

# Exploring The Relationship of Anterior Crowding and Oral Hygiene: A Pilot Study



Syed Ameer Hamza<sup>1</sup>

BDS

Arsalan Wahid<sup>2</sup>

BDS, M.Phil

Mian Farrukh Imran<sup>3</sup>

BDS, MDS

Khaled Khalaf<sup>4</sup>

FDS, RCS

Syed Akhtar Hussain Bokhari<sup>5</sup>

PhD

**OBJECTIVE:** Poor oral health is not uncommon among the population of Pakistan. Malocclusion may be one of the causes known so far. This study has evaluated the association of anterior teeth crowding with plaque, bleeding on probing and gingivitis and has noted the trend in families.

**METHODOLOGY:** Eleven families comprising of 41 members aged 30.3±15.3 (12-55) years were recruited for this cross-sectional study. Crowding of anterior teeth (canine-canine) of upper and lower jaws was recorded on study casts. Oral hygiene parameters of plaque, bleeding on probing and gingivitis were noted for the anterior teeth. Variables were analyzed in means and percentages and study participants were compared for differences in study parameters using the t-test and Chi-squared test. Statistical significance was set at  $p < 0.050$ .

**RESULTS:** Forty eight percent showed severe crowding, 34% had severe plaque, 100% showed mild to moderate gingivitis, 24% exhibited bleeding on probing. Significant difference ( $p=0.003$ ) was noted among orthodontic cases and family members. No significant difference was observed between inter- and intra-family regarding oral hygiene parameters. Comparison between parents and siblings showed no difference in all study parameters.

**CONCLUSION:** A significant association was found between the presence of anterior crowding and gingival index. This study has supported the notion that an association exists between crowding of anterior teeth and gingivitis.

**KEY WORDS:** Anterior Crowding, Plaque, Bleeding on probing, Gingivitis

**HOW TO CITE:** Hamza SA, Wahid A, Imran MF, Khalaf K, Bokhari SAH. Exploring the relationship of anterior crowding and oral hygiene: a pilot study. J Pak Dent Assoc 2019;28(2):78-84.

**DOI:** <https://doi.org/10.25301/JPDA.282.78>

*Received: 29 October 2018, Accepted: 04 February 2019*

## INTRODUCTION

Poor oral health is not uncommon among the population of Pakistan.<sup>1</sup> Mal-alignment of teeth might be one of the many predisposing factors supposed to be responsible for this condition. Irregularities in dentition cause difficulties in the cleaning of teeth and maintenance of good oral hygiene, therefore prompting to gingivitis and periodontitis.<sup>2</sup> However, there exist contradictions in research

findings concerning the relationship between dental irregularity and periodontal disease.<sup>3</sup> These contradictions arise due to difficulty in distinguishing the effects of irregularity from those of other important factors such as social class, gender, motivation, education and family background.<sup>4</sup> The main influence, in addition to other factors, on gingivitis would be through differences in the effectiveness of oral hygiene measures.

Buckley LA<sup>5</sup> found that individual tooth irregularity had a low, but statistically significant correlation with plaque and gingival inflammation in a group of 300 teenagers. Although he considered the likely reason was that crowded and irregular teeth facilitated the accumulation of bacterial plaque, thus indirectly contributing to gingival inflammation. However, no account was taken of the family background including education, socioeconomic status (SES) and motivation.

Ainamo et al.<sup>6</sup>, noted in a study of 154 army recruits

1. MPhil Student, Department of Oral Medicine, University Medical & Dental College Faisalabad Pakistan.
2. Assistant Professor, Department of Pathology, University Medical & Dental College Faisalabad Pakistan.
3. Associate Professor, Department of Prosthodontic, University Medical & Dental College Faisalabad Pakistan.
4. Associate Professor, Department of Orthodontic, College of Dentistry, King Faisal University, Saudi Arabia.
5. Professor, Department of Dental Public Health, College of Dentistry, King Faisal University, Saudi Arabia.

**Corresponding author:** "Dr Syed Ameer Hamza" <syedameerhamza@yahoo.com>

that periodontal disease was worse adjacent to malaligned maxillary anterior teeth and it was possible to envision malalignment as the cause, which makes it extremely difficult if not impossible to attain high standards of plaque control. The problem still remains that we do not know as yet the magnitude of risk of development of oral disease in individuals having malalignment. In addition, what is lacking in the literature is the exclusion of confounders as differences in familial background, SES and education status all of which have a role in maintaining oral hygiene.

Data on incisor irregularity is extremely limited<sup>7</sup>, the same trend has been observed in Pakistani population. The changes in diet patterns of Pakistani population, with the inclusion of soft diet, and use of pacifiers and bottles at a younger age may have led to the increase in prevalence of malocclusion including limitation of space and therefore tooth eruption in a regular manner has been affected. This highlights the importance of conducting detailed research in the Pakistani population to investigate the risk of development of oral disease based on malocclusion. Therefore, this pilot study was designed to assess the association of anterior crowding with oral hygiene after controlling SES, education status and family background and plan a large-scale study.

## METHODOLOGY

### *Study Type and Setting*

A pilot cross-sectional study was conducted by applying purposive convenient sampling technique. The study was conducted at Dental Clinics of the Medina Teaching Hospital, The University of Faisalabad, Pakistan.

### *Study Sample*

Patients attending the dental clinics for orthodontic treatment over a period of two months, 11th August-10th September 2017 were screened as per inclusion/exclusion criteria detailed below. Sixty five cases were screened for the study during the above mentioned period. Eligible individuals were fully informed about the study and requested to participate in the study.

## INCLUSION CRITERIA

- Age 14 to 25 years for orthodontic cases
- Both male and female patients
- Families resident of Faisalabad for the last (ten) years matching all educational and socioeconomic backgrounds
- Two siblings and at least one parent of family with anterior crowding
- Presence of full complement of the permanent dentition

from the first permanent molar to the contra-lateral first permanent molar

- Absence of any active periodontal disease and dental caries

## EXCLUSION CRITERIA

- Orthodontic patients with no anterior crowding
- Patients having systemic diseases and medically compromised individuals
- Mentally and physically challenging patients
- Smokers and ex-smokers
- Mouth breathers
- Antibiotic therapy during the last three months
- Abnormal para-functional habits
- Abnormal hard and soft tissue morphology like cleft lip and palate patients
- Patients having craniofacial syndromes
- Previous history of periodontal therapy
- Previous orthodontic treatment
- History of extraction of both primary and permanent dentition
- Congenitally missing teeth
- Supernumerary teeth
- Aberrations of tooth size and shape
- The presence of large restorations and fractured teeth
- Families with single child and single parent.

### *Clinical Examination*

Recruited orthodontic patients, who gave informed consent for the study, were asked to bring their siblings and parents for collection of socio-demographic information and detailed assessment of malocclusion and oral hygiene.

### *Measurement of Crowding*

Dental casts were constructed for all study participants and the mesio-distal dimensions of all anterior teeth (from the right canine to the left canine) of the upper and lower jaws were measured according to the method prescribed by Moore's and Reed<sup>8</sup> using a digital caliper set at 0.01mm accuracy under natural light. The anterior upper and lower dental arches were measured using a brass wire placed on the top of the dental arches from the distal surface of one canine to the distal surface of the contralateral canine. The wire was then spread out and its length measured using the digital caliper. The discrepancy between the sum of the mesiodistal measurements of the anterior teeth and the corresponding dental arch measurement was calculated which represented the amount of crowding. Crowding was classified according to the following criteria

Score 0 =  $\leq 2$ mm crowding

Score 1 = 2.1-5.0 mm crowding  
 Score 2 = 5.1-9.0 mm crowding  
 Score 3 = > 9.0 mm crowding

### *Oral Hygiene Measures*

Oral hygiene was recorded through 1) plaque index, 2) Gingival index, and 3) Bleeding on probing (BOP)<sup>9</sup>

### *Examiners' Training and calibration*

Two calibrated examiners (Dental internees) performed the clinical oral examinations and recorded anterior crowding on the study models. Calibration of examiners was performed by an experienced orthodontist and a periodontist with more than five years of experience in their respective fields.

### *Statistical Analysis*

Data was entered into computer for analysis with the help of SPSS version 16. Data was analyzed among study participants on the basis of all clinical parameters for inter- and intra-family members. Analysis of categorical data was carried out using Chi-squared test and independent t-test was used for continuous variables. For analysis purpose, crowding was classified into Category 0 (No crowding) (2mm or less), category 1 (Mild) (2.1-5.0mm), category 2 (Moderate) (5.1-9.0mm) and category 3 (Severe) (>9.00mm). Plaque index and Gingival index were categorized into mild-to-moderate and severe categories. Bleeding on probing (BOP) in percentage (%) was categorized into gingivitis (>20% bleeding sites) and no gingivitis (≤20% bleeding sites). Logistic regression was applied for evaluation of association between study parameters. All values were rounded off to the nearest digit.

### *Ethical Approval*

Study was approved by the Research and Ethical Committee of the University of Faisalabad vide approval letter No: BASR/TUF/2109/2015.

## RESULTS

Eleven families comprising of 41 members who consented to participate were registered for the current study over a period of two months. Eleven (27%) were orthodontic cases and 30 (73%) were parents and siblings. Mean age of participants was 30.34±15.35. Fourteen (34%) were males. Twenty-eight (68%) had higher secondary education and 35(85%) belonged to the low-income group. All subjects reported that they were using toothbrush as oral hygiene measure (Table 1).

Twenty (48%) had severe crowding, 7(17%) had moderate, 5(12%) had mild crowding and 9(22%) had no

crowding. Oral hygiene parameters of plaque, gingivitis and bleeding on probing were noted. Only 14(34%) showed severe plaque deposition, 41(100%) had mild to moderate gingivitis and 10(24%) demonstrated bleeding on probing. Nine (22%) subjects had no anterior crowding, 20(48%) had severe (>9.00mm) crowding (Table1).

A comparison of crowding and oral hygiene parameters between orthodontic cases and parents showed that 9(82%)

**Table 1: Distribution of Study Participants with respect to Study Variables**

Variables	Frequency	%
<b>Number of Study Participants</b>	41	100
<b>Number of Orthodontic cases</b>	11	27
<b>Number of Family members</b>	30	73
<b>Age (years)</b>		
Mean±SD	30.34±15.35	
Median	23	
Range	44	
<b>Gender</b>		
Males	14	34
Females	27	66
<b>Education</b>		
≤Higher Secondary	28	68
≥Graduate	13	32
<b>Family Income ( Pak Rupees per Month)</b>		
≤25000/-	35	85
>25000/-	6	15
<b>Oral Hygiene Habits</b>		
Use Tooth brush	41	100
<b>Anterior Crowding</b>		
Mean±SD	10.0±8.12	
0 (<2mm)	9	22
1 (2.1-5mm)	5	12
2 (5.1-9mm)	7	17
3 (>9.0mm)	20	48
<b>Oral Health Parameters</b>		
<b><u>Plaque Index Score</u></b>		
Mean±SD	2.0±1.25	
1 (0.1-1)	9	22
2 (1.1-2)	18	44
3 (2.1-3)	14	34
<b><u>Gingival Index Score</u></b>		
Mean±SD	1.1±0.33	
1 (0.1-1)	36	88
2 (1.1-2)	5	12
3 (2.1-3)	0	0
<b><u>Bleeding on Probing (% sites)</u></b>		
Mean±SD	15.0±18.0	
≤20%	31	76
>20%	10	24

cases had severe crowding as compared to 11(37%) of family members and it was significant (t-test p=0.003 and Chi-square test p=0.026). Four (36%) orthodontic cases had severe plaque as compared to parents (33%). Plaque amount was insignificantly higher in orthodontic cases (36% vs 33%), severe gingivitis was insignificantly higher in family members (13% vs 9%) and bleeding on probing was also

**Table 2: Comparison of Anterior Crowding and Oral Hygiene Variables between 'Cases and Family Members' and 'Siblings and Parents' [n (%)]**

Study Participants / Variables	Orthodontic Cases (n= 11)	Family Members (n= 30)	p-value	Siblings (n=21)	Parents (n=20)	p-value
<b>Crowding</b>						
Mean±SD	16.0±8.3	7.0±6.9	0.003*	12.0±8.7	8.1±7.0	0.125*
0 (<2mm)	0(0)	8 (27)	0.026**	4(19)	5(25)	0.370**
1 (2.1-5mm)	1(9)	5 (17)		2(9.5)	3(15)	
2 (5.1-9mm)	1(9)	6 (20)		3(14)	4(20)	
3 (>9.0mm)	9(82)	11 (37)		12(57)	8(40)	
<b>Plaque Index</b>						
Mean±SD	2.3±1.4	1.8±1.1	0.354*	2.0±1.3	1.9±1.2	0.781*
Mild-Moderate	7(64)	20(67)	0.756**	14(66)	13(65)	0.815**
Severe	4(36)	10(33)		7(34)	7(35)	
<b>Gingival Index</b>						
Mean±SD	0.6±0.2	0.6±0.4	0.787*	0.6±0.3	0.5±0.4	0.406*
Mild-Moderate	10(91)	26(87)	0.592**	20(95)	16(80)	0.156**
Severe	1(9)	4(13)		1(5)	4(20)	
<b>BOP%</b>						
Mean±SD	13.8±13.3	15.5±19.7	0.792*	11.5±11.8	18.8±22.5	0.201*
(≤20%)	9(82)	22(73)	0.454**	17(81)	14(70)	0.326**
(>20%)	2(18)	8(27)		4(19)	6(30)	
<b>Plaque Index:</b> Mild-to-Moderate=0.1-2.0; Severe=>2; <b>Gingival Index:</b> Mild-to-Moderate=0.1-2.0; Severe=>2; <b>BOP (Bleeding on probing)</b> = No Inflammation (≤20%); Inflammation (>20%) sites; *t-test, **Chi-square test						

**Table 3: Comparison of Crowding and Oral Hygiene Variables between Male and Female Participants [n (%)]**

Study Participants/ Variables	Males (n= 14)	Females (n= 27)	p-value	Siblings			Parents		
				Males (n=7)	Females (n=14)	p-value	Males (n=7)	Females (n=13)	p-value
<b>Crowding</b>									
Mean±SD	8.4±8.6	10.9±7.8	0.340*	8.7±6.7	13.6±9.3	0.234*	8.1±10.7	8.0±4.6	0.985*
0 (<2mm)	4(29)	5(18)	0.349**	1(14)	3(21)	0.472**	4(57)	5(38)	0.871**
1 (2.1-5mm)	3(21)	5(7)		2(29)	2(14)		1(14)	2(15)	
2 (5.1-9mm)	1(7)	6(22)		1(14)	6(43)		1(14)	3(23)	
3 (>9.0mm)	6(43)	14(52)		3(43)	3(21)		1(14)	3(23)	
<b>Plaque Index</b>									
Mean±SD	2.3±1.3	1.8±1.1	0.255*	2.6±1.6	1.7±1.0	0.186*	2.0±0.9	1.9±1.3	0.838*
Mild- Moderate	7(64)	20(67)	0.756**	3(43)	11(79)	0.261**	4(57)	9(70)	0.550**
Severe	4(36)	10(33)		4(57)	3(21)		3(43)	4(30)	
<b>Gingival Index</b>									
Mean±SD	0.7±0.3	0.5±0.4	0.294*	0.7±0.3	0.5±0.2	0.093*	0.7±0.4	0.6±0.4	0.904*
Mild- Moderate	10(91)	26(87)	0.592**	7(100)	14(100)	0.147**	7(100)	13(100)	0.561**
Severe	1(9)	4(13)		0(0)	0(0)		0(0)	0(0)	
<b>BOP%</b>									
Mean±SD	11.3±16.5	17.0±18.8	0.350*	9.1±8.4	12.7±13.3	0.530*	13.5±22.5	21.6±23.0	0.463*
(≤20%)	9(82)	22(73)	0.454**	6(86)	11(79)	0.593**	6(86)	8(62)	0.277**
(>20%)	2(18)	8(27)		1(14)	3(21)		1(14)	5(38)	
<b>Plaque Index:</b> Mild-to-Moderate=0.1-2.0, Severe=>2; <b>Gingival Index:</b> Mild-to-Moderate=0.1-2.0, Severe=>2; <b>BOP (Bleeding on probing)</b> = No Inflammation (≤20%), Inflammation (>20%); *t-test, **Chi-square test									



shown higher in family members (27%) as compared to cases (18%). A comparison between siblings and parents also showed no statistically significant difference in crowding as well as in oral hygiene variables (Table 2).

Difference of anterior crowding was insignificant among genders, although more females had a severe crowding. No gender differences were noted in oral hygiene variables. A comparison of males and females among siblings and parents also did not show any statistically significant difference in all study variables (Table 3).

Relationship of oral hygiene variables was observed in different categories of crowding. Statistical difference was noted only in mean bleeding on probing ( $p=0.012$ ). Mean values of all other variables and distribution of study participants was insignificant. (Table 4)

Pearson correlation coefficient values for crowding and oral hygiene measures is presented in table 5. A significant

**Table 4: Relationship of Crowding and Oral Hygiene Variables among Study Participants [Mean±SD and n (%)]**

Study Variable	Plaque Index			Gingival Index			BOP%		
	Mean±SD	Mild-Mod	Severe	Mean±SD	Mild-Mod	Severe	Mean±SD	Mild-Mod	Severe
Crowding									
0 (<2mm) (n=9)	2.11±0.92	5(56)	4(44)	1.00±0.00	9(100)	0(0)	12.77±14.651	7(78)	2(22)
1 (2.1-5mm) (n=5)	2.20±0.44	4(80)	1(20)	1.00±0.00	5(100)	0(0)	8.20±14.04	3(60)	2(40)
2 (5.1-9mm) (n=7)	1.71±0.75	6(86)	1(14)	1.25±0.44	7(100)	0(0)	17.85±29.44	6(86)	1(14)
3 (>9.0mm) (n=20)	2.25±0.71	12(60)	8(40)	1.12±0.74	15(75)	5(25)	14.35±16.52	15(75)	5(15)
	0.068*	0.277*		0.146*	0.113*		0.012*	0.783*	

\*ANOVA \* Chi-Square test

**Table 5: Pearson Correlation Coefficients for anterior crowding versus plaque index, gingival index, and BOP sites**

All Subjects (n=41)	Crowding Gingival Index	Plaque index	Gingival Index	BOP Sites
		0.064 (p=0.690)	0.328 (p=0.036)	0.013 (p=0.953)
Cases (n=11)		0.315 (p=0.045)		0.374 (p=0.040)
Family Members (n=30)		0.342 (p=0.303)	0.130 (p=0.702)	0.010 (p=0.976)
		0.039 (p=0.836)	0.429 (p=0.018)	0.033 (p=0.861)

Regression analysis showed a positive relationship between gingival index and crowding with  $p=0.030$  and  $\beta=2.634$

relationship is noted between crowding and plaque in all subjects. Family members showed significant relationship of crowding with gingival index. A significant relation was also found between gingival index and BOP sites.

## DISCUSSION

A relationship between malocclusion (mainly crowding) and occurrence of poor oral health (hygiene) measured through plaque amount and gingivitis has been assessed and reported (10-12). This pilot study assessed the status and association of anterior teeth crowding and plaque amount, gingivitis and bleeding on probing in 11 families and tried to observe any relationship of study parameters between siblings and parents. In Pakistan, studies on relationship of oral hygiene parameters (gingivitis, plaque and bleeding on probing) and malocclusion in adolescents and adults are scarce.

Malpositioned teeth are one of the predisposing factors

to inadequate oral hygiene because oral hygiene becomes more difficult without exerting additional efforts, time and be meticulous to further details and undercuts between the crowded teeth which are difficult to reach, bacterial plaque is retained and accumulates and, therefore, proliferates and leads to pathological periodontal changes.<sup>13</sup> The findings of this study has given some support to the notion that an association exists between crowding of anterior teeth and gingivitis as it was found that there was a statistically significant difference in BOP between the different categories of crowding. Furthermore, a significant correlation was found between the presence of anterior crowding and gingival index.

This study has shown that a statistically significant difference in status of crowding between cases and their family members. However, no statistically significant difference could be observed between siblings and parents. This shows that crowding was not traceable in the next generation as compared to their parents thus lending some support to the role of environment to the etiology of crowding.<sup>14,15</sup> This study did not find any statistical significant difference in oral hygiene parameters between cases and families nor between siblings and parents.

Level of malocclusion in subjects of this study is comparable with that of Nalcaci et al<sup>16</sup> however, this study reports more severe crowding. No significant difference was observed in crowding between males and females, but females had more severe crowding than males. This finding agrees with a study by Mugonzibwa et al<sup>17</sup> that reported no statistically significant differences in dental crowding between genders. No significant gender differences were also noted in oral hygiene parameters among cases, families, siblings and parents. Similar finding was also reported by a previous investigation.<sup>18</sup>

Status of oral hygiene parameters in categories of crowding has shown no statistical difference except in plaque and bleeding on probing. Irregular teeth retained more plaque than straight teeth by a modest extent though statistically significant ( $p<0.05$ ), but no significant differences in the incidence of gingivitis.<sup>2</sup>

Correlation and Regression analysis has shown a modest but significant relationship ( $r=0.328$   $p=0.036$ ) only between crowding and gingivitis. Addy M et al.<sup>19</sup> also observed a modest but significant positive correlation ( $r=0.24$ ,  $p<0.001$ ) between the subjects' mean plaque and mean irregularity indices in 11-12 years aged children. Ashley et al<sup>2</sup> also observed a relationship between incisor teeth irregularity and gingivitis not only in subjects with moderate oral hygiene, but also in subjects with poor oral hygiene with the majority of subjects of this study had mild to moderate level of oral hygiene measures.

Statistically significant results were found in the present study regarding the relationship between malocclusion and oral hygiene status ( $t=1.16$ ,  $P=0.022$ ). A recent study by Arora and Bhateja<sup>10</sup> found that there was a decrease in oral hygiene status of the school children having malocclusion (Mean Plaque  $1.21 \pm 0.41$ ) than those children who were having normal occlusion ( $1.12 \pm 0.33$ ). Similar results were also achieved by Buckley et al<sup>12</sup>, Ingervall et al<sup>20</sup>, and Behfelt et al<sup>21</sup>. Helm and Petersen<sup>22</sup> have also reported higher scores for gingivitis and periodontal pocketing in subjects with various malocclusions. Dhar et al<sup>23</sup> has observed 97% and 38 % adolescents with mild to moderate gingivitis and malocclusion respectively. This finding is concordant with this study where we have observed the same level of gingivitis.

In a study by Chiapinotto et al<sup>24</sup>, visible plaque was 89.7% (95% CI 88.0-91.3) and gingival bleeding on probing was 78.4% that corresponds to some extent to this study (76%). Behlfelt et al<sup>21</sup> found plaque and gingivitis were more widespread around malaligned upper lateral incisor and lower second premolars in 30 children with mean age 14.4 years. This study also demonstrated a strong relationship of gingival index and bleeding on probing ( $p=0.040$ ).

A previous study has shown that individual tooth irregularity measured as tilting, rotation, displacement and crowding had a low but statistically significant correlation with plaque, calculus and gingival inflammation. However, the study showed that these features of malocclusion were far less important than the extent of plaque and calculus deposits in the development of gingival inflammation<sup>5</sup>.

As this study was conducted on subjects from same families and all families did not show any statistical difference in their sociodemographic parameters; therefore whatever relationship of anterior crowding is found with those of oral hygiene parameters can be interpreted as independent of the sociodemographic parameters. One of the limitations of this study is being a pilot study and thus of a small sample size. However, the findings of this study recommend further research work using a larger sample so that conclusions that would be more definitive could be drawn.

### ACKNOWLEDGEMENT

Services of dental interneers are thankfully acknowledged in the conduction this study.

### CONFLICT OF INTEREST

Authors have no conflict of interest of any nature

### REFERENCES

1. Khan AA. Oral Health in Pakistan: Dental Disease Pattern. J Pak Dent Assoc 1989;5: 215-19.
2. Ashley FP, Usiskin LA, Wilson RF, Wagaiyu E. The relationship between irregularity of the incisor teeth, plaque, and gingivitis: a study in a group of schoolchildren aged 11-14 years. Euro J Orthodont 1998;20:65-72  
<https://doi.org/10.1093/ejo/20.1.65>
3. Shaw WC, O'Brien KD, Richmond S, Brook P. Quality control in orthodontics: risk/benefit considerations. Br Dent J 1991;170: 33-37  
<https://doi.org/10.1038/sj.bdj.4807399>
4. Addy M, Griffiths GS, Dummer PM, Kingdon A, Hicks R, Hunter ML, Newcombe RG, Shaw WC. The association between tooth regularity and plaque accumulation, gingivitis and caries in 11-12 year old children. Eur J Orthod 1988a;10:76-83  
<https://doi.org/10.1093/ejo/10.1.76>
5. Buckley LA. The relationship between malocclusion, gingival inflammation, plaque and calculus. J Periodontol 1981; 52: 35-40  
<https://doi.org/10.1902/jop.1981.52.1.35>
6. Ainamo J. Relationship between malalignment of the teeth and periodontal disease. Scand J Dent Res 1972;80:104-10  
<https://doi.org/10.1111/j.1600-0722.1972.tb00270.x>
7. Wagaiyu EG, Ashley FP. Mouth breathing, lip seal and upper lip coverage and their relationship with gingival inflammation in 11-14 year old schoolchildren. J Clin Periodontol 1991;18: 698-702  
<https://doi.org/10.1111/j.1600-051X.1991.tb00112.x>
8. Moores CFA, Reed RB. Correlations among Mesiodistal Crown Diameters of Permanent Dentition of American Negroes. Am J Orthod.1969; 55:600-16
9. Ngom PI, Diagne F, Benoist HM, Thiam F. Intraarch and interarch relationships of the anterior teeth and periodontal conditions. Angle Orthod 2006;76:236-42
10. Arora G, Bhateja S. Prevalence of dental caries, periodontitis and oral hygiene status among 12-year old school children having normal occlusion and malocclusion in Mathura city: A comparative epidemiological study. Indian J Dent Res 2015;26:48-52  
<https://doi.org/10.4103/0970-9290.156801>
11. Mtaya M, Brudvik P, and Astrøm AN. Prevalence of malocclusion and its relationship with socio-demographic factors, dental caries, and oral hygiene in 12- to 14-year-old Tanzanian schoolchildren. Eur J Orthod. 2009;31:467-76.  
<https://doi.org/10.1093/ejo/cjn125>
12. Buckley LA. The relationships between irregular teeth, plaque, calculus and gingival disease. A study of 300 subjects. Br Dent J 1980;148:67-9  
<https://doi.org/10.1038/sj.bdj.4804378>
13. Gusmão ES, Queiroz RDC, Coelho RS, Cimões R, Santos RL.

Association between malpositioned teeth and periodontal disease. *Dental Press J Orthod*. 2011;16:87-94

<https://doi.org/10.1590/S2176-94512011000400015>

14. Botero B, Etiology of crowding of the front lower teeth, *Temas Odontol*. 1974;12(117):488-500

15. Normando D, Almeida MA, Quintão CC. Dental crowding: the role of genetics and tooth wear. *Angle Orthod* 2013;83:10-5

<https://doi.org/10.2319/020112-91.1>

16. Nalcaci R, Demirer S, Ozturk F, Altan BA, Sokucu O, and Bostanci V. The relationship of orthodontic treatment need with periodontal status, dental caries, and sociodemographic factors. *Sci World J*. 2012;2012:498012

<https://doi.org/10.1100/2012/498012>

17. Mugonzibwa EA, Eskeli R, Laine-Alava MT, Kuijpers-Jagtman AM, Katsaros C. Spacing and crowding among African and Caucasian children. *Orthod Craniofac Res*. 2008;11:82-9

<https://doi.org/10.1111/j.1601-6343.2007.00416.x>

18. Oberoi SS, Mohanty V, Mahajan A, and Oberoi A. Evaluating awareness regarding oral hygiene practices and exploring gender differences among patients attending for oral prophylaxis. *J Indian Soc Periodontol*. 2014;18:369-74.

<https://doi.org/10.4103/0972-124X.134580>

19. Addy M, Dummer PM, Hunter ML, Kingdon A, Shaw WC. Changes in the prevalence of plaque, gingivitis and pocketing in a group of South Wales schoolchildren examined at the ages of 11-12 years and 15-16 years. *Community Dent Health*. 1988b;5:345-54

20. Ingervall B, Jacobsson U, Nyman S. A clinical study of the relationship between crowding of teeth, plaque and gingival condition. *J Clin Periodontol* 1977;4:214-22

<https://doi.org/10.1111/j.1600-051X.1977.tb02275.x>

21. Behlfelt K, Ericsson L, Jacobson L, Linder-Aronson S. The occurrence of plaque and gingivitis and its relationship to tooth alignment within the dental arches. *J Clin Periodontol* 1981;8:329-37.

<https://doi.org/10.1111/j.1600-051X.1981.tb02042.x>

22. Helm S, Petersen PE. Causal relation between malocclusion and periodontal health. *Acta Odontol Scand* 1989;47:223-28.

<https://doi.org/10.3109/00016358909007705>

23. Dhar V, Jain A, Van Dyke TE, Kohli A. Prevalence of gingival diseases, malocclusion and fluorosis in school-going children of rural areas in Udaipur district. *J Indian Soc Pedod Prev Dent* 2007;25:103-5

<https://doi.org/10.4103/0970-4388.33458>

24. Chiapinotto FA, Vargas-Ferreira F, Demarco FF, Corrêa FO, Masotti AS. Risk factors for gingivitis in a group of Brazilian schoolchildren. *J Public Health Dent*. 2013;73:9-17.

<https://doi.org/10.1111/jphd.12001>