These literature reviews have been prepared by the postgraduate students of the University of Otago, Dunedin, New Zealand.

Prevalence of gingival recession after orthodontic tooth movements

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Introduction: This study was designed to evaluate the long-term prevalence of gingival recession after orthodontic tooth movements, focussing on the effects of mandibular incisor proclination and expansion of maxillary posterior teeth.

Methods: Records of 205 patients (162 female, 43 male) were obtained from two private practice orthodontists. Using pretreatment (age, 14.0 ± 5.9 years) and post-treatment (age, 16.5 ± 6.0 years) lateral cephalograms and dental models, mandibular incisor proclination and maxillary arch widths were measured. Gingival recession was measured based on post-treatment and post-retention (age, 32.3 ± 8.5 years) intraoral photographs and models. Associations between tooth movements and gingival recession were evaluated statistically.

Results: Only 5.8% of teeth exhibited recession at the end of orthodontic treatment (only 0.6% had recession > 1 mm). After retention, 41.7% of the teeth showed recession, but the severity was limited (only 7.0% > 1 mm). There was no relationship between mandibular incisor proclination during treatment and post-treatment gingival recession. Incisors that finished treatment angulated (IMPA) at 95° or greater did not show significantly more recession than did those that finished less than 95°. There were weak positive correlations (r = 0.17–0.41) between maxillary arch width increases during treatment and post-treatment recession.

Conclusions: Orthodontic treatment is not a major risk factor for the development of gingival recession.

Although greater amounts of maxillary expansion during treatment increase the risks of post-treatment recession, the effects are minimal.

Critical appraisal: The research question of this study – ‘Does orthodontic treatment cause gingival recession?’ – is clinically relevant and was addressed using a retrospective study design. Patient records were sampled from two private orthodontic practices and included pre- and post-treatment photographs and study casts.

The study design was appropriate for answering the research question, although a longitudinal design would have represented a more robust methodological approach. A randomised control trial would have been impractical and unethical given the nature of this topic. The sample size was large; however, the percentage of patients excluded was also large. Of the 327 patient files reviewed, only 205 patient files were included. Although some cases were understandably excluded due to a lack of sufficient records for analysis, it does introduce the risk of selection bias if the excluded patients somehow differed to those included in the study.

The study subjects were mostly comprised of females (78.7%); in orthodontics, the majority of patients are female but not to such a significant extent. The use of a sample comprised of so many female subjects may not be representative of the typical orthodontic population. Additionally, patient files from only two private orthodontic practices were included. The recruitment of patients from a larger number of orthodontic practices would likely have increased the generalisability of the study.

Finally, recession was measured from intraoral photographs (and, to a lesser extent, stone models). Using intraoral photographs as tools for measurements means that each photograph taken had to be
standardised, as any changes to the photo angulation may alter the perception of the gingival height in the photographs. Since the records were collected retrospectively, standardisation of this technique was not possible.

The greatest problem with this study, however, is the lack of an untreated control group, as it did not account for other risk factors of gingival recession. Nonetheless, this study provided useful information towards answering a very commonly asked clinical question.

Wei Lin

**Midpalatal suture maturation in 11- to 15-year-olds: A cone-beam computed tomographic study**

Tonello DL, Ladewig VM, Guedes FP, Ferreira Conti ACC, Almeida-Pedrin RR and Capelozza-Filho L

Am J Orthod Dentofacial Orthop 2017; 152: 42-8

**Introduction:** Cone-beam computed tomography was used to evaluate the maturation stages of the midpalatal suture (MPS) in children aged 11 to 15 years. Maxillary expansion is successful for most patients in this age group, and so an attempt was made to identify the status of suture maturation in these subjects to use as a comparison for the prognosis of rapid maxillary expansion (RME) in older patients.

**Methods:** Tomographic images in axial sections of the midpalatal sutures from 84 children (40 boys, 44 girls; ages, 11–15 years) were classified using a scale denoting the suture’s maturation stage (A, B, C, D, and E). The chi-square test was applied to evaluate suture stages by gender and age groups.

**Results:** Stage A was observed in only one 11-year-old girl. Stage B was present at all ages but was more prevalent in those less than 13 years of age. Stage C was the most prevalent in all evaluated ages. Stages D and E showed low prevalence rates. Early stages of maturation were more prevalent in boys than girls.

**Conclusions:** The results of this study, which showed a dominant prevalence of stage C, suggested that conventional, nonsurgical RME performed in patients over 15 years old is justified by a satisfactory prognosis when assessment of the sutural status indicates stage C.

**Critical appraisal:** This was a cross-sectional study using cone-beam computed tomography to assess the so-called ‘maturation stages’ of the midpalatal suture (MPS) in children aged 11–15 years. The stages used in the study relied on the identification of distinct morphological features of the MPS when viewed in axial CBCT sections. These distinct features have previously been related to the concept of skeletal maturation and to the prognosis of RME. The concept of MPS maturation, as it appears on a CBCT, and its significance to clinical decision making and success of treatment, still remains to be validated by well designed studies and cannot be validated using the presented cross-sectional research design.

While the article stated the primary justification for the CBCT request was diagnosis of retained teeth, little information was available about the source of the sample (i.e., private practice, hospital, etc.) related to ethnicity, dentition stage, malocclusion characteristics, pubertal stages. Hence the representativeness (external validity) of the sample is unclear.

The maximum age of the study participants was limited to 15 years. Clinical experience suggests that the MPS can successfully be opened by RME in patients beyond this age, and well into early adulthood, when the MPS would be thought to be fused. It would therefore have been beneficial to extend the age range to include older individuals.

An error study to determine consistency of suture classifications between different examiners was mentioned in the text, but the results (kappa values) were not reported so the reliability of the method is unclear.

The results of the study were mainly descriptive of the ‘stages’ of MPS maturation by age groups and gender, mostly without statistical comparisons.

The authors concluded by claiming that the use of RME in patients over 15 years of age is justified if CBCT scans showed maturation was not complete. However, the authors should not make inference on patients older than 15 years as this was outside the range of the investigated age. The authors of the study concluded that RME is clinically successful in most young patients with prevalence of the earlier stages of MPS maturation. These conclusions are unsubstantiated by the study, which was not interventional but observational.

More evidence is needed before recommending the use of CBCT as a screening tool in patients requiring rapid maxillary expansion, especially when considering...
the principle of ALARA (as low as reasonably achievable), which applies to use of ionizing radiation for diagnostic imaging.

Divya Ramanan

**Quantitative analysis of enamel on debonded orthodontic brackets**

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*Am J Orthod Dentofacial Orthop 2017; 152: 312-9*

**Introduction:** Iatrogenic damage to the tooth surface in the form of enamel tearouts can occur during the removal of fixed orthodontic appliances. The aim of this study was to assess debonded metal and ceramic brackets attached with a variety of bonding materials to determine how frequently this type of damage occurs.

**Methods:** Eighty-one patients close to finishing fixed orthodontic treatment were recruited. All had metal brackets bonded with composite resin using a two-step etch-and-bond technique, ceramic brackets bonded with composite resin and a two-step etch-and-bond technique, composite resin using a self-etching primer, or resin-modified glass ionomer cement. Debonded brackets were examined by backscattered scanning electron microscopy with energy dispersive X-ray spectroscopy to determine the presence and area of enamel on the base pad.

**Results:** Of the 486 brackets collected, 26.1% exhibited enamel attached to the bonding material on the bracket base pad. The incidence of enamel tearouts for each group were: metal brackets, 13.3%; ceramic brackets, 30.2%; composite resin with self-etching primer, 38.2%; and resin-modified glass ionomer cement, 21.2%. The percentage of the bracket base pad covered in enamel was highly variable, ranging from 0% to 46.1%.

**Conclusions:** Enamel damage regularly occurred to a highly variable extent during the debonding process. Damage occurred more frequently when ceramic brackets were used (31.9%) compared with metal brackets (13.3%). The removal of ceramic brackets bonded with resin-modified glass ionomer cement resulted in less damage compared with the resin bonding systems.

**Critical appraisal:** Investigating the extent of iatrogenic enamel damage in different bracket and adhesive combinations has definite and very interesting clinical implications for decreasing iatrogenic enamel loss. This retrospective cohort study had a reasonably large sample size over multiple centres; however, there are a number of limitations.

The inclusion criteria focussed only on active self-ligating brackets and the locations of practices or age of patients was not included in the article. This convenience sampling may not be representative of an orthodontic population and is prone to selection bias.

A variable that was not included in the study design was the incidence of white spot lesions or the quality of enamel, which would affect the cohesive strength of enamel and result in larger areas of damage. This may explain why the percentage of tearouts was higher on lateral incisors, as these teeth are more frequently affected by white spot lesions.

It is unclear whether the same tooth bracket combinations were used for each patient or the length of time the brackets had been attached to the teeth. The aging of the adhesive may influence the bonding strength and therefore the resultant enamel loss during removal of the brackets. The volume of the enamel and therefore depth of the iatrogenic damage was also not assessed, which the authors discussed as one of their limitations. This may be more clinically relevant than the damaged surface area of enamel.

Whilst acknowledging these limitations, overall the study’s findings suggest that iatrogenic enamel loss occurs more frequently and to a greater extent with active ceramic self-ligating brackets bonded with composite resin. However, the clinical relevance of this potential iatrogenic damage remains to be established.

Ana Low

**Prevalence of extraction space reopening in different orthodontic treatment protocols**

Janson G, Valarelli DP, Rizzo M and Valarelli FP

*Am J Orthod Dentofacial Orthop 2017; 152: 320-6*

**Introduction:** This study aimed to compare the amount and frequency of extraction space reopening after two- and four-premolar extraction treatments in Class II, and four-premolar extractions in Class I malocclusion patients.

**Methods:** The sample comprised 105 subjects with full-cusp Class II and Class I malocclusions, divided into three groups.
• Group 1 consisted of 33 full-cusp Class II malocclusion patients treated with a two-premolar extraction protocol.
• Group 2 comprised 34 full-cusp Class II malocclusion patients treated with four-premolar extractions.
• Group 3 included 38 Class I malocclusion patients treated with four-premolar extractions.

The Peer Assessment Rating index was used to assess initial malocclusion severity and quality of the occlusal outcome, measured on dental casts. The amount of extraction space was measured with a digital caliper on the final and long-term post-treatment dental casts, after an average of 9.79 years post-treatment. Intergroup comparisons were performed by analysis of variance, followed by Tukey tests and chi-square tests.

**Results:** There were no significant differences regarding the amount and frequency of extraction space reopening among the groups.

**Conclusions:** Two- and four-premolar extraction cases in Class II and four-premolar extraction treatment in Class I malocclusion patients show similar reopening of extraction spaces in the long term.

**Critical appraisal:** This was a retrospective study that consisted of participants selected from an Orthodontic Department in Brazil. Participants were separated into three treatment groups of Class II and Class I malocclusions treated with different premolar extraction patterns, involving two or four premolars. Participants were reviewed approximately 9.5 years post-treatment, when immediate- and long-term post-treatment study casts were measured for the amount and frequency of space reopening. The study found there was no difference in the amount or frequency of space reopening between the three different treatment groups.

The study was generally well-written and included clear and concise objectives and eligibility criteria. The study also conducted a sample size calculation based on a power of 80% (minimum of 33 participants per group). Moreover, the authors attempted to match each group for age, sex, retention and long-term post-treatment recall time. The authors also conducted an error study to assess reliability.

There were a few study limitations, however. Firstly, this was a retrospective study, which may suffer from a level of bias compared with a prospective and randomised controlled trial. For instance, the sample population was recruited via convenience sampling from a population within the department patient database, which can result in potential selection bias. This in turn may make the results unrepresentative of the entire population.

Secondly, there was no exclusion of participants with incomplete space closure post-treatment. To achieve an adequate sample size (based on the calculated power), the authors included patients with residual post-treatment space. The inclusion of these cases may potentially have masked the extent to which space reopened.

Finally, the authors stated that periodontal problems were one of the key contributors to spaces reopening; however, no periodontal recordings were conducted at the long-term post-treatment recall.

In summary, this study attempted to identify an association between different extraction protocols and space reopening. While the study does have its merits, more research is needed to identify the causes of the relapse.

**Caleb Lawrence**

**Discomfort associated with Invisalign and traditional brackets: A randomized, prospective trial**

White DW, Julien KC, Jacob H, Campbell PM and Buschang PH


**Objectives:** To evaluate differences in discomfort levels between patients treated with aligners and traditional fixed orthodontic appliances.

**Materials and methods:** This blinded, prospective, randomised, equivalence, two-arm parallel trial allocated 41 adult Class I nonextraction patients to either traditional fixed appliance (6 males and 12 females) or aligner (11 males and 12 females) treatment. Patients completed daily discomfort diaries following their initial treatment appointment, after one month and after two months. They recorded their levels of discomfort at rest, while chewing, and while biting, as well as their analgesic consumption and sleep disturbances.

**Results:** Both treatment modalities demonstrated similar levels of initial discomfort. There were no
significant sex differences. Patients in the traditional fixed appliances group reported significantly ($p < 0.05$) greater discomfort than patients in the aligner group during the first week of active treatment. There was significantly more discomfort while chewing than when at rest. Traditional patients also reported significantly more discomfort than aligner patients after the first and second monthly adjustment appointments. Discomfort after the subsequent adjustments was consistently lower than after the initial bonding or aligner delivery appointments. A higher percentage of patients in the fixed-appliance group reported taking analgesics during the first week for dental pain, but only the difference on day two was statistically significant.

**Conclusions:** Patients treated with traditional fixed appliances reported greater discomfort and consumed more analgesics than patients treated with aligners.

**Critical appraisal:** This was a randomised, prospective trial investigating discomfort levels between Class I non-extraction patients treated with Invisalign® aligners and traditional fixed appliances. The methodological quality of the study was rated as medium using the evaluation method described in the Cochrane Handbook for Systematic Reviews of Interventions 5.1.0.

Participants were recruited from an ongoing university orthodontic department study, and may not reflect the general population. Patients were simply randomised to receive either traditional fixed appliances ($N = 18$, 6 males and 12 females) or aligner treatment ($N = 23$, 11 males and 12 females). Perhaps stratified randomisation may have been a more appropriate method for this small study to reduce imbalances between groups. Although baseline pain levels were similar, the study failed to comment about overall baseline characteristics of the participants themselves. Factors such as ethnicity and age have the potential to act as confounders for pain perception. Of an initial 240 eligible patients, only 41 (17%) met the inclusion criteria. This is a low percentage of the screened population and may again impact the generalisability of the study findings.

Patients were treated by two clinicians, one of whom completed all the ClinChecks for the aligner group. Self-reported pain after treatment was recorded in diaries using a visual analogue scale (VAS), and these were measured by a blinded investigator. The VAS is commonly used in orthodontic pain research but, as with other self-reported measures, is subject to response bias. Although the investigator was blinded to the outcome measure, the participants themselves would have been aware which treatment they had been assigned, making this study difficult to classify as a truly blinded randomised trial. Only 3% of self-reported diaries were not returned or lost, representing a high level of follow-up.

All participants were followed-up except for one in the aligner group who, interestingly, was not analysed because they refused to continue treatment due to TMJ discomfort. As this investigation is concerned with orthodontic pain and discomfort, this may be an important outcome in the aligner group. Major differences were seen in the initial stages of treatment, but these differences tended to diminish with time.

The trial was partially funded by Align Technology (the manufacturer of Invisalign®), indicating a possible conflict of interest.

Simon Olliver

**Severe obstructive sleep apnea treatment with oral appliance: the impact on obstructive, central and mixed events**

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Sleep Breath 2017, Jul 12. doi: 10.1007/s11325-017-1535-0. Epub ahead of print

**Aim:** The aim of the study was to evaluate the effectiveness of two types of oral appliance (OA) for the treatment of severe obstructive sleep apnea syndrome (OSAS).

**Method:** Forty-eight patients (53.7 ± 10.8 years) who were suffering from severe OSAS with a history of non-adherence to positive airway pressure therapy (PAP) were included in the study and treated with either a lingual orthosis (a spring attached to a maxillary acrylic plate to position the tongue forward) or with a combined orthosis (a mandibular advancement appliance combined with a lingual orthosis appliance). Full lab-based polysomnography (PSG) studies were performed before and after treatment. Computed tomography and cephalometric radiography were requested for all patients to evaluate the titrated position of the OA and the air space
obtained. Statistical analyses consisted of univariate tests with the level of statistical significance set at 5%.

Results: Twelve participants were treated with a lingual orthosis and 36 with a combined orthosis. Before treatment, the mean AHI for the entire sample was 56.3 ± 19.1 events/h. The prevalence decreased to 8.1 ± 5.2 after the OA titration (p ≤ 0.001). There was a significant reduction in the number of obstructive events from 43.0 ± 20.2 to 7.1 ± 4.6 events/h (p ≤ 0.001). The reduction in central events after OA treatment was also significant (from 5.1 ± 9.3 to 0.8 ± 1.9 events/h; p ≤ 0.001), whereas mixed events decreased from 6.4 ± 9.5 to 0.1 ± 0.3 events/h (p ≤ 0.001). The minimum oxygen saturation also showed significant improvement after treatment (p ≤ 0.001). There was no statistically significant difference between the oral appliances with respect to central events (p = 0.22) or mixed events (p = 0.98).

Conclusion: Both oral appliances were effective in reducing obstructive events, as assessed by AHI and minimum oxygen saturation. The oral appliances also normalised central and mixed events in patients with severe OSAS.

Critical appraisal: This study investigated the efficacy of two oral appliances for the management of severe obstructive sleep apnea. The appliances are infrequently used, probably because they are very bulky and invasive within the pharyngeal space.

One of the strengths of the study was the use of lab-based polysomnography, which is considered the gold standard for OSAS diagnosis. A second strength was the use of well-defined criteria in analysing sleep recording data.

The study lacked a passive control group or an active control group treated by conventional mandibular advancement appliances. There was no randomisation and the allocation of patients was decided by clinicians on the basis of clinical characteristics, including the number of teeth and temporomandibular disorders. It was therefore at high risk of bias.

The sample sizes of the two treatment groups were largely different, with 12 patients in one group and 36 in the other. It was reported that cephalometric radiographs and computed tomograms were collected from all participants before and after treatment, but no quantitative analysis was carried out on these images.

The demographic data of the participants was not adequately presented to check any differences at baseline between the treatment groups regarding gender, age, and body mass index.

The study did not report any information on patients’ compliance and adherence to treatment. This was very important because the appliances appeared highly uncomfortable, difficult to wear and caused significant side effects, related to swallowing, gagging, and vomiting in up to 80% of the participants. It would be noteworthy to have measured the actual wearing time using objective methods, such as, for example, by the use of thermal sensors (e.g. Theramon).

It can be expected that the appliances used in this study would disrupt sleep and, therefore, a reduction of sleep apnoea events might be ascribed, at least in part, to poor sleep quality. Unfortunately, no quantitative data were provided about total sleep time, sleep structure, and sleep quality, despite this information being generally available through PSG.

Within the discussed limitations, the current study provided a low level of evidence for the efficacy of tongue orthosis in severe OSAS cases.

Ghassan Idris