study casts of 25 consecutive patients (23 with Angle Class I malocclusion, two with ½ unit Class II malocclusion), mean age 12.8 ± 1.0 years, treated with a non-extraction protocol, were digitised using the 3Shape R700 model scanner (ESM Digital Solution Ltd, Dublin, Ireland). Control data from the Michigan Elementary and Secondary School Growth Study were matched for age, dentition stage, gender and malocclusion at T1 and then reassessed at T2, 1.7 ± 0.5 years later matched to the average treatment time of the study group. Sixty three-dimensional points were digitised on the maxillary and mandibular pre- and post-treatment virtual models. Pre- and post-treatment changes in transverse and anteroposterior arch dimensions and torque values were evaluated.

Results: There were no significant differences between the two groups at T1. Statistically significant differences were found from T1-T2 for: arch width increase with (0.9–2.2 mm) greater change in the test group for all teeth except the maxillary canines; greater arch perimeter increase of 2.3 mm and 2.5 mm for the maxilla and mandibular arches, respectively, in the treatment group; and maxillary first and second premolars exhibited larger increments in buccal root torque. No significant difference in the change occurring was found for arch depth, root torque of all mandibular teeth and for maxillary canines, incisors and molars.

Discussion: The self-ligating system tested resulted in a statistically significant widening of the maxillary and mandibular arches relative to a matched untreated control. The premolars showed proportionally the highest increase in width, explained by the width and shape of the arch forms used. The lack of overall change for maxillary canine width was the result of several canines displaced buccally at T1 and requiring constriction. The increase in arch width was less than that found in previous similar studies, and this can be explained by the palatal position of the points selected for measurement. The lack of change in anterior torque suggests that space for alignment was generated through posterior expansion rather than anterior proclination. The posterior expansion was associated with buccal flaring and loss of torque control of the upper bicuspids.

Anna Scott

Drifting of teeth in the mandible studied in adult human autopsy material

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Background: Late lower anterior crowding occurring after orthodontic treatment has often been attributed to relapse, but has also been observed in untreated Caucasian individuals. The aetiology behind late lower incisor crowding in adults is not well understood. A possible hypothesis could be that ongoing incisor movement is due to the surface characteristics and reduced thickness of bundle bone in the direction of drift.

Aim: To describe the pattern of tooth movement (translation vs tipping) in relation to the thickness of bundle bone around mandibular teeth and the distribution of eroding surfaces of the alveolar wall in human autopsy material.

Materials and methods: Histomorphometry was used
to analyse the distribution of bundle bone and eroding surfaces on 106 mandibular teeth and the surrounding bone obtained at autopsy from 35 deceased individuals with ages ranging from 19 to 55 years. The major limitation of the methodology was that only static quantitative parameters could be obtained, as intravital staining is obviously impossible when evaluating human autopsy material.

**Results:** The distribution of the bundle bone thickness and the vectors of eroding surfaces allowed the direction of tooth movement to be reconstructed. For the majority of teeth, the bundle bone thickness was lower at the coronal level on the mesial than on the distal side, indicating a dominance of mesial drift. This was also confirmed by more eroded surfaces on the mesial side. At the apical level, there was a larger variation, indicating that more uncontrolled tipping occurred.

In the bucco-lingual aspect at the coronal level, the results showed a lingual displacement of the anterior teeth, whereas the second premolars and molars seemed to have a buccal drift tendency. In all teeth apart from the second molars, the bucco-lingual drift occurred more as a translation than as a tipping movement.

The combination of mesial and lingual displacements of the anterior teeth can explain the increase in lower arch crowding and the deepening of the bite with age.

**Conclusion:** This histomorphometric analysis of human autopsy material supports the findings of previous authors that show mandibular arch perimeter decreasing and lower anterior crowding increasing during life, even after the cessation of rapid adolescent growth. The continued displacement of teeth exists, and the risk of late crowding is present in both treated and untreated individuals, with clinical implications for orthodontic retention regimes.

**Arjun Atresh**

**Three-dimensional analysis of palatal shape in patients treated with SARME using traditional and geometric morphometrics**

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**Background:** Maxillary expansion is required for patients who have transverse maxillary hypoplasia manifest as a transverse discrepancy in the size of the maxilla with respect to the mandible. Surgically-assisted rapid maxillary expansion (SARME) is a therapy indicated for adults and young patients who have already reached skeletal maturity. The advantage of surgery is that circum-maxillary rigidity is reduced, periodontal health is preserved, the risk of root resorption is diminished, and satisfactory results with long-term stability can be achieved. The morphological changes of the palate produced by SARME have been studied using three-dimensional (3D) technology.

**Aim:** To assess the effect of SARME on the size and shape of the palate and to compare palate configuration before and after therapy with an age-matched control group. To use the geometric morphometrics involving surface scanning of dental casts to achieve a detailed surface analysis, which provides more anatomical information compared with classical morphometrics or landmark data analysis.

**Materials and methods:** The material comprised maxillary plaster casts of 15 patients (mean age, 21.2 years; range, 16.6–34.1 years) who required complex orthodontic treatment, including SARME for unilateral or bilateral crossbite correction. The control group included maxillary dental casts of 50 healthy individuals who exhibited an Angle Class I first molar and canine relationship (mean age, 19.1 years; range, 16.6–25.5 years). Eighty dental casts were digitised using a 3D laser scanner and evaluated using traditional measurements of virtual models and shape analysis of the palatal surface.

**Results:** The conventional linear and angular measurements revealed that interdental distance and the interdental angle between the first molars had increased in the SARME group from T1 to T2. The shape analysis showed that the palate was widened, flattened and shortened by SARME. The palatal height also increased slightly but was not stable. There was a noticeable buccal shift of the lateral teeth associated with the flattening of the alveolar crest in the SARME group.

**Conclusion:** Transverse maxillary deficiencies can be successfully treated by SARME. The most remarkable differences between the pre- and post-treatment 3D models were widening of the palate and buccal shift of the lateral teeth associated with apparent flattening of the alveolar crest. The limitations of this study were: 1) a control group that was not closely matched; 2) the control group was not followed up; 3) there was no
sample size calculation; and 4) there was insufficient comparison between the conventional measurements and the new method.

Yunlong Kang

Effect of gender and Frankfort mandibular plane angle on orthodontic space closure: a randomized controlled trial

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Background: Many claims have been made regarding the influence of various factors on the speed of orthodontic tooth movement (OTM). Among these is the common assumption that space closure is slower in low-angle patients compared with high-angle patients due to the difference in occlusal forces. There is, however, currently no evidence to support this.

Gender is an additional factor that may influence space closure. Previous studies have been contradictory on the influence of gender and have only measured overall treatment time, which can be confounded by several factors (e.g., compliance, bite levelling, finishing time).

Aims: To determine the effect of gender and Frankfort mandibular plane angle (FMPA) on the rate of extraction space closure with fixed appliances.

Materials and methods: A single-centre, randomised, controlled, clinical trial was performed. One hundred subjects requiring full fixed appliances following the extraction of one premolar in each quadrant were recruited and randomly placed into three 0.022” bracket groups: conventional, passive self-ligating, and active self-ligating. Randomisation was also stratified into two age groups (11–14 years or 15–18 years) and three FMPA groups (low <22°, average 22–32°, or high >32°). All subjects were treated with the same bracket prescription (Roth), archwire sequence and space closure mechanics (NiTi closing coils on 0.019”x0.025” stainless steel archwires). Space closure was measured on models taken prior to bond up and every three months during treatment. Three types of space closure were defined: passive (from bond up until NiTi coils were applied), active (from start of NiTi coils until spaces were closed), and total (combined passive and active).

Results: There was no effect of bracket type on space closure. Therefore, the data were pooled across bracket types to analyse the effects of gender and FMPA. Space closure was faster in males. This was statistically significant in all three types of space closure (results are presented as effect size, lower and upper 95% confidence intervals, and probability): passive (1.064, 0.521, 1.607, 0.001), active (0.825, 0.312, 1.339, 0.002), and total (1.029, 0.527, 1.531, 0.001). There was no statistically significant effect of FMPA on space closure of any type.

Discussion: The authors theorised that during puberty, ‘teeth move more rapidly in a period of rapid bone turnover’. If so, the effect of gender on space closure was really due to the male subjects (mean age 14.2 years) being treated predominantly during their pubertal growth spurt. The mean age of the female subjects was similar (13.7 years), but since the female pubertal growth spurt occurs earlier, they were likely to have been treated after peak growth. This may explain why studies with older subjects found gender to have no effect, since most of the subjects were past peak growth. If it is accepted that there is no inherent difference in rate of OTM between genders as several studies suggest, then the results of this trial are the best evidence for the claim that OTM is faster in maximally growing patients. It is the only study with a randomised controlled clinical trial design measuring space closure in isolation, rather than overall treatment time. Regardless of whether the gender effect is due to growth or gender, the study highlights the importance of gender-matching young subjects in studies with controls.

The finding that space closure was unaffected by FMPA is counter-intuitive. No power calculations were reported, and perhaps a larger sample size is needed, given the large variation and relatively small effect size. If there truly is no effect, then this has important implications for anchorage assessment.

Limitations of the study are: 1. Treatment was performed by more than one clinician, although it was standardised as much as possible, 2. Clinicians could not be blinded to the variables studied (i.e., age, gender, bracket type, FMPA), and 3. Other factors possibly influencing space closure were not considered (e.g., was crowding similar across all groups? Were second molars included in the anchorage unit? Did elastic wear or extraction pattern bias the data for gender and FMPA? Did the extra time incurred by bracket failures during space closure affect the results?).

Annie Tong