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The Effect of Extraction of Third Molars on Late Lower Incisor Crowding: A Randomized Controlled Trial

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Abstract. *The problem of late mandibular incisor crowding is a well established phenomenon, the cause of which has been the substance of considerable debate over the years. A central issue is the possible role of the third molars though no definitive conclusions have been consistently drawn. This prospective study was designed to investigate the effects of randomly assigned early extraction of third molars on late crowding of the mandibular incisors. One-hundred-and-sixty-four patients entered the study from 1984 following completion of retention after orthodontic treatment. Seventy-seven patients (47%) returned for records up to a mean of 66 months later, and their start and finish study casts were digitized on a reflex microscope to determine Little's index of irregularity, intercanine width and arch length. Forty-four of the patients had been randomized to have third molars removed. There was no evidence of responder bias. Where third molars were extracted the mean increase in lower labial segment irregularity was reduced by 1·1 mm from a mean of 2·1 mm for the group where third molars were retained (P = 0·15, not statistically significant). This difference was also not considered to be clinically significant. The principal conclusion drawn from this randomized prospective study is that the removal of third molars to reduce or prevent late incisor crowding cannot be justified..*

Index words: Late Incisor Crowding, Little's Irregularity Index, Third Molars.

Introduction

Although Angle (1907) believed that stability of the arches could be ensured by creating a normal occlusion, the phenomenon of late lower arch crowding is well established, frequently seen, and the possible causes are the subject of considerable debate and controversy. Many potential aetiological factors have been investigated and include anterior growth and remodelling of the mandible (Broadbent, 1943; Björk, 1963; Björk and Skieller, 1983) mesial migration of the posterior teeth (Moss & Picton, 1972), anterior component of force on the occlusion (van Beek and Fidler, 1977; Southard *et al*., 1990, 1991), degree of original crowding (Richardson, 1982; Kahl-Nieke *et al*., 1995), tooth size and shape (Nordeval *et al*., 1975; Kahl-Nieke *et al*., 1995) and evolutionary factors (Björk, 1950). A further factor which has been the subject of several studies is the presence or position of the mandibular third molars. These studies have varied in their findings and interpretation, several studies finding no relationship between third molars and late anterior crowding, whilst others find a definite association to varying extents. This subject has been extensively reviewed in the literature (Bishara and Andreasen, 1983; Richardson, 1989; Vasir and Robinson, 1991; Richardson, 1996). Summarizing these reviews one author concluded that there was relatively little evidence to support a policy of third molar extraction in relation to incisor crowding (Toth, 1993). The characteristics of the data available to date preclude any firm conclusions either way about the relationship between third molars and anterior crowding, and only a brief review of the aspects of these studies which are pertinent to the current prospective study is appropriate here.

Several of the previous studies of the relationship between third molars and late crowding were longitudinal, but compared groups where the third molars were developmentally absent or present (Vego, 1962). In that study, the conclusion was that the group with third molars present had a slight increase in crowding and though the difference was small (0·8 mm) it was statistically significant. Similarly, Bergstrom and Jensen (1960) found that the crowding on the side of the mouth where the third molar was present was slightly greater that on the contra-lateral side where there was aplasia of the third molar. On the other hand, Shanley (1962) found no significant differences with bilaterally impacted, erupted or developmentally absent third molars and concluded that the third molar has little or no influence on late anterior crowding. A similar study by Kaplan (1974) on orthodontically-treated cases came to the same conclusions, but it has been suggested by Vasir and Robinson

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(1991) that if different statistical tests are applied to the available data, a small, but statistically significant difference between the groups would have been apparent.

A problem with studies involving developmental absence of a third molar is that these subjects may differ genetically in other important respects such as tooth or arch size. In addition, studies involving unilateral differences of third molar status are complicated by the potential for tooth-moving forces to cross the midline and effect contralateral dental alignment. In a study by Lindquist and Thilander (1982), third molar extractions were randomised unilaterally and compared with the contra-lateral non-extraction; a very small (0·16 mm on average) beneficial effect on the extraction side was found. Other studies have looked at many factors including third molar status which might be associated with late anterior irregularity. These have usually comprised patients who previously underwent orthodontic treatment. Ades *et al* (1990) and Richardson (1979) have reported no connection between third molar presence or position, and late incisor irregularity. Richardson and Mills (1990) did report that extraction of lower second molars decreased later lower incisor crowding and felt that this might be due to a reduction in the effect of crowded third molars. Kahl-Nieke *et al*. (1995) did report a small and statistically significant relationship with post-treatment increase in crowding which was on average 1·3 mm greater in the presence of third molars. However, in this latter study, some of the missing molars were the result of agenesis rather than therapeutic extraction and the possible drawbacks of co-inherited differences have previously been mentioned. Furthermore, the criteria for the decision to extract were unknown to the investigators. It is quite possible in such studies for the clinicians' criteria for extraction of third molars to unwittingly enhance or obscure the effects of such extractions because the extraction and non-extraction groups are likely to be unmatched with respect to other aetiological features.

The disadvantages of studies in which the patients were not matched in all aspects other than the decision to extract are particularly important when the factors causing the late anterior crowding are unclear and unquantified. This applies to the retrospective study by Schwarze (1973) who found that the average subsequent mesial movement of the first molars was 1·5 mm greater in the 49 patients with retained third molars than in the 100 who underwent early third molar germectomy. Extraction was carried out in those patients in whom a 'strong tendency to crowding and relapse' was diagnosed, but the basis for this diagnosis was not described. Schwarze felt that this study provided strong evidence supporting the beneficial effects of third molar removal, but it is possible that these effects would have been even more apparent had extractions not been confined to those subjects whom he felt were most at risk of late anterior crowding. The corollary also applies, namely that the apparent beneficial effects of third molar removal in this study could be due to incorrect assumptions about the features which indicate a tendency to late anterior crowding. Although fewer in number (24 out of 125 teeth extracted), he also looked at the upper arch in relation to third molar removal and found approximately 1 mm less mesial drift of the upper first molars where third molars had been removed.

It is clear that in the absence of robust data indicating the relevance and strength of any proposed aetiological features, a prospective study is required in which the patients are randomly assigned to extraction or retention of the third molars. The lack of knowledge about aetiological factors causing late anterior crowding does not then prevent the examination of the effects of such extraction because the two groups will, by the process of random assignment be matched in all relevant respects, known and unknown. The current study is a randomised controlled trial to assess the effects on late anterior alignment of third molar removal—a procedure which is associated with significant morbidity and cost (Shepherd and Brickley, 1994).

Subjects and Methods

The principle aim of the study was to investigate prospectively the effects, if any, of early extraction of third molars on late lower incisor crowding. Plaster study casts, OPT and cephalometric lateral skull radiographs were obtained from 164 patients at the start of the study. At that time in 1984, the senior orthodontic clinicians at Bristol Dental Hospital varied greatly in their practice regarding prophylactic third molar removal following orthodontic treatment, reflecting the variety of opinion and of the findings of the investigations to date. It was the normal practice of one clinician to almost always recommend the extraction of third molars at the end of orthodontic treatment, whereas another almost never recommended extraction unless local signs or symptoms (e.g. pericoronitis) were present indicating the need for removal of the third molar on its own merits. The clinicians concerned agreed that with such a dichotomy of treatment philosophy they would be prepared to randomly allocate extraction or retention of third molars in all patients meeting the following criteria:

1. All patients had previously undergone orthodontic treatment, but on entry into the study were no longer wearing any orthodontic appliances or retainers. Orthodontic treatment comprised active treatment in the upper arch only with either removable appliances or a single arch fixed appliance, with no treatment or premolar extractions only being carried out in the lower arch.
2. All patients had crowded third molars—that is third molars whose long axis and, therefore, presumed path of eruption was through the adjacent second molar.

Having first decided that the criteria were met in an individual case, a list of randomly generated numbers was used to allocate extraction or retention of the third molars for that patient. As many patients as possible were contacted after a minimum of five years from entry into the study when a further set of records was taken. This time period was estimated as the minimum which would give clinically meaningful differences. Extensive effort was given to contacting those who did not attend for their five year review. Letters were sent out to individuals, and where this failed endeavour was made to contact the patient via known family, doctor, and dentist telephone numbers.

The upper and lower entry and exit casts of responders were digitized using a reflex microscope linked to a microcomputer. Lower study casts of the non responders were also digitised in order to verify if any differences were present between those patients who entered the study and successfully completed it compared with those who entered but did not complete (Kahl *et al*. 1995). A jig was designed in order to practice the digitizing technique, calibrate the digitizer, and to assess both precision and reproducibility. The third molar status was unknown to the digitizer in order to eliminate sub-conscious bias. Approximately 10 per cent of records were redigitized after an interval of at least 3 months in order to calculate the error of the method. The mesial and distal anatomical contact points of all teeth from the first molars mesially in both jaws were digitized and the three-dimensional co-ordinates stored. Data were stored and analysed using Minitab^{TM} and GLIM statistical software. The programme was used to calculate Little's two-dimensional Index of Irregularity (Little, 1975; Fig. 1), intercanine width and arch length in both the upper and lower arches (Fig. 2).

Error of the Method

Any factor capable of altering the observed differences between repeated measurements of the same study cast must be considered as a source of error. The total variance of the sample may be described as the sum of the biological variance and the error variance. By calculating the mean and standard deviations of the differences between first and second digitizations of the same cast, it is possible to determine the error variance. Midtgard *et al* (1974) suggested that the error variance should not exceed 3 per cent of the variance in the material as a whole and if it exceeds 10 per cent, the applied method of measuring is probably inappropriate. Appreciable method errors mean that it is not possible to be sure whether small changes measured are real or are methodological errors (Houston, 1983).

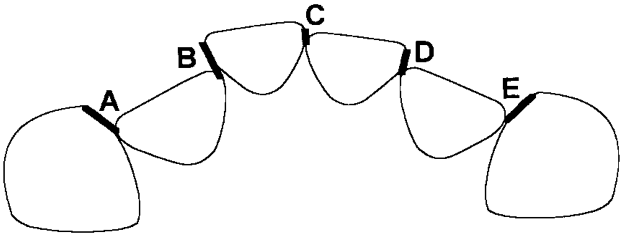

FIG. 1. Little's Index of Irregularity is the sum of the contact point displacements from anatomic contact point to contact point (A + B + C + D + E).

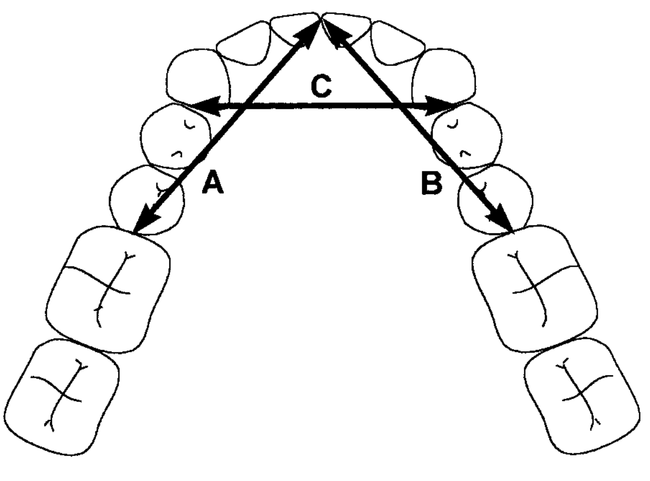

FIG. 2. Intercanine width was measured across the anatomic distal contact points of the canines, arch length being the sum of the distances from the mesial contact of the first molar to the midline contact point (A + B).

Results

Of the original 164 patients who entered the trial, 90 (55 per cent) were female and 74 (45 per cent) male (Table 1). Forty-seven per cent of patients (77) completed the trial of whom (58 per cent) (45) were females. The mean age at entry into the trial was 14 years and 10 months (SD 16·2 months) and the mean length of follow-up was 66 months (SD 12·6 months). Generalized linear modelling was carried out resulting in the initial casts of 44 of the non-responders being digitized to ascertain if any responder bias was present with respect to the outcome measurements. All values fell within the 96 per cent confidence intervals and it was concluded that no systematic differences occurred between those patients who entered the trial and completed and those who entered and did not complete.

Error of the Method (Table 2)

The very small mean differences between first and second digitizations indicate an absence of systematic error. With regard to random error, the error variance was less than 3 per cent of the total variance for all variables including

TABLE 1 *Sample data: generalized linear modelling demonstrated no systematic differences between those patients who entered the study and completed, and those who entered and did not complete*

	Entered	Completed	Non-completed
Numbers	164	77	87
Females	90	45	48
Males	74	32	39
mean age of entry	14·10		
Third molars removed		44	

TABLE 2 *Error study: 16 casts were redigitized and the difference between the two readings calculated. From this the means of the differences were obtained, the variance determined and the percentage of the total variance calculated for Little's index of irregularity (LII) intercanine width (ICW) and arch length (AL)*

	LII	ICW	AL
Total variance	3·32	4·37	38·92
Mean of differences	0·15	0·01	0·13
SD of differences	0·42	0·18	0·35
Variance	0·09	0·02	0·06
Variance (%)	2·69	0·37	0·16

Little's irregularity index (2·7 per cent). It was concluded that the measurement error of the method was within acceptable limits for this study.

From the start and end study casts, the differences between the three measurements were calculated; Little's index of irregularity, intercanine width and arch length. For the data as a whole, there was a mean increase in incisor irregularity of 0·9 mm, a decrease in inter-canine width of 0·4 mm and a decrease in arch length of 1·5 mm (Table 3). The data were split into two groups depending on whether the patient was randomized to have their third molars removed ($n = 44$) or retained ($n = 33$). Two sample *t*-tests and confidence intervals were calculated for the differences between the two groups (Table 4). Where third molars were extracted the mean increase in irregularity was 0·80 mm compared with 1·10 mm where they were not ($P = 0{\cdot}55$). This difference is within the 95 per cent confidence interval of −0·7 – 1·3 (i.e. not statistically significant at the 5 per cent level). For the intercanine width there was no clinical or statistically significant difference. There was however a small but statistically highly significant ($P = 0{\cdot}0001$) greater decrease in the arch length for the non-extraction group (2·1 mm) compared with the extraction group (1·1 mm). This greater decrease in arch length for the non-extraction group could not at first sight be easily reconciled with the lack of a statistically significant difference in Little's index between the groups and a closer examination of the casts was therefore made. Thirty-nine of the recalled patients had undergone lower premolar extractions and it was apparent that some of the casts at entry still had some slight residual premolar extraction space which was not fully closed, despite absence of space being an intended criterion for entry into the study. There were 23 such cases and a further analysis was made excluding these to examine the possible effects of this factor (Table 5).

This analysis reveals a slight increase in the mean difference for Little's index of irregularity (1·1 mm) between the non-extraction group compared with the extraction group, but with values still within the 95 per cent confidence interval (−0·5 – 2·7) and, therefore, not significant statistically ($P = 0{\cdot}15$). The disparity in decrease in arch length was reduced to 0·7 mm mean difference in arch length between the two groups ($P = 0{\cdot}0035$).

Table 6 shows the data for the upper arch and indicates that there are no statistical differences between the two groups for any of the three measurements.

TABLE 3 *The changes in Little's index of irregularity (LII), intercanine width (ICW), and arch length (AL) for the sample taken as a whole (responders)*

	Mean change	SD
LII	0·93	1·99
ICW	−0·37	0·78
AL	−1·54	1·76

TABLE 4 *The changes in Little's index of irregularity (LII), intercanine width (ICW), and arch length (AL) for the third molar extraction (3EX) and non-extraction (3NEX) groups*

	Group	Mean change	SD	*P*
LII	3NEX	1·10	2·72	
	3EX	0·80	1·23	0·55
ICW	3NEX	−0·38	0·85	
	3EX	−0·37	0·73	0·92
AL	3NEX	−2·13	0·97	
	3EX	−1·1	1·13	0·001***

$n = 44$ for 3EX group and 33 for 3NEX group.
*$P < 0{\cdot}05$; **$P < 0{\cdot}01$; ***$P < 0{\cdot}001$.

Discussion

In all prospective studies it is important to address the question of responder bias. As only 77 of the original 164 patients returned five years after the end of all retention, it was important to ascertain through generalized linear modelling whether differences in relevant variables were present at the start of the study between those 'responders' who returned for follow-up records after five years and those 'non-responders' who did not. The initial casts of 44 of the non-responders were therefore digitized to determine if responder bias was present in respect of the measurements made. The values for the observed differences between the three measurements for the responders and non-responders all fell within the 95% confidence intervals and it was concluded that no systematic differences existed between those patients who entered the trial and completed, and those who entered and did not complete. It is important to note that no subject in the study was unwilling to return for follow-up records. All patients who were contacted were prepared and able to attend for follow-up records. Responder bias in relation to patient location or attitude was therefore not relevant. All non-attendance at follow-up was due to the large number of subjects in their late teens and early twenties who were lost to all contact with the occupiers of their previous address, and with their previous general dental and medical practitioners, an incidental finding of

TABLE 5 *Two sample* t*-testing for the sample excluding those cases with some residual spacing on entry to the study*

	Group	Mean change	SD	*P*
LII	3NEX	2·09	3·08	
	3EX	0·97	1·21	0·15
ICW	3NEX	−0·55	0·99	
	3EX	−0·37	0·79	0·52
AL	3NEX	−1·75	0·71	
	3EX	−0·98	1·13	0·0035**

$n = 36$ for 3EX group and 18 for 3NEX group.

TABLE 6 *The changes in Little's index of irregularity, intercanine width, and arch length for the third molar extraction and non-extraction groups, for the upper arch*

	Group	Mean change	SD	*P*
LII	3NEX	−1·14	1·97	
	3EX	−0·70	2·3	0·40
ICW	3NEX	0·356	0·64	
	3EX	0·66	1·74	0·39
AL	3NEX	1·67	2·21	
	3EX	1·61	2·12	0·91

$n = 30$ for 3EX group and 26 for 3NEX group.
*$P < 0{\cdot}05$; **$P < 0{\cdot}01$; ***$P < 0{\cdot}001$.

wider interest in its own right. The central finding of this study is that it is very unlikely that third molar removal has a clinically significant effect on later change in incisor irregularity. The difference in statistical significance between the results for arch length and those for the irregularity index is also of interest as is the related factor of residual premolar extraction site spacing. The work of Richardson (1979) strongly supports the view that whatever the cause of late anterior crowding, it is associated with mesial movement of posterior teeth rather than lower incisor retroclination. The removal from analysis of those cases with small residual spaces produced results which support this view and indicate that such spaces may well provide a slight 'safety valve' for the labial segment from the influence of mesial molar migration. It happened that there were more cases with small residual spaces in the third molar extraction group and removal of these cases from analysis enlarged the mean difference in increase of irregularity index from 0·3 to 1·1 mm and reduced the mean difference in arch length reduction. It is of interest that the difference in decrease in lower arch length was still statistically significant at the 1 per cent level, whilst the difference in increase of lower arch irregularity was still not statistically significant. It is possible that any effect of third molars on more anterior teeth is only partially expressed as an increase in anterior irregularity and may cause minor changes in arch form which shorten the arch length as measured in this study using the method employed by Little (1975).

There are two sorts of significance attached to the findings of any study. Statistical tests show that the differences between the changes in incisor irregularity in the two groups in this study are likely to have been due to chance. The statistical significance of any such difference is quantifiable and can be demonstrated, but the clinical significance of any finding is open to subjective opinion. For example, even if shown to be statistically significant, what level of reduction of later incisor irregularity would be considered clinically significant: 1, 2, 3, 4 mm, or more? Before carrying out the statistical analysis, the authors came to the view that a difference of 2 mm in later incisor irregularity would be the minimum that could be regarded as clinically significant. Analysis revealed that the 95 per cent confidence interval for the difference in Little's Index was between −0·7 and +1·3 mm. At the upper limit of the confidence interval, third molar extraction produced a benefit of 1·3 mm, some way short of the minimum considered to be clinically significant. Of relevance to a prospective study, these confidence intervals also supported the view that successful recall of all 164 cases would not have revealed an effect of third molar extraction which was both statistically and clinically significant. Removing from the analysis those cases with slight residual premolar spacing increased both the mean difference and also the 95 per cent confidence interval (−0·5 to +2·7). This implies that with very large samples there is a small chance that a mean difference of 2 mm in the increase in Little's irregularity index could be attributed to the extraction of third molars. Whilst the chance of a real clinically significant benefit from third molar extraction is therefore statistically small, this part of the analysis suggests that the extraction of crowded third molars following orthodontic treatment might on average produce a small (approximately 1 mm) reduction in lower labial segment irregularity 5 years later and that this effect is of the same order as may be attributable to leaving very small residual extraction spaces in the premolar region.

Conclusions

While no similar prospective study exists in the literature, the results of this investigation supports the work of Linquist and Thilander (1982) who extracted third molars unilaterally and Vego (1962) who examined aplasia of third molars, both of whom found a very small increase in crowding with third molars present but no clinically significant effect. Similar conclusions were drawn by Ades *et al*., (1990) in their retrospective study of patients who had received orthodontic treatment. This study does not support the conclusions of Schwarze (1973) based on a retrospective study of non-randomized extractions, that third molar extractions are clearly beneficial in reducing later anterior irregularity, and this study also failed to support his view that third molar extraction was of benefit to upper arch irregularity in that no significant differences were seen in any of the three measurements for the upper arch. The current study does support the view of Richardson (1975, 1996) that pressure from behind results in increased incisor irregularity, but also supports the work of Southard *et al*. (1991) in finding no evidence that this pressure is significantly influenced by third molar extraction. The principal conclusion drawn from this investigation is that removal of the third molars in an attempt to reduce the degree of late lower incisor crowding cannot be justified.

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