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Correlation between Retromolar Space and Arch Length Tooth Size Discrepancy in Teen and Young Adults

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ABSTRACT:

Background-This study investigated the relationship between space available for eruption of impacted mandibular third molars (retromolar space) and arch length tooth size discrepancy (ALTSD) in young adults. The findings provide valuable insights into the aetiology of third molar impaction and its association with dental crowding. **Aim-**The aim of this study was to evaluate the correlation between retromolar space (RMS) and arch length tooth size discrepancy (ALTSD) in young adults. Understanding this relationship can inform orthodontic treatment planning and prevent complications. **Materials and Methods:** The study comprised of 100 patients. Arch length tooth size deficiency scoring was calculated from study models, space availability for third molars-retromolar space was measured from OPG, Mandible length and skeletal malocclusion was identified from Cephalogram. **Results-**The data showed a significant negative correlation between arch length tooth size deficiency and retromolar space with a correlation coefficient of 0.286 (P=0.04). The scatter plot defines the negative correlation of molar and difference, as the difference increases the space for molar is decreasing with a correlation value of -0.286, which is statistically significant (p=0.004). **Conclusion:** The study documents a significant correlation between RMS for third molars and arch length tooth size discrepancy in young adults. These findings suggest that ALTSD is a contributing factor to third molar impaction.

Keywords: Orthopantomogram (OPG), Arch Length Tooth Size Discrepancy (ALTSD), Crowding, Impaction, Mandibular Third Molar, Orthodontics, cephalogram

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1. Introduction

A tooth that is prevented from erupting to its proper position due to malposition, lack of space, or other impediments is called as impacted teeth¹. On average, the eruption of third molars occurs during the late teenage years to early twenties, roughly between 17 and 21 years old². The radiographic detection of third molars can occur between 5 and 16 years of age^{3,4}. Initially, many mandibular third molars exhibit mesial inclination, which progressively corrects to a more upright position by age 25 years⁵⁻⁷. The typical eruption period spans from 18 to 24 years⁵. However, spatial constraints often result in impaction, affecting approximately 73% of young adults with at least one impacted lower third molar⁶. The high incidence of impaction in mandibular and maxillary third molars can be attributed to two key factors Late eruption in the dental arch and Inadequate development of the retromolar space^{7,8}.

The loss of other teeth can increase the chances of lower wisdom teeth erupting properly⁹. For instance, removing premolars in the lower jaw can make successful eruption four times more likely¹⁰. Additionally, every millimetre of space gained by the movement of adjacent molars improves the eruption chances by 10%¹¹.

Dental crowding, especially in the lower front region, is the most common type of malocclusion^{12,13}, influenced by factors like impacted mandibular third molars, jaw-to-tooth size discrepancies, dental arch shape, and lower front tooth retroclination, while also being affected by skeletal and soft tissue growth, posterior tooth drifting, gender, periodontal forces, and the natural ageing process¹⁴.

The presence of wisdom teeth significantly influences orthodontic treatment planning, despite their lack of direct involvement. A survey of orthodontists and oral surgeons revealed that approximately two-thirds of respondents believe unerupted third molars can generate anteriorly directed forces, potentially contributing to mandibular incisor crowding¹⁵.

Despite the clinical significance of molar impaction, the association between impaction and mesio-distal width of permanent teeth (molars, premolars, canines, and incisors) remains poorly understood. While logical assumptions suggest larger teeth increase crowding risk, empirical evidence is lacking.

Efforts to establish reliable pretreatment parameters for predicting mandibular third molar impaction or eruption have yielded inconclusive results, highlighting the need for further investigation^{16,17}. Numerous studies have investigated the relationship between available space and molar eruption, revealing a significant correlation between retromolar space and the likelihood of eruption. Specifically, increased retromolar space is associated with a higher probability of successful eruption¹⁸.

The objective of this study was to evaluate the correlation between arch length tooth size discrepancy and the space available for lower third molar by calculating the retro molar space in late teens and young adults.

2. Materials and methods

Data collection for this cross-sectional multi-centre study was carried out between January 2023 and October 2024. The participant's records were obtained from individuals seeking orthodontic treatment in the orthodontic unit, Christian medical college in and around Vellore. The records of patients with comprehensive pretreatment records were collected, consisting of high-quality study casts, digital panoramic

radiographs (OPG), and lateral cephalometric radiographs. From the samples size of 200 patient 100 patients were selected for the analysis.

The study's inclusion criteria consisted of:

- Age: 15 years and above
 - No previous orthodontic treatment
 - Well-erupted permanent dentition
 - Bilaterally similar Impaction or erupted lower third molars
- Exclusion criteria included:
- Systemic conditions affecting lower jaw growth/development
 - Dentofacial deformities
 - Facial asymmetries
 - Syndromes
 - Tumours
 - Dental anomalies (e.g., missing/extra/decayed teeth, worn dentition, larger restorations)

Prior to data analysis, a calibration exercise was conducted among three examiners

- a professor, assistant professor, and senior house surgeon. They individually assessed 20 randomly selected study casts, 10 OPGs, and 10 cephalograms to ensure reliability. The four-week calibration process revealed excellent inter-rater agreement, with a Kappa statistic of 0.95.

Study Data collection: -

Arch length tooth size deficiency scoring (Carey's analysis)-

To measure arch length, a 0.20" brass wire was used, tracing the curvature of the dental arch from the mesio buccal line angle of the permanent first molar, along the buccal cusp and incisal edges of the anterior teeth, to the opposite side, with adjustments made for Proclined incisors: wire passed through the cingulum region Retroclined incisors: wire placed labial to the incisors.

To assess crowding, total tooth material (mesiodistal width of teeth mesial to the first molar) was compared to arch length. The required space was calculated as:

Required Space = Total Tooth Material - Arch Length¹⁹

Crowding severity was classified based on arch discrepancy:

- No crowding: ≤ 0
- Mild: 0-2.5 mm
- Moderate: 2.5-5 mm
- Severe: > 5 mm

Along with Carey's analysis the clinical finding of the lower anteriors such as crowded, Proclined, upright and retroclined were noted. Radiographic interpretation of space availability for 3rd molar and length of the mandible:

The difference between the space available (space between anterior border of ramus to the distal side of second molar). The type of impaction like Vertical, Mesioangular, Horizontal and Distoangular was calculated in OPG²⁰. The length of the body of the mandible was measured from Menton to Gonion (Menton-Gonion) and the length of the mandible from articular to gonion (Articular-Gonion) in lateral cephalometry²¹.

Statistical analysis: - The scatter plot defines the negative correlation of molar and difference, as the difference increases the space for molar is decreasing with a correlation value of -0.286, which is statistically significant ($p=0.004$)

Ethical considerations-

This study obtained ethical clearance from the Christian Medical College, Vellore. The

researchers ensured, Data confidentiality and anonymity will be maintained.

3. Results

Study population Characteristics

A total of 100 patients met the inclusion criteria and were included in the analysis. The study patients were aged in the range of 15-24 years, with 48 participants (48%) under 18 years and 52 participants (52%) 18 years or older and 66% (N=66) of them being females.

Clinical Characteristics

The mean tooth size, arch length, and Arch Length-Tooth Size Discrepancy (ALTSD) were 70.3 mm, 64.9 mm, and 4.77 mm, respectively. The severity of crowding was categorized as follows: no crowding (16%), mild (21%), moderate (25%), and severe(38%).

Lower incisor alignment was assessed, revealing normal inclination in 16% of participants, proclination in 21%, retro-inclination in 1%, spacing in 9%, and crowding in 53%. Using OPG third molar impaction status was evaluated, with 14% exhibiting horizontal impaction, 41% Mesioangular impaction, 14% vertical impaction, and 31% showing no impaction (well-erupted third molars) table 2.

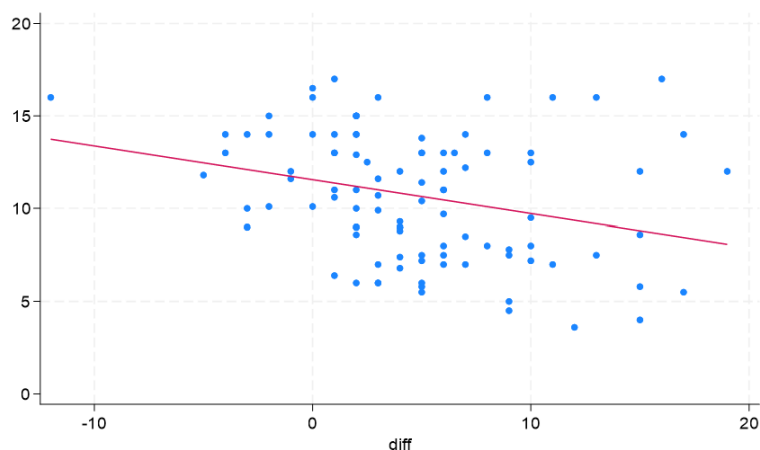
Comparative Analysis of Study Variables ALTSD and RMS:

Linear Regression Analysis Reveals Significant Association Between Retromolar Space and Lower Arch Crowding. Our study found a robust, statistically significant relationship between retromolar space and lower arch crowding ($p = 0.004$). (table 1).

Table 1 (comparison between ALTSD and retromolar space)

Quantiles									
Variable	n	Mean	S.D.	Min	.25	Mdn	.75	Max	
ASTLD	100	4.79	5.37	-12.00	2.00	4.00	8.00	19.00	
RMS	100	10.68	3.42	3.60	7.50	11.00	13.00	17.00	

Scatter plot test



Gender Comparison

A significant gender-related differences were observed in average tooth size, arch length, Length of the mandible, Body of the mandible and Skeletal malocclusion. (Table3)

Table 2 (Description of data)

		n=100		
age, mean (SD)		19.54 (3.77)		
RECODE of age (age)	<=18	48(48.0%)		
	>18	52(52.0%)		
Gender	F	65(65.0%)		
	M	35(35.0%)		
tooth size, mean (SD)		70.38 (3.93)		
arch length, mean (SD)		64.99 (4.91)		
ALTSD, mean (SD)		4.77 (5.34)		
RECODE of difference (difference)	No crowding	16 (16.0%)		
	mild	21 (21.0%)		
	moderate	25 (25.0%)		
	severe	38 (38.0%)		
Arch	crowding	53 (53.0%)		
	normal	16 (16.0%)		
	Proclined	21 (21.0%)		
	retroclined	1 (1.0%)		
	spacing	9 (9.0%)		
type of impaction	horizontal	14 (14.0%)		
	Mesioangular	41 (41.0%)		
	No impaction	31 (31.0%)		
	vertical	14 (14.0%)		
RMS, mean (SD)		10.66 (3.41)		
length of mandible, mean (SD)		105.58 (7.07)		
body of mandible, mean (SD)		71.23 (5.04)		
skeletal malocclusion	Class I	45 (45.0%)		
	Class II	47 (47.0%)		
	Class III	8 (8.0%)		

Table 3 (variable- gender)

Variable		Female	Male	p-value
		n=65	n=35	
age, mean (SD)		19.62 (3.88)	19.40 (3.59)	0.79
RECODE of age (age)	<=18	30 (46%)	18 (51%)	0.61
	>18	35 (54%)	17 (49%)	
tooth size, mean (SD)		69.88 (3.87)	71.29 (3.91)	0.097
arch length, mean (SD)		64.22 (4.76)	66.39 (4.95)	0.040

ALTSD, mean (SD)		4.92 (5.02)	4.50 (5.97)	0.71
RECODE of difference (difference)	No crowding	9 (14%)	7 (20%)	0.76
	Mild	14 (22%)	7 (20%)	
	Moderate	18 (28%)	7 (20%)	
	Severe	24 (37%)	14 (40%)	
Arch	Crowding	31 (48%)	22 (63%)	0.26
	Normal	11 (17%)	5 (14%)	
	Proclined	17 (26%)	4 (11%)	
	Retroclined	0 (0%)	1 (3%)	
	Spacing	6 (9%)	3 (9%)	
type of impaction	Horizontal	9 (14%)	5 (14%)	0.67
	Mesioangular	28 (43%)	13 (37%)	
	No impaction	19 (29%)	12 (34%)	
	Vertical	9 (14%)	5 (14%)	
RMS, mean (SD)		10.57 (3.24)	10.82 (3.73)	0.73
Length of mandible, mean (SD)		102.54 (4.91)	111.23 (7.03)	<0.001
body of mandible, mean (SD)		69.18 (4.06)	75.03 (4.48)	<0.001
skeletal malocclusion	Class I	31 (48%)	14 (40%)	0.047
	Class II	32 (49%)	15 (43%)	
	Class III	2 (3%)	6 (17%)	

Age Comparison (15-18 vs. 19-24 years)

Comparison of age groups revealed no significant differences in Crowding severity, Tooth size, Arch length, ALTSD, Angulation of impacted teeth, Body of the mandible and Skeletal malocclusion. However, significant age-related differences were observed in arch length, Retromolar space (RMS) and Length of the mandible.

TABLE 4 (variable- age: 15-18, 19 -24)

Variable	AGE		p-value	
	<=18 n=48	>18 n=52		
tooth size, mean (SD)	70.50 (4.18)	70.25 (3.68)	0.76	
arch length, mean (SD)	65.70 (3.83)	64.26 (5.77)	0.16	
ALTSD, mean (SD)	4.72 (3.87)	4.82 (6.45)	0.93	
RECODE of difference (difference)	no crowding	5 (10%)	11 (21%)	0.35
	Mild	12 (25%)	9 (17%)	
	Moderate	14 (29%)	11 (21%)	
	Severe	17 (35%)	21 (40%)	
Arch	Crowding	28 (58%)	25 (48%)	0.095
	Normal	10 (21%)	6 (12%)	
	Proclined	9 (19%)	12 (23%)	
	Retroclined	0 (0%)	1 (2%)	

	Spacing	1 (2%)	8 (15%)	
type of impaction	Horizontal	4 (8%)	10 (19%)	0.21
	Mesioangular	24 (50%)	17 (33%)	
	No impaction	12 (25%)	19 (37%)	
	Vertical	8 (17%)	6 (12%)	
RMS, mean (SD)		9.60 (3.19)	11.64 (3.33)	0.002
Length of mandible, mean (SD)		104.02 (7.02)	107.02 (6.86)	0.033
body of mandible, mean (SD)		70.79 (5.17)	71.63 (4.93)	0.41
skeletal malocclusion	Class I	20 (42%)	25 (48%)	0.23
	Class II	26 (54%)	21 (40%)	
	Class III	2 (4%)	6 (12%)	

Crowding Comparison

Analysis of crowding severity revealed significant differences in tooth size, arch length, ALTSD, Gradient of crowding, Type of impaction, RMS, Length of the mandible and Body of the mandible.

Table 5 (variable- crowding)

Variables		Crowding				p-value
		No crowding	mild	moderate	severe	
		n=16	n=21	n=25	n=38	
tooth size, mean (SD)		65.58 (2.50)	69.17 (3.46)	70.96 (3.90)	72.17 (3.08)	<0.001
arch length, mean (SD)		68.08 (4.68)	67.25 (3.04)	66.74 (3.67)	61.76 (4.72)	<0.001
ALTSD, mean (SD)		-2.62 (2.96)	1.69 (0.51)	4.08 (0.86)	10.04 (3.79)	<0.001
Arch	crowding	0 (0%)	7 (33%)	13 (52%)	33 (87%)	<0.001
	normal	5 (31%)	9 (43%)	2 (8%)	0 (0%)	
	Proclined	1 (6%)	5 (24%)	10 (40%)	5 (13%)	
	Retroclined	1 (6%)	0 (0%)	0 (0%)	0 (0%)	
	Spacing	9 (56%)	0 (0%)	0 (0%)	0 (0%)	
type of impaction	Horizontal	0 (0%)	2 (10%)	3 (12%)	9 (24%)	<0.001
	Mesioangular	2 (12%)	5 (24%)	16 (64%)	18 (47%)	
	No impaction	12 (75%)	10 (48%)	1 (4%)	8 (21%)	
	Vertical	2 (12%)	4 (19%)	5 (20%)	3 (8%)	
retromolar space, mean (SD)		12.94 (2.37)	12.00 (3.01)	9.28 (2.86)	9.87 (3.66)	<0.001

Length of mandible, mean (SD)		106.94 (7.17)	106.81 (8.24)	105.44 (5.90)	104.42 (7.10)	0.53	
body of mandible, mean (SD)		72.44 (4.13)	73.10 (6.06)	70.72 (3.99)	70.03 (5.15)	0.100	
skeletal malocclusion	Class I	10 (62%)	9 (43%)	12 (48%)	14 (37%)	0.18	
	Class II	5 (31%)	8 (38%)	13 (52%)	21 (55%)		
	Class III	1 (6%)	4 (19%)	0 (0%)	3 (8%)		

Figures

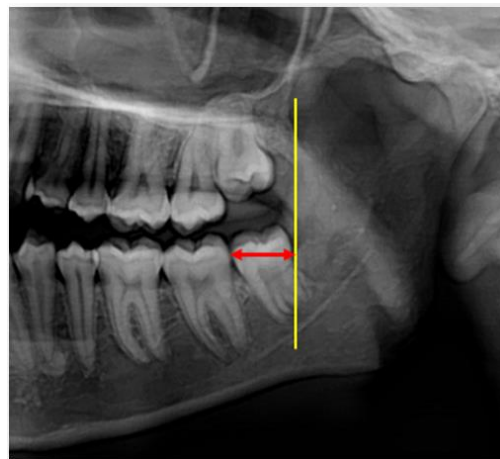


Figure 1(measurement for RMS)

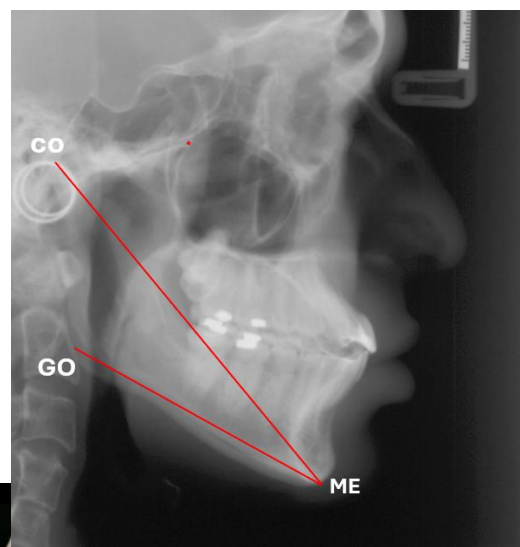


Figure (Measure of length of mandible)

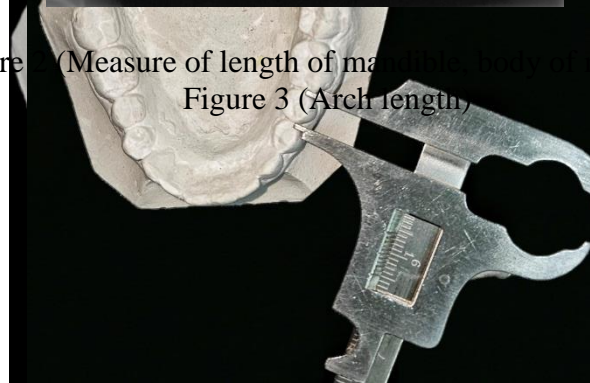


Figure 3 (Arch length)

Figure 4 (Tooth size measurement)

Discussion:

Throughout an individual's life, the dentoalveolar structure undergoes substantial changes, particularly during growth and development^{22,23}. Although these changes slow down after reaching adulthood²⁴, adaptations continue in response to environmental factors^{25–28}. During late mixed dentition (around 10-12 years old), anterior tooth malalignment becomes apparent, affecting facial aesthetics and often leading to anterior dental crowding - a common reason patients seek orthodontic treatment^{29,30}. Assessing the eruption or impaction of permanent teeth requires consideration of three local factors: space availability, stage of formation, and tooth size. This is particularly relevant for mandibular third molars, where developmental stage has been linked to chronological and skeletal ages, informing predictions of impaction or eruption^{31–33}. Anatomical differences among individuals can influence tooth development, leading to variations in developmental stage, even when chronological and skeletal ages are similar. This highlights the importance of individualized assessment in orthodontic treatment planning³⁴. The Developmental Relationship Between Mandibular Third Molars and Retromolar Space. Research reveals a significant association between the formation of mandibular third molars and available retromolar space. Notably, increased retromolar space correlates positively with eruption likelihood. Furthermore, an advanced stage of mandibular third molar development may serve as an additional predictor of successful eruption³⁵. Retromolar space availability significantly influences mandibular third molar development and eruption. Increased space enhances eruption likelihood, informing orthodontic treatment planning. A 5 mm increment in retromolar space was associated with a 1.8-stage advancement in tooth development³⁵.

In this study, participants were stratified into four categories based on the severity of crowding in the lower arch: nil, mild, moderate, and severe. A significant inverse relationship was observed between the severity of crowding and retromolar space (RMS). Specifically, the results revealed that RMS decreased proportionally with increasing crowding severity.

The present study found that Mesioangular impaction was the most prevalent type, accounting for 41% of cases, followed by no impaction (31%) and equal proportions of vertical and horizontal impaction (14% each). Statistical analysis revealed no significant difference in the occurrence of these impaction types. Our findings are consistent with previous research, which also reported Mesioangular impaction as the most common pattern of lower third molar impaction, with similar frequencies of horizontal and vertical impaction³⁶. Males demonstrated significantly larger tooth size (+2 mm, $p < 0.09$) and arch length (+3 mm) compared to females. However, no gender difference was found in

Length-Tooth Size Discrepancy (ALTSD), aligning with previous research on Bolton tooth size ratio³⁷. Males demonstrated significantly greater mandibular length (+9 mm, $p = 0.001$) and body length (+6 mm, $p = 0.001$) compared to females which is in agreement with a research where human mandible was compared between male and female.³⁸ However, the increased mandibular dimensions did not reduce ALTSD ($p = 0.71$) or increase the RMS ($p = 0.73$), potentially due to proportionally larger tooth size in males. There was a significant increase in the overall mandible size both and RMS seen in individuals above 18 years, but no significant difference was seen in the distribution impacted teeth in age groups both above and below 18 years of age. A constant pattern of an increase in the retromolar space was noticed with increasing age of patients ($P = 0.001$) in a study by Rayalat et al.³⁹ Comparative analysis revealed significant differences in most

parameters across varying crowding severities, except for mandibular length. Key findings include Up to 7 mm difference in tooth size between severe and no crowding groups. Mesioangular impaction predominated in moderate and severe crowding groups. Impaction frequency decreased with reduced crowding severity. Significant reductions in Retromolar space (RMS): up to 3 mm, Mandibular length: up to 2 mm and Body of mandible: up to 2 mm was seen in severe vs. no crowding categories. Notably, crowding distribution remained unaffected by skeletal malocclusion type ($p > 0.18$), suggesting that impaction and RMS are primarily influenced by crowding severity, arch length, and mandibular dimensions. In this study it was noticed that when the severity of crowding increased due to more than 2 blocked out teeth the RMS increased providing space for eruption of third molar these types of arch form were like extraction cases where we see in previous study that extracted individuals has reduced number of impacted third molar.⁴⁰

4. Conclusion

This study investigated the relationship between retromolar space (RMS), crowding, and third molar impaction. The key findings lead to the following conclusions:

1. A significant negative correlation exists between RMS and crowding severity.
2. Despite larger arch and mandibular dimensions in males, crowding distribution remains equivalent between genders.
3. Increased RMS due to growth does not alleviate third molar impaction in crowded arches.
4. Mesioangular impaction predominates across all Arch Length-Tooth Size Discrepancy (ALTSD) categories.
5. Skeletal malocclusion does not significantly influence impaction prevalence.

Collectively, these findings suggest that crowding severity can serve as a reliable predictor of third molar impaction. These results have implications for orthodontic treatment planning and third molar management strategies.

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