European Journal of Orthodontics 28 (2006) 573–579
doi:10.1093/ejo/cjl031
Advance Access publication 6 September 2006

Maxillary third molar position in Class II malocclusions: the effect of treatment with and without maxillary premolar extractions

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SUMMARY The present study compared the number of erupted and functioning maxillary third molars and their mesio-distal angulation in patients with Class II malocclusions orthodontically treated with and without extraction of two maxillary premolars and fixed appliances. For that purpose, the records of 55 patients were selected, which were divided into two groups. Group 1 was treated without extractions and comprised 28 patient records (19 males and 9 females), with a mean age of 19.03 years [standard deviation (SD) = 2.33], treatment time of 2.59 years (SD = 1.08), and follow-up time of 6.48 years (SD = 2.42). Group 2 was treated with extractions and comprised 27 patient records (14 males and 13 females), with a mean age of 19.94 years (SD = 2.87), treatment time of 2.95 years (SD = 1.17), and follow-up time of 5.88 years (SD = 2.96). Analysis of the erupted and functioning maxillary third molars was conducted on the maxillary and mandibular dental casts. The mesio-distal angulations of the maxillary third molars were assessed on panoramic radiographs with the presence of both maxillary third molars.

The results demonstrated that the number of erupted and functioning maxillary third molars was statistically greater ($P = 0.01$) in Class II subjects treated with extraction of maxillary premolars, when compared with those treated without extractions. The patients treated with two maxillary premolar extractions presented significantly smaller third molar mesio-distal angulations, that are more favourable to eruption, than those treated non-extraction.

Introduction

Impacted third molars may commonly be observed in patients referred for orthodontic treatment with extraction of premolars (Dierkes, 1975; Haavikko *et al*., 1978). However, the incidence of impaction of third molars seems to be lower among these patients than in the general population (Goblirsch, 1930; Ford, 1940; Haavikko *et al*., 1978). The explanation for such a finding is that extraction of premolars allows mesial movement of the posterior segments, which provides more available space in the third molar area (Weinstein, 1971; Kim *et al*., 2003).

Treatment of moderate to severe Class II malocclusion patients with a protruded maxillary base and/or teeth, without cephalometric discrepancy, and/or with a minimal amount of mandibular crowding, during growth, usually comprises distal movement of the maxillary dentition or extraction of two maxillary premolars for correction of the problem (Bishara and Andreasen, 1983; Moyers, 1988). The first option largely relies on patient compliance to wear extraoral headgear to distalize the maxillary teeth and/or restrict forward maxillary growth, and consequently is more susceptible to failure. The second option also requires patient compliance, yet to a much smaller extent. Thus, it may lead to a higher rate of treatment success (Andrews, 1976; Bishara and Andreasen, 1983; Moyers, 1988). Some conservative clinicians and parents may prefer the first option with the intention of preserving teeth (Moyers, 1988). Several studies have demonstrated that in subjects where extractions have been carried out, there is a smaller prevalence of impacted third molars compared with non-extraction cases (Weinstein, 1971; Richardson, 1974; Kim *et al*., 2003). Nevertheless, the relationship between the extraction of maxillary premolars in Class II malocclusion subjects and the availability of space for the maxillary third molars has not been specifically investigated. Therefore, the present study compared the clinical presence and angulation of the maxillary third molars in moderate to severe Class II malocclusion subjects treated with and without extraction of the maxillary premolars. The following null hypothesis was investigated: there is no difference in the number of erupted third molars or their angulations between moderate and severe Class II malocclusion subjects treated with or without extraction of two maxillary premolars.

Materials and methods

Materials

Selection of the sample was obtained retrospectively from the files of the Orthodontic Department at Bauru Dental

School, University of São Paulo. Fifty-five records, which fulfilled the inclusion criteria, were obtained from a total sample of 900 Class II malocclusion patient records, treated with fixed appliances, which were divided into two groups. Group 1 comprised 28 records of patients (19 males and 9 females) treated without extractions, during a mean time of 2.59 years [standard deviation (SD) = 1.08), with a mean age of 19.03 years at the last follow-up examination (SD = 2.33, ranging from 14.08 to 23.92 years) and a mean follow-up time of 6.48 years (SD = 2.42, ranging from 2.08 to 11.42 years). Fourteen had bilateral full-cusp (complete) Class II malocclusions and 14 a bilateral half-cusp Class II malocclusion molar relationship (Andrews, 1975; Wheeler *et al*., 2002). Group 2 comprised the records of 27 patients (14 males and 13 females) treated with extraction of two first maxillary premolars, during a mean time of 2.95 years (SD = 1.17), with a mean age of 19.94 years at the last follow-up examination (SD = 2.87, ranging from 14.75 to 25.67 years) and a mean follow-up time of 5.88 years (SD = 2.96, ranging from 0.8 to 10.50 years). Twenty had bilateral full-cusp Class II malocclusions and seven a bilateral half-cusp Class II malocclusion molar relationship (Andrews, 1975; Wheeler *et al*., 2002). The basic criteria used for sample selection were the presence of a molar relationship of at least a half unit Class II on both sides, absence of tooth agenesis or supernumerary teeth at the pre-treatment stage, and the presence of all permanent teeth (excluding maxillary premolars in the extraction group) except for the mandibular third molars, which could be absent, at the last follow-up examination.

Treatment in both groups was undertaken using either the standard or pre-adjusted edgewise technique, which is characterized by the use of 0.022 × 0.028 inch brackets with extraoral headgear to reinforce anchorage for the maxillary teeth. In group 1, extraoral headgear was used to correct the Class II relationship, while in group 2, extraoral headgear was used to reinforce anchorage during retraction of the anterior segment. For levelling and alignment, the usual wire sequence of a 0.015 inch twist-flex or 0.016 inch nitinol wire, followed by 0.016, 0.018, and 0.020 inch stainless steel round wires was used. Anterior retraction and the finishing procedures were accomplished by either 0.019 × 0.025 or 0.021 × 0.025 inch rectangular wires and 0.018 inch round wires, respectively. After the active treatment period, a Hawley retainer was used in the maxillary arch and a bonded canine-to-canine retainer in the mandibular arch.

Methods

Evaluation of erupted maxillary third molars. This evaluation was performed on 55 pairs of dental casts obtained at the last follow-up examination. The number of erupted and functioning maxillary third molars observed on these dental casts was recorded on specific forms for each group, by a single investigator (LMP). The tooth was regarded as functioning when it had occlusal contact with the mandibular teeth. In subjects where the mandibular third molars were absent, only the eruption of the maxillary third molar was considered to satisfy the criterion.

Evaluation of maxillary third molars mesio-distal angulation. This evaluation was performed on 55 panoramic radiographs obtained at the last follow-up examination. The panoramic tracings and landmark identification were performed manually on a 14 × 30 cm acetate paper by a single investigator (LMP).

Anatomic tracing. The anatomical structures, landmarks, reference lines, and variables are illustrated in Figure 1 (Mitchell, 1963).

Error study. Fifteen randomly selected panoramic radiographs were retraced and remeasured by the same examiner (LMP) after a 1-month interval from the first measurement. The casual error was calculated according to the formula of Dahlberg (1940) $S^2=\sum d^2/2n$, where S^2 is the error variance and d is the difference between the two determinations of the same variable. Systematic errors were determined with

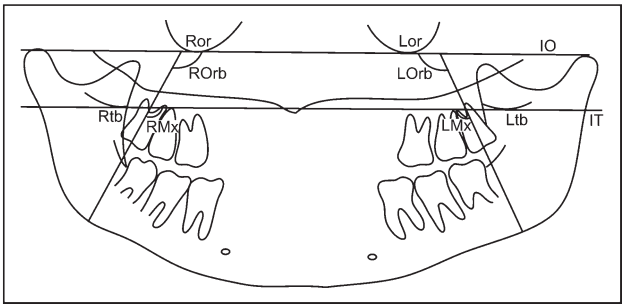

Figure 1 Anatomical structures: lower contour of the orbits, contour of the maxillary tuberosities, contour of the hard palate, anterior nasal spine, and contour of the maxillary third molars. Landmarks: Right orbital (Ror), most inferior point of the right orbital cavity; Left orbital (Lor), most inferior point of the left orbital cavity; Right tuberosity (Rtb), most inferior point of the right maxillary tuberosity; and Left tuberosity (Ltb), most inferior point of the left maxillary tuberosity. Reference lines: interorbital line (IO), line passing through Ror and Lor; intertuberosity line (IT), line passing through Rtb and Ltb and the long axis of the maxillary third molars, defined by a line bisecting the furcation of the maxillary third molars and the middle of the crown. The intertuberosity line was also used because in seven patients in group 1 and five patients in group 2 on the initial panoramic radiograph and in five patients in group 1 and two in group 2 on the follow-up panoramic radiographs, the orbits were inadvertently cut during exposure. Variables: ROrb, angle between the right maxillary third molar and the interorbital line; LOrb, angle between the left maxillary third molar and the interorbital line; MeRLOrb: mean angulation of the right and left maxillary third molars and the interorbital line; RMx, angle between the right maxillary third molar and the intertuberosity line; LMx, angle between the left maxillary third molar and the intertuberosity line; MeRLMx, mean angulation between the right and left maxillary third molars and the intertuberosity line; ROrbMx, mean angulation between the right maxillary third molar and the interorbital and intertuberosity lines; LOrbMx, mean angulation between the left maxillary third molar and the interorbital and intertuberosity lines; MeOrbMx, mean angulation between the right maxillary third molar and the interorbital and intertuberosity lines and the left maxillary third molar and the interorbital and intertuberosity lines.

dependent *t*-tests at a level of significance of $P < 0.05$ (Houston, 1983).

Statistical analyses. In order to compare the treatment time and to test the groups' initial malocclusion severity and the final occlusal results compatibilities, the initial and final weighted Peer Assessment Rating scores (Richmond *et al*., 1992) adjusted for Americans (DeGuzman *et al*., 1995) and maxillary and mandibular initial crowding were compared by means of *t*-tests. The number of patients with complete and half Class II malocclusions in the groups was compared with the chi-square test. The gender percentages in the groups were compared by the test of differences between two percentages.

Comparison of the number of erupted and functioning third molars between groups was conducted using the chi-square test and the mesio-distal angulations of the third molars between groups with independent *t*-tests on the software (Statistica for Windows 5.0A; Statsoft, Tulsa, Oklahoma, USA). The results were regarded as statistically significant at $P < 0.05$.

Results

None of the variables presented statistically significant systematic errors (Table 1). The groups were similar with regard to treatment time, initial malocclusion severity, final occlusal results, maxillary and mandibular crowding, third molar angulations, and the number of complete and half Class II malocclusions (Tables 2 and 3). The gender percentages in the groups were not statistically different ($P = 0.226$). Group 2 had a significantly greater number of erupted and functioning third molars than group 1 (Table 3). The evaluation of age and follow-up time of the groups was similar, while the mesio-distal angulation of maxillary third molars in group 2 was significantly smaller and more favourable to eruption (for the third molars that had not yet erupted) than group 1 (Table 4).

Discussion

Ideally, the selected records should have presented a complete symmetrical bilateral Class II antero-posterior dental relationship. However, from the 900 available Class II cases from the Orthodontic Department, many were excluded according to the treatment protocol. Therefore, subjects presenting a symmetrical bilateral molar relationship of at least half Class II were accepted. They had to be symmetrical because the aim of the study was to evaluate the eruption space for the maxillary third molars and their mesio-distal axial inclinations on both sides. Additionally, patients with smaller antero-posterior Class II discrepancies were excluded from the sample because this would attenuate the characteristics of a Class II malocclusion and consequently decrease the probability of finding differences in third molar space between the groups.

Thus, 28 patients in group 1 and 27 patients in group 2 fulfilled these criteria. This may seem to be a small sample compared with the total number of patients with Class II malocclusions, which is usually predominant in the orthodontic clinic (Andrews, 1976; Moyers, 1988); however, it should be remembered that the established criteria excluded many potential patients. Kim *et al.* (2003) used 157 patients, however, they consisted of Class I or Class II cases, without antero-posterior discrepancy severity discrimination, with only one third molar present before or after treatment. Richardson (1975) and Dierkes (1975) reported that experimental groups comprising large numbers of individuals are difficult to find, especially when the selection criteria employed are highly specific.

Methodology

The best way to evaluate the number of erupted third molars would obviously be a direct clinical evaluation of each patient (Lewis *et al*., 1982). Nevertheless, this type of evaluation would be almost impossible to perform because of the retrospective design of the study. The first

Table 1 The casual and systematic errors (paired *t*-test).

Variables (degrees)	First measurement ($n = 15$)		Second measurement ($n = 15$)		Dahlberg	*P*
	Mean	SD	Mean	SD		
ROrb	116.73	8.43	116.53	7.21	4.26	0.885
LOrb	114.53	11.92	115.33	11.21	3.53	0.583
MeRLOrb	115.36	8.58	115.93	7.80	2.51	0.598
RMx	116.80	7.86	116.06	7.24	3.43	0.611
LMx	114.60	11.19	116.00	10.52	3.03	0.371
MeRLMx	115.70	8.40	116.03	7.69	2.45	0.776
ROrbMx	124.46	30.55	116.30	7.15	3.75	0.290
LOrbMx	114.56	11.50	115.66	10.82	3.21	0.461
MeOrbMx	115.50	8.47	115.94	7.73	2.45	0.693

SD, standard deviation.

Table 2 Comparison of the treatment times, initial and final malocclusion severity [Peer Assessment Rating (PAR) score], and initial third molar angulations (*t*-test).

	Group 1, non-extraction			Group 2, two maxillary premolar extractions			df	*P*
	Mean	SD	*n*	Mean	SD	*n*		
Treatment time	2.59	1.08	28	2.95	1.17	27	53	0.230
Initial PAR	24.25	7.40	28	25.70	7.30	27	53	0.466
Final PAR	2.35	3.03	28	1.76	1.94	27	53	0.395
Maxillary crowding (mm)	0.17	1.90	28	0.22	1.05	27	53	0.917
Mandibular crowding (mm)	1.28	2.05	28	1.33	1.64	27	53	0.924
ROrb (°)	129.59	15.18	21	127.77	20.27	22	41	0.741
LOrb (°)	124.28	12.54	21	126.84	15.59	22	41	0.558
MeRLOrb (°)	126.94	12.54	21	127.30	16.73	22	41	0.935
RMx (°)	129.02	15.32	28	125.75	18.61	27	53	0.479
LMx (°)	125.02	12.25	28	128.18	16.88	27	53	0.429
MeRLMx (°)	127.02	12.44	28	126.96	16.64	27	53	0.987
RorbMx (°)	129.30	15.23	21	126.76	19.40	22	41	0.635
LorbMx (°)	124.65	12.38	21	127.51	16.18	22	41	0.520
MeOrbMx (°)	126.98	12.48	21	127.13	16.68	22	41	0.972

df, degrees of freedom; SD, standard deviation.

Table 3 Comparison of the number of patients with complete or half unit Class II malocclusions and the number of erupted third molars in the groups.

Variables	Complete Class II	Half unit Class II		Total number of patients	Chi-square test
Group 1, Non-extraction	14	14		28	$\chi^2 = 3.37$, $P = 0.06$
Group 2, two maxillary premolar extractions	20	7		27	
	Erupted	Unerupted	Total number of teeth	Total number of patients	
Group 1, non-extraction	12 (21.42%)	44 (78.58%)	56	28	$\chi^2 = 6.62$, $P = 0.01$
Group 2, two maxillary premolar extractions	24 (44.44%)	30 (55.56%)	54	27	

problem is the difficulty in tracing patients several years after treatment completion. Even if a significant number of patients could attend, evaluation would be affected by possible subsequent dental losses, and many may have had the unfavourably positioned third molars extracted (Little *et al*., 1981; Shields *et al*., 1985). A prospective study may have been more satisfactory, with patients being randomly assigned to one group or the other. However, most of the studies on this topic, if not all, have been retrospective (Goblirsch, 1930; Ledyard, 1953; Weinstein, 1971; Richardson, 1974; Dierkes, 1975; Kaplan, 1975; Haavikko *et al*., 1978; Kim *et al*., 2003).

Compatibility of the groups

The groups were compatible regarding treatment time, initial malocclusion severity, final occlusal result, maxillary and mandibular crowding, the number of patients with complete and half unit Class II malocclusions, the initial third molar angulations, and gender distribution (Tables 2 and 3). Despite being statistically similar, it may be considered that the number of half Class II cases is clinically different between the groups. However, this difference would favour the non-extraction group that presented more half Class II cases, which consequently would require less maxillary molars distalization that could compromise third molar space angulation. The number of patients in each group was very similar, with 28 patients in group 1 and 27 in group 2. The mean age at the last follow-up examination, with the presence of the third molars, was 19.03 years for group 1 and 19.94 years for group 2. Thus, the ages and follow-up times were not statistically different (Table 4). Although compatible, the mean ages may be criticized for being too young to evaluate third molar eruption because of the variations in eruption time (Goblirsch, 1930; Bishara

Table 4 Comparison of the mean and standard deviation (SD) of third molar angulation in the groups (*t*-test).

Variables	Group 1, non-extraction ($n = 28$)		Group 2, two maxillary premolar extractions ($n = 27$)		df	*P*
	Mean	SD	Mean	SD		
Age (years)	19.03	2.33	19.94	2.87	53	0.203
Follow-up time (years)	6.48	2.42	5.88	2.96	53	0.417
ROrb (°)	119.13	13.50	111.32	12.64	46+	0.044*
LOrb (°)	118.95	13.17	111.28	11.25	46+	0.034*
MeRLOrb (°)	119.04	11.07	111.30	10.22	46+	0.015*
RMx (°)	119.00	14.97	109.59	15.75	53	0.027*
LMx (°)	121.00	12.58	111.07	12.17	53	0.004*
MeRLMx (°)	120.00	11.38	110.33	12.57	53	0.004*
ROrbMx (°)	119.15	13.85	111.34	12.35	46+	0.044*
LOrbMx (°)	118.82	12.71	111.24	11.19	46+	0.033*
MeOrbMx (°)	118.98	11.03	111.29	10.21	46+	0.015*

df, degrees of freedom.
+Group 1, $n = 23$; Group 2, $n = 25$.
*$P < 005$.

and Andreasen, 1983). However, the records of many older patients showed that their third molars had been extracted because of the absence of available space or because of poor prognosis for eruption as a result of unfavourable mesio-distal angulation. While this mean age may in some way be criticized regarding the eruption evaluation, it would not significantly affect the angulation comparison. Even if the tooth root is not completely formed, its angulation can be measured based on its crown, provided there is no dilaceration. As the mean ages were similar, it was anticipated that a similar number of younger patients with incompletely formed roots would be present in both groups.

Number of erupted third molars

Analysis of the results demonstrated a significantly greater number of erupted third molars in the two maxillary premolar extraction group (group 2) than in the non-extraction treated group (group 1), as demonstrated in Table 3. This result seems to be due to the greater space available either by maintaining the maxillary posterior segment in place in complete Class II antero-posterior discrepancy cases or by gaining space through mesial displacement of the posterior segment in half Class II antero-posterior discrepancy cases when treatment is performed with extraction of two maxillary premolars, as compared with the non-extraction approach. In the non-extraction protocol, as the maxillary posterior teeth are distalized, less space would be available for the third molars. These results resemble those of Richardson (1974, 1975), Dierkes (1975), Kaplan (1975), and Kim *et al*. (2003) for the maxillary arch.

The current findings suggest that unerupted maxillary third molars might be a greater problem either after two maxillary premolar extraction or after non-extraction approaches in Class II subjects, than reported by Kim *et al*. (2003), who studied impaction more specifically (Table 3). They reported impaction rates of 50 and 16 per cent for non-extraction and extraction treatments, respectively. This can probably be explained by the fact that their sample included Class I and Class II malocclusion patients. For four premolar extraction Class I malocclusions that do not require severe anchorage reinforcement, greater mesial displacement of the maxillary molars can occur, providing more space for the third molars. For non-extraction Class I malocclusions, the maxillary molars do not have to be distalized and consequently will not decrease the space for the third molars (Ledyard, 1953). The difference in impaction frequency is considerably large, despite the younger age of the current study sample as compared to theirs. Richardson (1975) also found that 56 per cent of patients following orthodontic treatment without premolar extractions required posterior surgical treatment for extraction of impacted third molars. The results of the current study indicate a frequency of unerupted maxillary third molars even greater than this in the non-extraction approach. Again, the explanation could be that Richardson (1975) included Class I and Class II malocclusion patients in their investigation, while in this study, only Class II malocclusion subjects in which the maxillary molars had to be distalized, decreasing the space for third molars were included. Ledyard (1953) found a greater frequency of impacted maxillary third molars in non-extraction Class II malocclusions as compared with Class I malocclusions, which supports this speculation.

The sample selection may be criticized for including only patients with third molars (erupted or not), obviously excluding older patients where third molars had been extracted. To assume that patients in whom maxillary third molars had been extracted would affect the current results, the following scenario would have to be contemplated: the

significant majority of patients who had their maxillary third molars extracted, due to lack of space or unfavourable angulation, would have to belong to the two maxillary premolar extraction group. However, this would be very unlikely based on previous findings (Richardson, 1974, 1975; Dierkes, 1975; Kaplan, 1975; Kim *et al*., 2003). Besides, the results on the dental casts were confirmed by radiographic evaluation of the third molars angulations.

Radiographic results

The mesio-distal axial angulations of the maxillary third molars of group 2 were more upright and consequently more favourable to eruption than of group 1, when evaluated either through the interorbital or intertuberosity lines or through a combination of the two lines (Table 4). However, the use of panoramic radiographs in this evaluation may be criticized. Although linear measurements, especially horizontally, are unreliable because they are influenced by projection and motion factors (Kane, 1964; Richardson *et al*., 1969; Zach *et al*., 1969; Hauck, 1970; Lund and Manson-Hing, 1975; Philipp and Hurst, 1978; Alpern, 1979), angular measurements are not so variable (Frykholm *et al*., 1977; Mayoral, 1982; Samawi and Burke, 1984; Larheim and Svanaes, 1986; Lucchesi *et al*., 1988; Ursi *et al*., 1990). Therefore, their use in this comparative evaluation seems satisfactory. These radiographic findings support the results of the evaluation of the number of erupted third molars in these groups. Additionally, both results confirm a clinical expectation that would occur when comparing long-term Class II patients treated non-extraction and with two maxillary premolar extraction protocols. However, due to the relatively young age of the subjects, these results should be regarded as a tendency which would require future studies with larger samples at a more advanced age, using corrected oblique cephalometric radiographs.

Clinical implications

The results of this study demonstrate that there is a greater probability of maxillary third molar eruption and improved mesio-distal angular positioning of these teeth, when treatment of moderate to severe Class II discrepancy malocclusion patients with a protruded maxillary base and/or teeth, without cephalometric discrepancy, and/or with a minimal amount of crowding are treated with two maxillary premolar extraction rather than non-extraction. This should be taken into account during treatment planning. The decision in all treatment planning is dependent on a cost/benefit ratio (Shaw *et al*., 1991). When analysing the several variables involved, the greater maxillary third molar impaction probability in non-extraction treatment of these cases should also be considered. Preserving the maxillary premolars may result in later extraction of the third molars. Premolar extraction surgery is usually easier and less expensive than maxillary third molar extraction (Kim *et al*., 2003). Additionally, patient compliance in using extraoral appliances in Class II non-extraction cases is greater than in two premolar extraction cases (Andrews, 1975). Yet, in non-compliant patients, use of mini-implants as anchorage to distalize the maxillary teeth may also contribute to increased maxillary third molar impaction in non-extraction Class II malocclusion treatment. Therefore, careful consideration of these aspects will help in establishing a better treatment plan for each patient.

Conclusions

The null hypothesis was rejected because the number of erupted maxillary third molars was greater in the subjects treated with extraction of the maxillary premolars than in those treated non-extraction, and their mesio-distal angulations were smaller and more favourable to eruption.

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