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Third molar influence on dental arch crowding

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SUMMARY The aim of the present study was to measure the dental arches in order to assess the potential influence of third molars on lower incisor crowding. Changes in dental arch dimensions were assessed in 47 patients (36 females, 11 males) three years following either removal of the third molars or deciding to leave them *in situ*. A dental pantomogram (DPT) was taken at the start of the study and plaster study models were obtained at both the beginning and end of the observation period. The study models were used to measure crowding, and to prepare photocopies for linear measurements of the dental arch (length and width). Using the DPT, the ratio of retromolar space to the width of the crown of the third molar was calculated using the method originally described by Olive and Basford and later modified by Ganss (Ganss ratio).

The results showed that the measurements of crowding and arch length and width had changed in 12 lower and two upper dental arches. The relationship between these results and the Ganss ratio was statistically significant. Calculation of the Ganss ratio may therefore assist investigations into the development of dental arch crowding and also help determine the indications for third molar removal.

Introduction

The effect of third molar retention on incisor crowding has been investigated for over 140 years. Sheneman (1968), in a study of 49 patients who had undergone orthodontic treatment for crowding, compared three groups of subjects, i.e. with bilateral eruption, bilateral impaction, or developmental absence of the third molars. She found that retention of third molars was associated with severe incisor crowding, which was not observed when the teeth were absent. Lindquist and Thilander (1982) examined 23 male and 29 female patients, with bilateral impaction of the lower third molars and anterior crowding. Unilateral extraction of one of the impacted third molars was carried out and study casts and cephalograms were assessed annually for a period of three years post-extraction. The authors concluded that third molar extraction relieved anterior crowding in 70 per cent of the patients. Richardson (1979) observed first molar drift and incisor crowding in subjects with retained third molars. She believed that third molar impaction was one of the causative factors because anterior crowding was found more frequently in patients with third molar impaction than in subjects in whom the teeth were correctly positioned in the dental arch (Richardson, 1989, 1996). Mesial drift of the third molars has been documented following extraction of other teeth (Richardson, 1975; Stephens, 1980; Faubion, 1968; Graber, 1981). Lundström (1969), who examined the dental arches of 111 thirteen-year-old boys, and Moorrees and Reed (1952) who studied the mandibular dentition in 72 female American patients between 18 and 20 years of age, both found a decrease in crowding when the third molars were missing.

There are, however, opponents of the hypothesis that third molars affect anterior tooth position. They propose several causes of incisor crowding, but do not believe there is an association with third molar eruption. Little *et al.* (1981) analysed data from non-orthodontic subjects, and concluded that incisor crowding became more severe in adolescents, young adults or even later in life with no obvious cause. According to Weinstein (1971), Björk and Skieller (1972) and Siatkowski (1974), a tendency for incisors to retrocline with age may account for increased crowding. Siatkowski (1974) claimed that lower incisors might move under the forces of tongue and lip muscle contraction and this concept was supported by Lundström (1969), who observed incisor crowding when the third molars were missing or had been extracted. Björk and Skieller (1972) studied facial development and tooth eruption throughout adolescence, but found no evidence to confirm a relationship between late lower labial segment crowding and third molar eruption. Kaplan (1975) evaluated post-retention crowding in three subject groups, i.e. third molar absence, impaction or extraction. Whilst some degree of lower incisor crowding was observed in most patients, no significant differences were found between the three groups. That author concluded that the third molars did not exert any significant influence on the length and width of the dental arches and did not contribute to incisor crowding. In a similar, but non-orthodontic group, Richardson (1982), observed mesial drift of the lower first molars (51 patients, aged 13–17 years) and suggested that this might have resulted in an increase in lower arch crowding. An attempt to determine the relationship between the third molars and changes in lower dental arch parameters was also undertaken by Ades *et al.* (1990). Their investigation was based on the analysis of models and lateral cephalograms of 97 subjects with bilaterally erupted, impacted, developmentally missing or extracted third molars. In view of the fact that there was no difference between the groups in dental arch length and width or incisor crowding, the authors proposed that third molar removal to decrease incisor crowding was unjustified. This was in agreement with a later study in which Southard (1992) concluded that 'removing these teeth (i.e. the third molars) for the exclusive purpose of relieving interdental force and thereby preventing incisor crowding is unwarranted'.

The aims of the present study were therefore (1) to undertake measurements of the dental arches in order to assess potential third molar influence on lower incisor crowding (2) to localize the sites of most noticeable dental arch changes (3) to assess the usefulness of photocopies of study models in linear measurements and (4) to find correlations, if any, between dental arch parameters and the measurement of retromolar space/lower third molar crown width.

Subjects and methods

The study population consisted of patients seen in the Oral and Maxillofacial Surgery Department in 1993 in whom incisor crowding was diagnosed during third molar development, eruption or impaction. The most frequent reasons for referral were problems related to third molar eruption (51%), and orthodontic indications (34%).

Patients who had undergone orthodontic treatment or who had malocclusions were excluded from the study. At the end of the three-year observation period six patients who had undergone extraction of their first molars were excluded and 25 were lost to follow-up. Twelve pairs of models (taken from six patients) were rejected due to cast inaccuracy or mechanical damage. Therefore following the preliminary examination of 106 subjects and subsequent exclusion of the patients mentioned, data was available for 36 females and 11 males at the three-year time point (Table 1).

Table 1 Age distribution in the study groups.

Patients' age in years	Study group			
	2M3ex	1M3ex	2M3	M3ag
14 – 18	6	3	8	0
19 – 32*	11	9	8	2
Group comparison – Fisher's exact test				
2M3ex	X	$P = 0.69$ (NS)	$P = 0.49$ (NS)	X
1M3ex	$P = 0.69$ (NS)	X	$P = 0.25$ (NS)	X
2M3	$P = 0.49$ (NS)	$P = 0.25$ (NS)	X	X

2M3ex, bilateral third molar removal or bilateral third molar germectomy; 1M3ex, extraction of one lower third molar; 2M3, retention of both lower third molars; M3ag, unilateral third molar agenesis.
*The groups were combined for the purpose of statistical analysis.
X, no statistical analysis was carried out.

The patients were divided into two age and four treatment groups. In terms of age, the first group comprised 17 patients aged 14 to 18 years of age, and the other 30 patients aged 19 to 32 years. Four groups were formed depending on third molar treatment strategy. Group 2M3ex comprised 17 patients who had undergone bilateral third molar removal or bilateral third molar germectomy; Group 1M3ex 12 subjects who had undergone extraction of only one lower third molar. The control group 2M3 consisted of 16 subjects with both lower third molars retained, and group M3ag two patients with unilateral third molar agenesis. The tooth was retained in one subject, but removed in the other due to recurrent pain. Upper third molars were evaluated in all subjects, but the group distribution was different, i.e. 2M3ex = 6; 1M3ex = 5; 2M3 = 29, and M3ag = 7 patients.

At the beginning of the study period, each subject had a panoramic radiograph taken and alginate impressions to allow casting of plaster models. These records were repeated at the end of the three-year observation period. The models were used for measurement of crowding and also to prepare photocopies for linear measurements of the dental arch (length and width).

Analysis of the photocopies of plaster casts

Alginate impressions were taken at the start and end of the three-year observation period and were cast, using dental plaster, to obtain upper and lower models which were subsequently photocopied. A single photocopy showed both pairs of models from each patient and this enabled linear measurements of the dental arch width and length to be carried out using Korkhaus callipers, accurate to 0.02 mm. Arch length and width were measured on two pairs of models per patient (maxilla and mandible), and differences were noted between the parameters obtained for each study subject. The mean error of the measurement was 0.02 mm (Table 2).

Three dimensions of the six used by Lavelle and Foster (1969) were selected. Additionally, a 'd' dimension was introduced (Figure 1). Intercanine, interpremolar, and intermolar widths were also assessed; the latter was measured on the second molars (Figure 1). The results of the photocopy dental arch measurements were compared with those obtained from plaster models. A Student's *t*-test was used for statistical analysis (Table 2).

Analysis of the plaster casts

Using the simplified method of Lundström (1969), the parameters shown in Figure 1 (S1, S2, S3, S4, S5, and S6) were measured using callipers with the pinpoint placed parallel to the masticatory surface of the dental arch segment. Differences between the baseline and end study measurements were calculated. Crown width was also measured since this parameter could change, for

Table 2 Means and standard deviations (SD) of measurements taken on the model and photocopy of the mandibular study cast.

Dimension	Mean (mm)	SD (mm)	Student's *t*-test	
			t (t_{kr} = 2.01)	Statistical significance
a_r	0.017	0.084	1.37	NS
b_r	0.013	0.068	1.27	NS
c_r	0.015	0.072	1.40	NS
d_r	0.006	0.064	0.68	NS
a_l	0.019	0.071	1.83	NS
b_l	0.011	0.063	1.14	NS
c_l	0.015	0.069	1.46	NS
d_l	0.004	0.055	0.52	NS
a	0.008	0.065	0.88	NS
b	0.011	0.063	1.14	NS
c	0.019	0.077	1.69	NS

r, right side.
l, left side.
NS, not significant ($P > 0.05$).

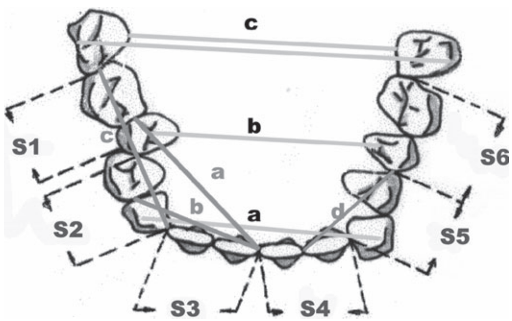

Figure 1 Measurements of the dental arch. Length: a = distance between the mesial edge point of the medial incisor, and the middle point of the mesial surface of the lower first molar; b = distance between the mesial edge point of the medial incisor and the middle point of the canine distal surface; c = distance between the middle point of the mesial surface of the canine and the middle point of the distal surface of the lower first molar; d = distance between the mesial edge point of the lateral incisor and the middle point of the distal surface of the first premolar. Width: **a** = distance between the canine cusps; **b** = distance between the second premolars measured in the middle of the intercuspal fissure; **c** = distance between the buccal surfaces of the lower second molars + distance between the lingual second molar surfaces, divided by two. If the intercuspal fissure was clearly defined, the measurement was taken in the middle of the fissure. Crowding: S1arch segment: first molar and second premolar of the right dental quadrant. Space available for the teeth was assessed by measuring the distance between the distal surface of the first premolar and the mesial surface of the second molar; S2 arch segment: first premolar and the canine of the right quadrant; S3 arch segment: lateral and medial right incisors; S4 arch segment: medial and lateral left incisors; S5 arch segment: canine and first premolar in the left quadrant; S6 arch segment: second premolar and first molar in the left quadrant.

example, if caries affected the mesial and/or distal tooth surfaces. However, as no differences were found between the results, no further analysis of crown width was carried out. The three-year differences in dental arch length, width, and crowding were specified as positive (size increased), negative (size decreased) or unchanged.

Radiographic analysis

Each patient had a panoramic radiograph taken at the first appointment, based on which the position of the third molars were determined. The available retromolar space was also measured in addition to third molar crown width. Tracing paper was laid over the radiograph, and an occlusal line drawn through the tips of the superior cusp of the first premolar and the superior mesial cusp of the second molar. A second line, vertical to the occlusal line, was drawn through the distal point of the superior cusp of the second molar crown. The available retromolar space was defined as the distance between the distal border of the second molar and the anterior border of the ramus measured on the occlusal plane, in proportion to the width of the third molar crown (Figure 2). The third molar crown width was then measured, and the ratio of retromolar space to crown width was calculated according to the method described by Olive and Basford (1981) and later modified by Ganss *et al.* (1993) (known as the 'Ganss ratio'). The measurements were obtained for each quadrant of the dental arch before a decision was made concerning third molar removal or retention. It was hypothesized that if there was insufficient space available for eruption, the third molar might influence the movement of other teeth.

The dental arch measurements were analysed statistically in relation to the Ganss ratio.

Results

Of the 47 patients, length, width and crowding measurements changed over the three-year period in 12 lower and two upper dental arches. In view of the small number of subjects who experienced changes in the maxillary arch, these measurements were not subject to analysis.

Lower arch length, width and six dental arch segments, and the Ganss ratio (*Tables 3 to 5*)

The length, width and six dental arch segments showed an increase in the extraction groups, and a decrease when the third molars were retained, in which case the Ganss ratio was lower (0.60 to 0.65). Medium to high ratios (0.85 to 0.89) correlated with a lack of change in the lower arch measurements.

Changes in the length of the lower dental arch

In groups 1M3ex and 2M3, the length of the arch decreased by –1.15 to –0.25 mm on the side where the third molar was retained. In contrast, in groups 1M3ex and 2M3ex, arch length increased by 0.40 mm to 0.70 mm. No changes in dental arch length were observed in M3ag subjects.

The Ganss ratio was relatively low (0.61) in those patients in whom the length of the lower right quadrant either increased following third molar extraction or decreased when the third molar was left *in situ*. In the majority of patients there was no change in the length of the segment and the mean value of the Ganss ratio was higher at 0.89. These relationships were statistically significant at $P < 0.001$ for the right side, and $P < 0.05$ for the left side (Table 3).

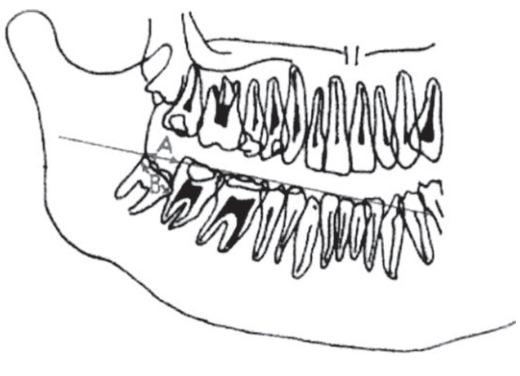

Figure 2 Measurement of Ganss factor (ratio of accessible retromolar space to the width of the crown of the third molar (A:B)) on the panoramic radiographs.

Changes in the width of the lower dental arch

The interpremolar and intermolar widths decreased, from –1.10 to –0.50 mm, in subjects in the 1M3ex or 2M3 groups. Unilateral extraction of third molar germs (group M3ag) and bilateral extraction of third molars (group 2M3ex) seemed to result in an increase in width of between +0.45 to +1.05 mm. The intercanine width did not change in any of the four groups over the three-year period.

Where a high Ganss ratio existed, no differences in dental arch width were found. Where a width reduction occurred, this correlated with a low Ganss ratio (Table 4).

Changes in the six segments of the lower arch

In groups 2M3, 2M3ex and 1M3ex, on the side of third molar retention, there was an increase in severity of crowding. This was most pronounced in the segments comprising two incisors and the canine and first premolar (range –0.80 to –0.20 mm). Crowding was more frequently decreased (+0.10 to +0.60 mm) on the side where the third molar was absent in the corresponding segments of the following groups: 1M3ex, 2M3ex, and 2M3ag. No changes were observed in segments S1 and S6, comprising the first molar and second premolar. Increased or decreased crowding in the six lower arch segments over the three-year observation period were significantly associated with the Ganss ratio ($P < 0.001$) as shown in Table 5.

Comparison of the length and width of the lower arch on photocopies and models

Measurement of arch length and width was carried out on photocopies of the mandibular models and then also undertaken directly on the models. The means and standard deviations are presented in Table 2.

Differences in the 47 measurements performed on the photocopies and models were not statistically significant ($P = 0.05$) thus indicating that the photocopies were sufficiently detailed reflections of the plaster models, and can thus be used in the assessment of dental arch length and width changes.

Table 3 Means and standard deviations (SD) of the Ganss ratio on the left and right sides depending on mandibular length changes.

Right side					Left side				
Changes a_r, b_r, c_r, d_r	*n*	Mean	SD	Behrens–Fisher test	Changes a_l, b_l, c_l, d_l	*n*	Mean	SD	Behrens–Fisher test
Yes	8	0.61	0.13	C = 0.71; V = –5.14	Yes	7	0.60	0.26	C = 0.90; V = –2.50
No	38	0.89	0.18	$P < 0.001$	No	39	0.86	0.21	$P < 0.05$

a, distance between the mesial edge point of the medial incisor and the middle point of the mesial surface of the first molar.
b, distance between the mesial edge point of the medial incisor and the middle point of the distal surface of the canine.
c, distance between the middle point of the mesial surface of the canine and the middle point of the distal surface of the first molar.
d, distance between the mesial edge point of the lateral incisor and the middle point of the distal surface of the first premolar.
r, right side. l, left side.

Table 4 Means and standard deviations (SD) of the Ganss ratio on the right and left sides depending on mandibular width changes.

Right side					Left side				
Changes a, b, c	*n*	Mean	SD	Behrens–Fisher test	Changes a, b, c	*n*	Mean	SD	Behrens-Fisher test
Yes	6	0.65	0.15	C = 0.81; V = –3.23	Yes	7	0.62	0.25	C = 0.89; V = –2.29
No	40	0.87	0.19	$P < 0.02$	No	39	0.85	0.21	$P < 0.05$

a, distance between the canine cusps.
b, distance between the second premolars measured at the middle of the intercuspal fissure.
c, distance between the buccal lower second molar surfaces plus the distance between the lingual surfaces of the lower second molar, divided by two.

Table 5 Means and standard deviations (SD) of the Ganss ratio on the right and left sides depending on changes in mandibular crowding measured according to Lundström's method.

Right side					Left side				
Changes S1, S2, S3	*n*	Mean	SD	Behrens–Fisher test	Changes S4, S5, S6	*n*	Mean	SD	Behrens–Fisher test
Yes	7	0.60	0.13	C = 0.74; V = –5.09	Yes	7	0.66	0.25	C = 0.88; V = –1.88
No	39	0.89	0.18	$P < 0.001$	No	39	0.85	0.22	$P > 0.05$ (NS)

S1, arch segment: first molar and second premolar of the right dental quadrant. Space available for the teeth was assessed by measuring the distance between the distal surface of the first premolar and the mesial surface of the second molar; S2, arch segment: first premolar and the canine in the right quadrant; S3, arch segment: lateral and medial right incisors; S4, arch segment: medial and lateral left incisors; S5, arch segment: canine and first premolar in the left quadrant; S6, arch segment: second premolar and first molar in the left quadrant.

Discussion

According to Asanami and Kasazaki (1995), forces generated during the eruption of the third molars can cause incisor crowding, but also buccal or lingual inclination of the second molars. This was also observed in the present population in the measurement of inter-second molar widths. In theory, third molars cannot exclusively influence the incisors, without exerting an effect on the buccal segment and the canine. Richardson (1979) and Sanin and Savara (1973) emphasized that first molars can also be moved depending on their original position in the dental arch. Thus, both the anterior and buccal segments of the dental arch were measured in an attempt to determine which region of the arch is at the greatest risk of change when third molar eruption starts. A method was also sought to facilitate linear measurements, i.e. length and width of the lower arch. Photocopies were found to be a reliable representation of plaster models as they eliminate picture depth, thereby facilitating linear measurements. This might prove useful for future studies.

An increase or decrease in lower arch length, width and crowding as measured over the three-year period in relation to the Ganss ratio, based on the patient's panoramic radiograph, was statistically significant. It may therefore be proposed that, provided sufficient space is available for the third molar to erupt, the tooth assumes a normal position in the arch, and does not exert any disadvantageous effect on the other teeth, whereas if the space is inadequate, third molars may aggravate already existing crowding. The changes occurring at low values of the Ganss ratio may be accounted for by the physics of force vectors. Third molars might represent additional forces capable of exerting further influence on abnormally positioned teeth (Kahl-Nieke, 1995). Most of these changes were noted in the canine and incisor region. Considering the shape of the dental arch (most typically parabolic), it might be concluded that movement in the buccal segment results in rotation and mesial drift of the canine as it is positioned on the greatest curvature of the dental arch. The resultant force vectors affecting the canines could even cause rotation of the teeth in relation to their original position and this might help account for an increase in incisor crowding.

Conclusions

Calculation of the Ganss ratio may provide information regarding future development of dental arch crowding and indications for third molar removal.

Photocopies are reliable representations of plaster models and may be used in linear measurements of the dental arch.

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References

Ades A G, Joondeph D R, Little R M, Chapko M K 1990 A long-term study of the relationship of third molars to changes in the mandibular dental arch. American Journal of Orthodontics and Dentofacial Orthopedics 97: 323–335

Asanami S, Kasazaki Y 1995 Third molars extraction. Kwintesencja, Warszawa

Björk A, Skieller V 1972 Facial development and tooth eruption. An implant study at the age of puberty. American Journal of Orthodontics 62: 339–383

Faubion B 1968 The effect of extraction of premolars on the eruption of the mandibular third molars. Journal of the American Dental Association 76: 316–320

Ganss C, Hochban W, Kielbassa A M, Umstadt H E 1993 Prognosis of third molar eruption. Oral Surgery, Oral Medicine, Oral Pathology 76: 688–693

Graber T M, Kaineg T E 1981 The mandibular third molar – its predictive status and role in lower incisor crowding. Proceedings of the Finnish Dental Society 77: 37–44

Kahl-Nieke B 1995 Einführung in die Kieferorthopädie. Urban and Schwarzenberg.

Kaplan R G 1974 Mandibular third molars and postretention crowding. American Journal of Orthodontics 66: 411–430

Lavelle C L B, Foster T D 1969 A cross-sectional study into age changes of the human dental arch. Archives of Oral Biology 14: 71–86

Lindquist B, Thilander B 1982 Extraction of third molars in cases of anticipated crowding in the lower jaw. American Journal of Orthodontics 81: 130–139

Little R M, Wallen T R, Riedel R A 1981 Stability and relapse of mandibular anterior alignment – first premolar extraction cases treated by traditional edgewise orthodontics. American Journal of Orthodontics 80: 349–365

Lundström A 1969 Changes in crowding and spacing of the teeth with age. Dental Practice-Dental Record 19: 218–223

Moorrees C F A, Reed R B 1952 Biometrics of crowding and spacing of the teeth in the mandible. American Association of Physical Anthropology 21: 77–88

Olive R, Basford K 1981 Reliability and validity of lower third molar space-assessment techniques. American Journal of Orthodontics 79: 45–53

Richardson M E 1975 The relative effect of the extraction of various teeth on the development of the mandibular third molars. Transactions of the European Orthodontic Society, pp. 79–85

Richardson M E 1979 Late lower arch crowding: facial growth or forward drift? European Journal of Orthodontics 1: 219–225

Richardson M E 1982 Late lower arch crowding in relation to primary crowding. Angle Orthodontist 52: 300–312

Richardson M E 1989 The role of the third molar as the cause of late lower arch crowding: a review. American Journal of Orthodontics and Dentofacial Orthopedics 95: 79–83

Richardson M E 1996 Orthodontic implications of lower third molar development. Dental Update April: 96–102

Sanin C, Savara B S 1973 Factors that affect the alignment of the mandibular incisors: A longitudinal study. American Journal of Orthodontics 64: 248–257

Sheneman J R 1968 Third molar teeth and their effect upon the lower anterior teeth: a survey of forty-nine orthodontic cases five years after band removal. Thesis, St. Louis University

Siatkowski R E 1974 Incisor uprighting: mechanism for late secondary crowding in the anterior segments of the dental arches. American Journal of Orthodontics 66: 398–410

Southard T E 1992 Third molars and incisor crowding: when removal is unwarranted. Journal of the American Dental Association 123: 75–79

Southard T E, Southard K A, Weeda L W 1991 Mesial force from unerupted third molars. American Journal of Orthodontics and Dentofacial Orthopedics 99: 220–225

Stephens C D 1980 The effect of third molar removal on the size of premolar extraction spaces in the lower arch. British Journal of Orthodontics 7: 189–193

Weinstein S 1971 Third molar implications in orthodontics. Journal of the American Dental Association 82: 819–823