Review

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Pooled prevalence estimates of malocclusion among Indian children and adolescents: a systematic review and meta-analysis

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Abstract

Objectives: To estimate the pooled prevalence estimates of the malocclusion among child and adolescent population of India.

Contents: A comprehensive electronic search was carried to find studies related to assessing malocclusion in Indian children and adolescent population. Indices and classifications considered for pooled analysis were Dental Aesthetic Index, Index of Orthodontic Treatment Needs, Angles classification and terminal plane relationship of primary secondary molars. An eligibility criterion was prepared and quality assessment was done for all the eligible studies. Initial search produced 1090 titles. After removal of duplicates, 850 records were left for further screening. Eighty one articles were found eligible for full text reading. Finally 60 studies were included in this meta-analysis. Pooled prevalence was used to estimate overall effect, with 95% confidence intervals (CI). Statistical difference between the two genders was calculated using chi square test.

Summary and outlook: The high prevalence of malocclusion is a public health problem around the world. The current status of burden of malocclusion among Indian children and adolescents is not known. Results of this

pooled analysis showed that prevalence of malocclusion among Indian children and adolescents has increased since the last national oral health survey. Prevalence of malocclusion ranged from 28.4% (CI 25.02, 31.9) to 66.7% (CI 50.7, 81.06) depending on the type of index or classification used for recording. Boys recorded higher cumulative prevalence than girls. These findings can be utilized by oral health policy makers to draft measures required for reducing this burden of malocclusion.

Keywords: adolescents; child; India; malocclusion; meta-analysis; pooled prevalence; systematic review.

Introduction

Malocclusion is defined as an irregularity of the teeth or a malrelationship between the dental arches beyond the range of what is accepted as normal. It is a multifactorial oral condition caused by general factors such as heredity, congenital defects, nutritional deficiencies and abnormal pressure habits. Malocclusion can also occur due to factors located in the dental arch such as anomalies of tooth size, shape, supernumerary teeth, dental caries and premature loss of primary teeth [1, 2]. Measurement of extent and severity of malocclusion in an individual or population is done by indices such as Dental Aesthetic Index (DAI) [3], Index of Orthodontic Treatment Needs (IOTN) [4] or through Angles classification [5]. In primary dentition, terminal plane relationship of second molars is recorded to predict possible malocclusion in future [6]. Epidemiology of malocclusion is predominantly assessed based upon individual studies or national health oral survey although systematic reviews were being conducted in recent past among Iranian [7] and Chinese children [8]. There are no data available regarding the prevalence of malocclusion in global oral data bank of World Health Organization (WHO) because it considers malocclusion as a condition rather than a disease [9].

In India, only one national oral health survey has been conducted in the year 2002–03. This survey had reported a

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huge burden of untreated oral diseases including malocclusion across the country [10]. India is a young country with children of up to 0–14 years of age constituting 29% of its population [11]. This can be considered as an opportunity for public health dentists and other oral health policy makers to plan and implement various primary preventive dentistry programs which can have long term benefits for our future generations. However, for planning such programme we need recent data on burden of oral diseases in India.

Currently, India has no mechanism for continuous surveillance of oral diseases nor there is no separate budget for oral health [12]. Therefore, to fill up the time gap before another nationwide survey is instituted, integrated studies such as a systematic review and meta-analysis can act as an invaluable tool to update oral health policy makers regarding the current burden of oral diseases in Indian population. Hence, we conducted this systematic review and meta-analysis with the aim to provide a comprehensive data to relevant stakeholders on prevalence of malocclusion among children and adolescent population of India. The patient, intervention, comparison, outcomes (PICO) method as applicable in relation to the topic of the review:

Patient: Indian children and adolescents less than or equal to 19 years of age

Intervention = clinical examination for assessing malocclusion

Comparison: Not applicable

Outcomes: prevalence of malocclusion

Focused question:

What is the pooled prevalence of malocclusion among children and adolescent population in India?

Methods

The review protocol is registered with PROSPERO (registration number – CRD42018094345). PRISMA guidelines for conducting a systematic review were followed throughout the study period [13].

Information sources and literature search

Relevant articles were retrieved electronically by searching PubMed/MEDLINE, PubMed Central, Scopus, Complimentary index, Ebscohost, SciELO, Open DOAR, TRIP databases, Science Citation Index, Web of Science and finally Google Scholar. The search period was restricted from 1st January 2000 in order to obtain data from recent studies only. Other

filters used were restrictions on language i.e. English and study participant's age should be under 20 years.

The search strategy was built with medical subject headings (MeSH) terms and relevant text words. The MeSH terms employed were “Malocclusion” [All Fields] AND “child” [All Fields] AND Adolescent [All fields] AND “India” [All Fields] as search strategy if the search engine permits. In addition, key words such as prevalence, Dental Aesthetic Index (DAI), Index of Orthodontic Treatment Needs (IOTN), Angle classification of malocclusion and primary dentition were used in order to broaden the search.

Relevant studies were searched independently by two authors (AM and AV). Initially titles were searched followed by abstracts and finally full texts were read. The first round of search was upto 30th April 2018; a second round was performed to include the entire list of relevant articles published upto 31st December 2019.

The calibration of the reviewers was done by conducting discussion sessions prior to the commencement of the study. A list of inclusion and exclusion criteria was prepared and both the reviewers were subjected to analyse 10 abstracts. Afterwards, an assessment was done and this procedure was repeated until a high inter-examiner agreement ($k=0.92$) was achieved. The results were then compared after the complete selection of the eligible articles by both the reviewers and in case of disagreement, a third reviewer (AN) was asked to review the article independently for inclusion. After the identification of articles in the databases, the articles were imported into Mendeley reference manager for the removal of duplicate articles. In addition, reference list of retrieved studies were searched to look out for more studies. In case of any clarification or additional data were required the concerned study author/s were contacted via e-mail.

Study selection (inclusion and exclusion criteria)

This systematic review concentrated on short listing the population or school based cross sectional studies conducted on Indian children and adolescents (<20 years) assessing prevalence of malocclusion according to different indices and classifications. Studies that did not report the prevalence of dental malocclusion, sample size, abstracts submitted to conferences, case report studies, seminars, case-control studies and clinical trials not providing an accurate estimation of the prevalence were excluded from this review. Studies that did not obtain a minimum score of quality assessment and studies with a participant population of over 19 years of age were also excluded.

Studies recording malocclusion as a part of a study on the associations with specific parameters such as nutrition status, socioeconomic status, quality of life, caries and periodontal diseases, studies conducted on special children, those suffering from any systemic condition or syndrome were not included in this review.

Data extraction

Relevant data were extracted by two independent reviewers (AM and AV) from eligible studies under the following domains: study characteristics (study ID, first author's name, year of publication, sampling technique, total sample size, sample size in terms of gender and age, age range of the studied population); Description and assessment of exposure (overall and gender wise prevalence and severity of malocclusion according to different indices or classification).

Data for each index or classification were entered in terms of percentage of subjects falling into following categories:

- (1) DAI- no malocclusion (<25), definite malocclusion (26–30), severe malocclusion (31–35) and handicapping malocclusion (>35).
- (2) IOTN-no , moderate and definitive need according to severity of malocclusion
- (3) Angle's classification-class – I, II, III and normal occlusion
- (4) Primary dentition- mesial step, distal step and flush terminal.

Quality assessment

For assessing quality of the eligible studies for meta-analysis a checklist used in previous studies was utilized [7, 14]. This checklist contains twelve (12) questions which are designed to assess the methodological quality of the observational studies. The main domains covered using these questions were: appropriateness and/or description of the (1) sample size, sample characteristics and sampling method (2) research question and study design (3) role of researcher (4) data collection methods (5) data analysis methods. For each question a score of 0 or 1 is assigned based on whether the answer is negative or positive, respectively. Two reviewers (AM and AV) carried out the quality assessment independently. Points of diversion were discussed with third reviewer (AN) and consensus was obtained for final score of the study in question.

Statistical analysis

Statistical analyses were performed in MedCalc software. Heterogeneity between the eligible studies was calculated using Cochrane Q and I^2 Based on level of heterogeneity, random or fixed effects model were utilized to estimate the overall prevalence of malocclusion. Confidence interval was kept at 95% and relevant forest plots were prepared for each scoring criteria category of indices and classification used in the review as well as for the overall prevalence. Gender wise pooled estimate of prevalence was calculated from the data available from the included studies. Statistical difference between the two gender was calculated using chi-square test at significance level of $p < 0.05$.

Results

Literature search and quality assessment

Figure 1 describes the whole sequence of literature search and shortlisting of studies. Initial search with pre-selected key words and identified MeSH terms from various databases produced 1,090 titles. After removal of duplicates, 850 records were left. All these remaining records were screened for their titles and abstracts; and 81 articles were found eligible for full text reading. Further, 21 studies were excluded for not meeting the inclusion criteria. Finally, sixty (60) articles were found eligible for final qualitative and quantitative analysis.

Characteristics of included studies and pooled prevalence

Basic characteristics of individual studies conducted using different malocclusion indices and classification are summarized in Tables 1, 2. Statistically significant heterogeneity was observed among primary studies therefore we used random effects model for estimation of pooled prevalence. Pooled estimates of malocclusion according to different measurement tools are described as follows:

Dental Aesthetic Index (DAI)

We found 34 studies [15–48] and one nationwide survey [10] eligible for pooling data where DAI was used for assessing malocclusion. The pooled prevalence was 28.4% (CI 25.02, 31.9) from a sample of 71409 children. Statistically significant higher proportion of malocclusion was seen among boys (43.6%, CI 35.5, 51.9) as compared with

girls [28.1%, CI 23.1, 33.3, $p < 0.001$]. “Very severe” type of malocclusion was observed in 4.8% (CI 3.7, 6.1) children (Table 3).

Index of orthodontic treatment needs

The total sample size obtained from 10 primary studies was more than nine thousand [49–58]. Overall pooled prevalence for any type of treatment need arising from malocclusion was 60.4% (CI 49.2, 71.1). More than one-third children were in need of definitive treatment. Five studies reported gender wise data [49–52, 58]. Higher overall prevalence was observed in boys in comparison to girls. However, more proportion of girls requires definite treatment (Table 3).

Angles classification

Eight studies had assessed malocclusion using Angles classification [59–66]. According to this classification, around two-third (66.7%, CI 50.7, 81.06) of 10,663 children were suffering from malocclusion. Here also boys reported higher overall prevalence than girls. Class I malocclusion was most common affecting more than half of the children (51.3%, CI 36.2, 66.3). Class II malocclusion affected 10.2% (CI 6.3, 14.9) and just 2.2 % (0.8, 4.2) children had class III malocclusion. Boys had higher proportion of class I and III whereas class II malocclusion was more prevalent in girls (Table 3).

Terminal plane relationship of second primary molars

Flush terminal plane and mesial step relationship together accounted for more than 80% cases. Less than ten percent children had distal step relationship and asymmetric molar relationship. Out of the seven studies [67–73] included in this category, only one study had provided gender wise data. The authors of this study reported that males had significant to highly significant higher prevalence for all the three molar relationships compared to females [70].

Discussion

The results of our review showed that the pooled overall prevalence of malocclusion in Indian children and adolescents ranged from 28.4% in studies conducted using DAI to more than 60% for IOTN and Angles classification. The National Oral Health Survey of India conducted in the year 2002–03 had reported the prevalence of malocclusion (using DAI) to be 23.6, and 23.9 % in 12 and 15 years age group, respectively [10]. As compared to this nationwide survey our review reports a five percent increase in prevalence of malocclusion in Indian children. We included the data from this national survey except for five year old children since DAI is not recommended for this age group [75]. We did not find any other nationwide survey or

Figure 1: Literature search strategy.

Table 1: characteristics of studies conducted to assess malocclusion using DAI.

S. no.	Author	QA score	Year of publication	Region of study	Sample size	Age group	Prevalence of malocclusion		
							Overall	Boys	Girls
1	Baskaradoss JK [15]	12	2013	Tamilnadu	1,800	11–15	15.4	17	13.2
2	Bhardwaj VK [16]	10	2011	Himachal	622	16–17	20.4	20	21.1
3	Chandrashekher BR [17]	11	2013	Andhra	1,268	15	18.2	13.5	23.9
4	Damle D [18]	10	2014	Haryana	1,322	12–15	23.6	24.9	22.2
5	Jha K [19]	9	2011	Uttar Pradesh	697	12–15	30.4	35.3	21.1
6	Nagalakshmi S [20]	12	2017	Tamilnadu	1,078	12–15	17.3	18.8	15.9
7	Shetty R [21]	12	2018	Karnataka	1,001	15	30	29.3	30.8
8	Sanadhya S [22]	9	2014	Gujarat	947	12–15	33.4	38.1	27.6
9	Sivakumar KM [23]	12	2009	Karnataka	1,000	12–15	19.9	20.3	19.5
10	Sripriya N [24]	12	2010	Karnataka	1,618	14–15	21	22.3	19.5
11	Fotedar S [25]	12	2013	Himachal	943	12–15	40.8	57.2	53.3
12	Tak M [26]	12	2013	Rajasthan	887	12–15	33.3	38.7	26.3
13	Babu S [27]	8	2005	Karnataka	300	13–15	38.7	37.6	40
14	Chandra shekhar BR [28]	9	2014	Andhra	1,484	15	17.9	13	23.6
15	Reddy VC [29]	9	2011	Tamilnadu	300	12–15	73.7	–	–
16	Deepthi A [30]	11	2016	Andhra	200	12	31.5	–	–
17	Hemapriya S [31]	12	2013	Tamilnadu	500	12	75	–	–
					500	15	75.4	–	–
18	Kaipa S [32]	11	2009	Andhra	2,126	13–15	49.2	53.6	44.7
19	Khan MK [33]	11	2014	Uttar Pradesh	807	12–15	30.7	–	–
20	Pruthi N [34]	12	2013	Himachal	961	12–15	52.8	54.1	50.3
21	Reddy S [35]	10	2010	Tamilnadu	613	12	42.9	44.6	40.9
22	Gupta R [36]	11	2015	MP	549	13–15	21.5	24.2	19
23	Sushanth VH [37]	10	2008	Tamilnadu	1,800	12–13	21.1	–	–
24	Thakur AS [38]	12	2017	Karnataka	525	12	13.8	–	–
25	Suma S [39]	11	2011	Andhra	1,794	15	17.2	13.2	21.8
26	Shivakumar [40]	11	2010	Karnataka	1,800	12–15	20.1	19.9	20.4
27	Handa S [41]	12	2013	Haryana	324	12–15	38.91	–	–
28	John J [42]	9	2011	Tamilnadu	613	12	43.7	70.2	73.4
29	Sivakumar V [43]	12	2016	Karnataka	319	12	32.9	–	–
30	Prasad SN [44]	8	2014	Karnataka	450	10–12	65.2	69.4	61
31	Mallick S [45]	12	2017	Karnataka	710	15	29.3	31.3	28
32	Kumar N [46]	12	2010	Karnataka	2,001	12–15	16.6	–	–
33	Singh A [47]	12	2011	Karnataka	927	12	18	–	–
34	Bali RK [10]	11	2002	India	19,144	12	23.6	–	–
					18,915	15	23.9	–	–
35	Gaikwad SS [48]	9	2013	Maharashtra	880	12–15	26.8	–	–

systematic review conducted on Indian children for comparison with our data. Systematic reviews conducted in Iran [7] and China [8] have reported prevalence of 83.1 and 45.5% for any type of malocclusion in their native children. These reviews included studies conducted using Angles classification only.

It has been well-established that different types of malocclusions are associated with impaired oral health and function [76]. Possible consequences of untreated malocclusion are pain in temporomandibular joint/s region, increased risk of trauma, speech problem and

difficulty in mastication leading to food restriction [77, 78]. In the current review, the overall pooled prevalence as per Angles classification was 66.7%. Angles class 1 was the most prevalent type of malocclusion observed in Indian children. This finding is in consensus with studies and systematic reviews conducted in other countries [7, 8]. Angles class I malocclusion can cause visible irregularities such as crowded anterior teeth or large midline diastema between incisors in the dental arches [7, 79]. A systematic review conducted to assess global prevalence of class 3 malocclusion has reported a

Table 2: Characteristics of studies conducted to assess malocclusion using IOTN, Angles Classification and terminal plane relationship.

S. no.	First author	Index/classification used	QA score	Publication year	Place of survey	Sample size	Prevalence of malocclusion		
							overall	Boys	Girls
1	Bhagyalaxmi A [49]	IOTN	10	2017	Karnataka	409	58.2	60.1	–
2	Chaitra K [50]	IOTN	10	2014	Karnataka	1,000	75.9	47.9	44.8
3	Singh J [51]	IOTN	10	2011	Karnataka	529	47.4	50.6	43
4	Kumar P [52]	IOTN	8	2013	Maharashtra	1,200	53.7	34.2	34.3
5	Shashidhar J [53]	IOTN	12	2018	Karnataka	500	35.5	–	–
6	Singh S [54]	IOTN	10	2014	Himachal	2,000	68.4	–	–
7	Bhagyalaxmi A [55]	IOTN	12	2015	Karnataka	363	80.4	–	–
8	Sachdeva A [56]	IOTN	12	2016	MP	1,822	85.5	–	–
9	Vishnoi P [57]	IOTN	8	2017	Rajasthan	1,029	51.2	–	–
10	Bhatia R [58]	IOTN	10	2016	Maharashtra	604	41.3	43.6	39.2
11	Kaur H [59]	Angles	10	2013	Karnataka	2,400	87.6	–	–
12	Patil D [60]	Angles	12	2017	Karnataka	800	–	71	69.9
13	Kumar M [61]	Angles	8	2014	Maharashtra	985	33	43	42
14	Trehan M [62]	Angles	9	2009	Rajasthan	700	66.7	67.2	64.5
15	Prabhakar RR [63]	Angles	8	2014	Tamilnadu	532	89.2	45.8	43.3
16	Reddy ER [64]	Angles	12	2013	Andhra Pradesh	2,135	51.7	–	–
17	Retna KN [65]	Angles	11	2016	Kerala	2,366	83.3	85.5	80.7
18	Das UM [66]	Angles	8	2008	Karnataka	745	70.6	73.4	67.7
							Mesial step	Distal step	Flush terminal
19	Khan R [67]	Terminal plane	9	2014	Uttar Pradesh	453	31.3	6.4	62.3
20	Hedge S [68]	Terminal plane	9	2012	Rajasthan	200	50	1	49
21	Bhayya D [69, 70]	Terminal plane	11	2012	Karnataka	1,000	36.9	8.4	52.5
22	Bahadure RN [71]	Terminal plane	8	2012	Maharashtra	1053	57.3	11.7	31.1
23	Fernandes S [72]	Terminal plane	10	2017	Gujarat	383	43.3	1.3	55.4
24	Anitha XL [73]	Terminal plane	10	2013	Tamilnadu	1,836	38	21	41
25	Lochit S [74]	Terminal plane	8	2014	Haryana	1,000	12.8	2.4	65.1

prevalence range of 0–26.7 %, whereas, our review shows a pooled prevalence of 2.2% only. Studies have reported a low prevalence of class III malocclusion in Indian children when compared with other racial groups [8, 80].

The evaluation of terminal plane relationship of primary second molars can act as predictor for assessing future malocclusions in children. Pooled estimates of our review shows that half of Indian children have flush terminal plane or commonly known as end-on relationship. The future forward growth of mandible can lead to development of class III malocclusion in children with flush terminal relationship [81]. We observed a higher prevalence of malocclusion among Indian boys as compared to girls. These results are contradictory to the trends seen in Iran [7] where girls had a higher prevalence of malocclusion. No gender difference was observed among the Chinese children [8].

Strengths and limitations

One of the limitations of the present review is that we didn't search data from grey literature which might be relevant to this review. Other major limitation is the occurrence of statistically significant heterogeneity among primary studies. We were unable to identify the source/s of this heterogeneity although we have used random effect model for estimation of results. The variation in quality of studies could be another possible limitation. In spite of these limitations, our review has many positive aspects. It is the first systematic review where all the studies conducted using most common indices and classification used for recording malocclusion were included for pooled analysis. We have followed international guidelines for data search and extraction and each study was scrutinized for its quality based on criteria

Table 3: Cumulative prevalence estimate of malocclusion among Indian children according to different indices and classification.

Index/classification	Categories of malocclusion	Sample size	Overall Pooled prevalence (95% CI)	boys		Girls	
				Sample size	Pooled prevalence (95% CI)	Sample size	Pooled prevalence (95% CI)
Dental aesthetic index	No malocclusion	71,409	71.2 (67.6, 74.6)	14,024	63.6 (56.9, 70.06)	12,176	66.3 (60.9, 71.4)
	Definitive		15.4 (13.5, 17.3)		20.3 (16.9, 24.02)		19.2 (16.6, 21.8)
	Severe		6.2 (5.2, 7.3)		8.4 (6.5, 10.4)		7.1 (5.8, 8.6)
	Very severe		4.8 (3.7, 6.1)		3.8 (2.7, 5)		3.5 (2.4, 4.7)
	Overall prevalence		28.4 (25.02, 31.9)		43.6 (35.5, 51.9)		28.1 (23.1, 33.3)
Index of orthodontic treatment needs	Little/no need	9,456	41.1 (28.6, 54.2)	2,209	52.8 (43.5, 62.04)	1,533	59.7 (54.7, 64.7)
	Moderate		25.3 (20.2, 30.7)		17.7 (7.6, 31.02)		14.3 (4.5, 28.3)
	Definitive		36.01 (20.6, 53)		16.5 (5.2, 32.4)		24.1 (13.1, 37.1)
	Overall prevalence		60.4 (49.2, 71.1)		47.17 (37.9, 56.4)		40.2 (35.2, 45.2)
Angles classification	No malocclusion	10,663	31.9 (18.7, 46.7)	3,374	34.8 (20.8, 50.4)	2,559	38.09 (24.6, 52.5)
	Class 1		51.3 (36.2, 66.3)		44.1 (25.9, 63.2)		40.5 (21.4, 61.2)
	Class 2		10.2 (6.3, 14.9)		7.97 (5.1, 11.3)		8.26 (5.1, 12.07)
	Class 3		2.2 (0.8, 4.2)		1.53 (0.47, 3.18)		0.93 (0.1, 2.5)
	Overall prevalence		66.7 (50.7, 81.06)		66.8 (52.3, 79.9)		60.4 (52.3, 68.1)
Terminal plane relationship	Mesial step	5,925	37.7 (26, 50.2)		—		—
	Distal step		6 (2.3, 11)		—		—
	Flush terminal		50.6 (40.6, 60.6)		—		—
	Asymmetric relationship		1.8 (0.5, 7)		—		—

covering different aspects of reporting a descriptive survey. We searched different electronic databases for this review thereby leading to higher number of included studies and larger sample size. All these points improve the generalizability of our results.

Conclusions

Apart from these functional problems, malocclusion has a significant impact on the social esteem and emotional well-being of a person. All the visible malocclusions have often been associated with bullying and a lower self-esteem among teenagers [76, 82]. A recent systematic review reported that malocclusion has a negative impact on oral health related quality of life of individuals [83]. Therefore, the knowledge of burden of malocclusion in a

population is important for instituting preventive measures especially in children and adolescents to avoid its physical and psychosocial impact later in their life.

To conclude, the pooled data analysis of this review showed that the prevalence of malocclusion is increasing in Indian children. The reason for higher prevalence of malocclusion among Indian boys in comparison to girls needs to be investigated further. These results can help policy makers to work on feasible preventive and interceptive orthodontic measures for controlling malocclusion among Indian children and adolescents.

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