REVIEW ARTICLE

Prevalence of malocclusion among children of the Kingdom of Saudi Arabia – A systematic review and meta-analysis

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Abstract *Objective:* Systematic review and meta-analysis are of a great tool in assessment of malocclusion, which is major public health concern. This study aims to explore the prevalence of malocclusion among the children of the Kingdom of Saudi Arabia through a meta-analysis and systematic review.

Materials and methods: Registered with PROSPERO as CRD42020198427, an authentic and global scale database search using relevant MeSH (Medical Subject Headings) terms was performed. Literature search and articles screening done following PRISMA guidelines.

For the dichotomous variables, 95% confidence intervals (CIs) were set for statistical data analysis. The heterogeneity index between the studies was determined using indices Tau^2, Chi^2, df and I^2 and Test for overall effect as Z.

Results: A total of 7930 candidates were reported to have either one of the three malocclusions. Prevalence of Class I, Class II and Class III Malocclusions were found to be 66.51%, 17.70%, 15.79% respectively. Among the small subsample of these candidates, male children with Class I, Class II and Class III Malocclusion were 43.80%, 12.27% and 7.40% respectively whereas female children were 22.07%, 10.93 %, 3.52 % respectively.

Conclusions: According to the 26 studies included in the systematic review, there were 72% of the candidates with malocclusion in Saudi Arabia. Prevalence of Class I, Class II and Class III

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malocclusion were 66.51%, 17.70%, and 15.79% respectively. In both male and female participants, the prevalence of Class I was the highest followed by class II and III malocclusion.

Contents

1. Introduction

This study reports for the first time a systematic review and meta-analysis specifically in children (<18 years) of Saudi Arabia with respect to malocclusion. Like any other ailment orthodontic malocclusion have multiple etiology that often links to environmental, genetic and social aspects (Heimer et al., 2008; Dimberg et al., 2015; Debnath, 2017). In children malocclusion may manifest in a more complex fashion because several oral habits and dental hygiene have also been linked to its occurrence. Mal-relationship or wrong relationship between the dental arches beyond an acceptable limit can be termed as Malocclusion (Peres et al., 2007). Along with other dental problems such as dental caries, gingival disease and dental fluorosis, Malocclusion is also considered one of the most common dental problems (Gupta et al., 2016).

There is a wide range of results regarding the data and reports on primary research regarding malocclusion. The reason behind this may be the differences in ethnic groups, age groups, registration procedures and classification of malocclusion (Dhar et al., 2007; Grewe et al., 1968). The prevalence of malocclusion in general population in various geographical locations is also varied. For example 30% of people have normal occlusion in the USA but prevalence of Class 1 malocclusion was between 50 and 55%, with Class II and Class III malocclusion is 15% and <1%, respectively (Mills, 1966).

Prevalence of normal malocclusion in Denmark is reported to be 14% but prevalence of Class I malocclusion, Class II malocclusion, and Class III malocclusion were reported to be 58%, 24%, and 4% respectively (Proffit et al., 1998). In a population of Chinese living in Australia, the prevalence of normal malocclusion was reported to be 7.1% (Helm, 1968). However, several studies focused on occlusion problem in Saudi Arabia but cater to the general population rather than children. Several studies have reported molar relationship as well as canine relationship of malocclusion (Lew et al., 1993; Alharbi, 2020). Drawback of some studies has been the lack of male and female children candidates for including in the study. The systematic analysis of performed research regarding malocclusion in children from various parts of Saudi Arabia has therefore been attempted that demanded substantial effort for organization of the meta-analysis for a detail scientific insight.

2. Materials and methods

A systematic review and meta-analysis was conducted according to the guidelines provided by the Preferred Reporting Items for Systematic reviews and Meta-analyses (PRISMA) statement (Moher et al., 2009a). However, the schematic representation of protocol followed for the Systematic Review executed in this paper is depicted as a schematic and the PRISMA protocol is depicted as Fig. 1. Figure Supplementary figure 1

Malocclusion is an orthodontic condition and may have influence on other pathologies, quality of life as well as co-morbid aspects related to it. For the Systematic review for "Prevalence of malocclusion among children of the Kingdom of Saudi Arabia", a multi step protocol was followed aligning to the PRISMA statement (Moher et al., 2009b). The literature search was initiated on 30th July 2020 and done till 8th August 2020.

2.1. Database search

In the stepwise database search initiative the focus was on peer reviewed literature available in the internet. The list of databases searched is given in the.

In order to collect up-to-date information no date limit was set (literature published till 08–08–2020 were included in the study) during the Boolean search of the databases with AND/OR terms. The Keywords used were "MALOCCLUSION", "CHILDREN", "DENTAL MALOCCLUSION", "PRE-VALENCE", and finally "SAUDI ARABIA". The MeSH terms (Medical Subject Headings) were re-framed so that no paper is left out. In order to ensure stringent systematic analysis interaction with orthodontist and periodontal fraternity in Asian subcontinent was done for updates on malocclusion in children from Saudi Arabia. Orthodontic and Periodontal hygiene impacts systemic aspects such as cardiac and immuno-logic wellbeing.[3] The search strategy executed with the specific MESH terms is given as Annexure I.
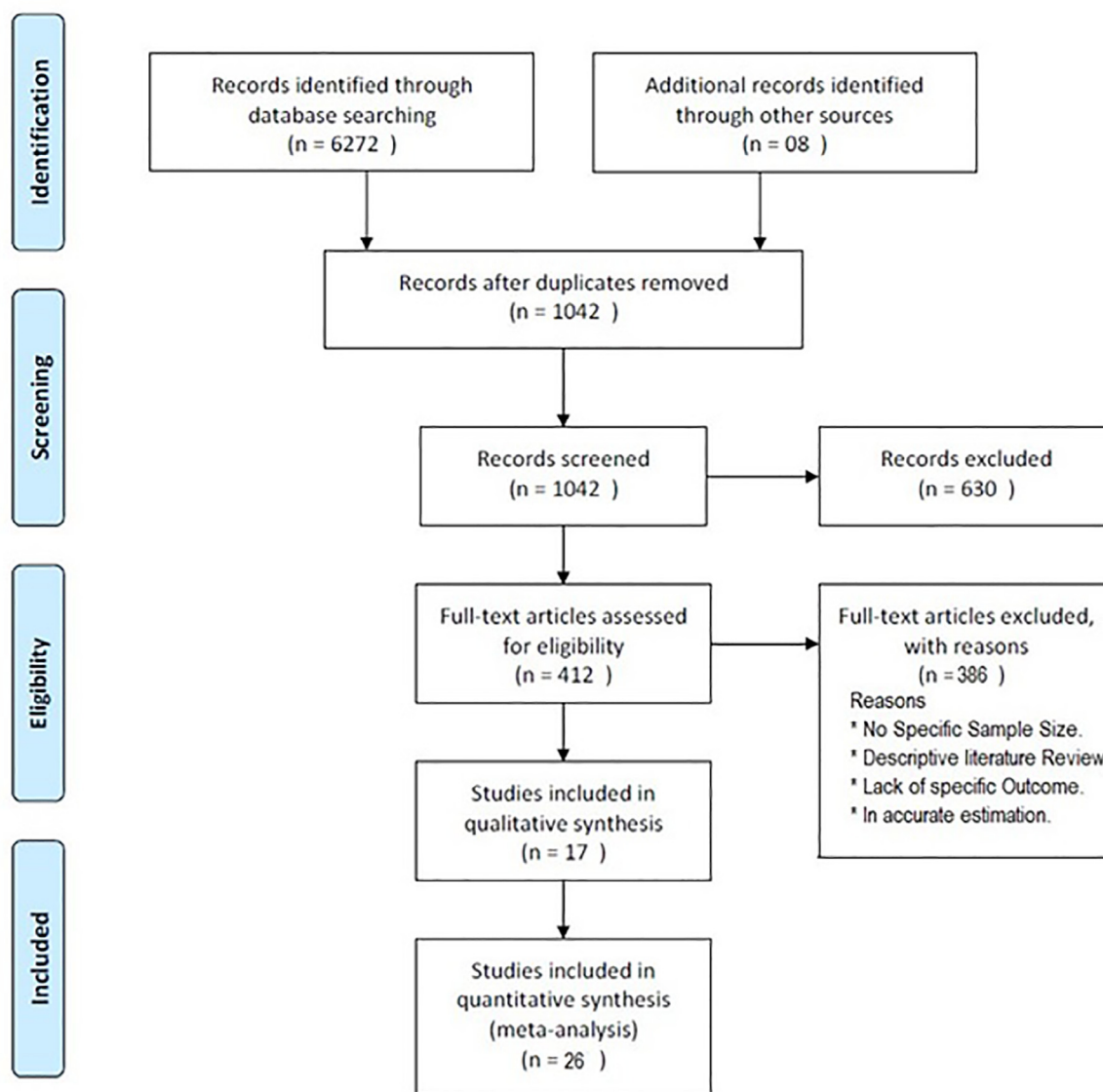

Fig. 1   Flowchart of the Systematic Analysis of literature Review PRISMA.

2.2. Screening strategy

Establishing Inclusion and Exclusion criteria is vital step in a systematic review in order to increase sensitivity and specificity in terms of the objective of the study.

2.2.1. Inclusion criteria

The studies that report the prevalence of Class I, Class II and Class III and normal malocclusion in candidates of both sexes (males and females) under the age of 18 years were included for further analysis. Research papers in English as well as papers with an Arabic abstract along with English were also included.

2.2.2. Exclusion criteria

Any study on dental malocclusion reported in adult of Saudi Arabia was excluded. Irrelevant studies that do not report the prevalence of dental malocclusion and abstracts submitted to conferences and seminars were excluded from the analysis. Qualitatively inferior studies and studies with an unspecified sample size were excluded.

2.3. Selection of studies for this systematic review

Advance search protocol of the databases was used for the full text or abstracts of all papers, documents, and reports for this study. In order to eliminate republishing bias and repetitive information sufficient measures were deployed (Fig. 1). The full text articles selected for the study were analyzed for their publication date to examine the frequency of reports published in the context of the study.

2.4. Assessment of quality

For overall quality assessment of the included literature, a four tier quality control measure was followed. From the initial collection of peer reviewed materials containing the required search terms, only the following studies were finally selected: (i) studies with an appropriate sample size, (ii) studies with a standard data collection method, (iii) use of proper data collection tools for identification of malocclusion and (iv) studies that have used suitable statistical analysis for reporting the study.

2.5. Extraction of data

From the finally selected studies the data for the meta-analysis was extracted in a spread sheet. The following data points such as 1) Article data: title of the article, first author's name, year of the study, 2) Sample data: total sample size, sample size of male and female, age range of the specific population, 3) overall prevalence of malocclusion in males and females, normal malocclusion, in males and females, prevalence of Class I, Class II and Class III malocclusion and 4) any other outcome (Table 1). The dataset was generated using Excel program.

2.6. Statistical analysis

All statistical analyses were performed using the Rev Man 5.3 software. The 95% confidence intervals (CIs) were used to ana-lyze dichotomous variables and the analysis was represented in terms of heterogeneity Tau^2, Chi^2, df and I^2 to investigate the degree of statistical heterogeneity among studies. The z-statistics was used to quantify the overall effect. Risk differences, Risk ratios and Odd ratios were analyzed depending on the objectives of the analysis. Results were represented in the form of forest plots. The size of the square in a forest plot represents the weight of each study that is included in the meta-analysis. On the other hand the side lines show the confidence interval of 95%. Weights from random effect analysis were also estimated in the analysis. The ultimate graphical representation of the canopy in the forest plot indicates the favorable factor in the comparability study.

2.7. Risk of individual studies & risk of bias across the studies

In order to eliminate republishing bias and repetitive information sufficient measures were deployed. The Risk of Bias analysis is used to assess heterogeneity & to examine the quality of included studies in the Meta-analysis. The analysis generally includes the appraisal of allocation concealment, random sequence generation, blinding of the participants/personnel, blinding of outcome assessment, and some other bias measurements.

The Risk of Individual studies as well as risk of bias across the studies were analyzed. The risk of bias analysis included seven different parameters ensuring the robustness of the process.

3. Results

3.1. Outcomes of the search process

The result of the literature search is demonstrated in the Fig. 1. In this study eight different databases were searched in a systematic way. The preliminary search resulted in a total of 6272 titles. Eight more articles were assessed from the author's own collection. After removing the duplicates 1042 articles were further processed. However 386 articles were eliminated due to unspecified sample size and inaccurate estimations. Among some articles analyzed with respect to their publication date, it is found that after 2010 there has been a renewed interest in the assessment of Malocclusion in Children in Saudi Arabia. For the final meta-analysis 26 full text papers in peer reviewed journals on malocclusion in males and females among Saudi Children below the age of 18 in Saudi Arabia were selected on the basis of overall quality of the study. Figure Supplementary figure 2

3.2. Primary outcomes

Our synthesis was based on 4 main types of articles that were included in the overall analysis. (1) Retrospective studies, (2) Comparative studies with Control groups, (3) Cross-sectional studies as well as (4) Cross sectional surveys. Some special case studies on children with Down's syndrome, Autism, etc were also included in the present study with subsequent adjustments.

According to the synthesis of the analysis the following were the major outcomes of the study. The minimum age of

the study participants was 3 years and the maximum age of the participants was 17 years. However, mean minimum age of all candidates including all the studies was 9.4 years excluding the studies that reported only the mean ages of the participants. Similarly the mean of maximum age of the participants of all included studies was 13.65 years. The total number of participants in all the selected studywas14898. Among them there are 7615 males. While in the overall study there were be 7283 females.

Among all studies included in the final synthesis 10 studies were reported from Riyadh, Saudi Arabia. The total study sample from Riyadh region comprised of 6380 candidates out of which 3286 are females and 3094 were male participants. The origin or the locations of studies included in the synthesis is demonstrated within a Map of Saudi Arabia that also includes the Northern region, Western region as well as the eastern province of Saudi Arabia. Figure Supplementary figure 3

3.3. Secondary outcomes

Outcome of the meta-analysis using REVMAN was done. Analysis of Class II malocclusion among the genders, favors the female participants with homogeneity of included studies ($I^2 = 93\%$). Similar observation was found even for Class III malocclusion ($I^2 = 78\%$).

Among the male and female participants in all studies included in this research, the female candidates were favored (Fig. 2). Figure Supplementary figure 4 The heterogeneity indices were as follows: $Tau2 - 0.93$ and $Z - 1.20$. These tests were used to investigate the degree of statistical heterogeneity

among studies and it was significantly high. Similarly, in the analysis on Cases of Malocclusion and Normal Occlusion among Saudi Children (Fig. 3), it is seen that the analysis have significant limitation of heterogeneity among studies. Whereas it was observed that the Class I + Malocclusion was favored among female participants, although there was significant heterogeneity among the studies. Figure Supplementary figure 5

When the analysis was done for Class II malocclusion in among Saudi Children, it was observed that I2value was 93% and the Z value was 0.69. With respect to the analysis of Class III malocclusion, significant improvement in the quality of the analysis was observed with I^2 value of 78% and Z value of 4.47. For complete assessment of the phenomenon of malocclusion among Saudi Children, a comparative analysis was executed through meta-analysis. To the best of our knowledge this approach is novel and is demonstrated in this study for the first time.

Class I malocclusion was compared to all other malocclusion and control among Saudi Children. Figure Supplementary figure 7 In this analysis it was observed that the I2value was 98% and Z value was 3.92. The I^2 value for the analysis on Class II malocclusion done in comparison to all other malocclusion and control among Saudi Children was also 98%. However, the Z value in this analysis was 6.24. The comparative meta-analysis on Class III malocclusion in comparison to all other malocclusion and control among Saudi Children revealed an I^2 value of 99% and Z value of 6.38. Therefore, it was clearly indicated that there was significant heterogeneity among studies.
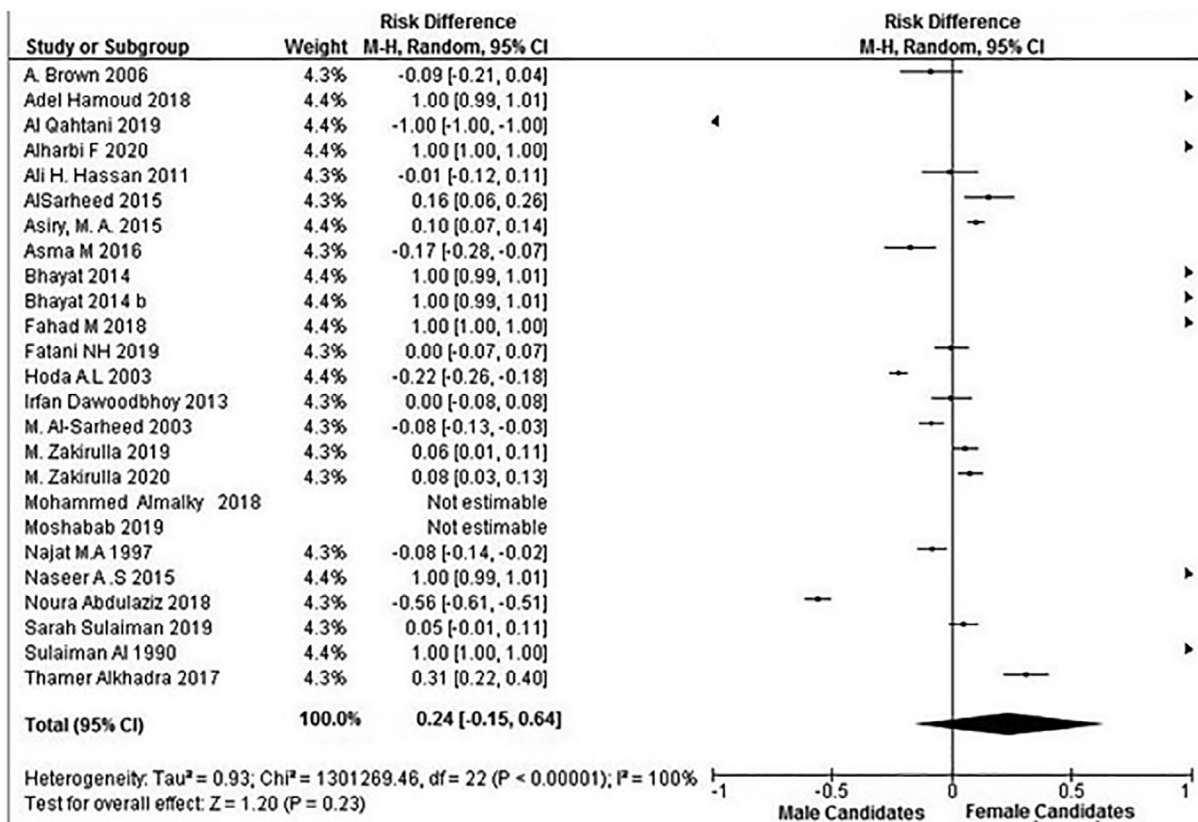
Study or Subgroup	Weight	Risk Difference M-H, Random, 95% CI
A. Brown 2006	4.3%	-0.09 [-0.21, 0.04]
Adel Hamoud 2018	4.4%	1.00 [0.99, 1.01]
Al Qahtani 2019	4.4%	-1.00 [-1.00, -1.00]
Alharbi F 2020	4.4%	1.00 [1.00, 1.00]
Ali H. Hassan 2011	4.3%	-0.01 [-0.12, 0.11]
AlSarheed 2015	4.3%	0.16 [0.06, 0.26]
Asiry, M. A. 2015	4.4%	0.10 [0.07, 0.14]
Asma M 2016	4.3%	-0.17 [-0.28, -0.07]
Bhayat 2014	4.4%	1.00 [0.99, 1.01]
Bhayat 2014 b	4.4%	1.00 [0.99, 1.01]
Fahad M 2018	4.4%	1.00 [1.00, 1.00]
Fatani NH 2019	4.3%	0.00 [-0.07, 0.07]
Hoda A.L 2003	4.4%	-0.22 [-0.26, -0.18]
Irfan Dawoodbhoy 2013	4.3%	0.00 [-0.08, 0.08]
M. Al-Sarheed 2003	4.3%	-0.08 [-0.13, -0.03]
M. Zakirulla 2019	4.3%	0.06 [0.01, 0.11]
M. Zakirulla 2020	4.3%	0.08 [0.03, 0.13]
Mohammed Almalky 2018		Not estimable
Moshabab 2019		Not estimable
Najat M.A 1997	4.3%	-0.08 [-0.14, -0.02]
Naseer A .S 2015	4.4%	1.00 [0.99, 1.01]
Noura Abdulaziz 2018	4.3%	-0.56 [-0.61, -0.51]
Sarah Sulaiman 2019	4.3%	0.05 [-0.01, 0.11]
Sulaiman Al 1990	4.4%	1.00 [1.00, 1.00]
Thamer Alkhadra 2017	4.3%	0.31 [0.22, 0.40]
Total (95% CI)	100.0%	0.24 [-0.15, 0.64]

Heterogeneity. $Tau^2 = 0.93$; $Chi^2 = 1301269.46$, $df = 22$ ($P < 0.00001$); $I^2 = 100\%$
Test for overall effect: $Z = 1.20$ ($P = 0.23$)

Fig. 2   Gender Differences in the Included Studies.
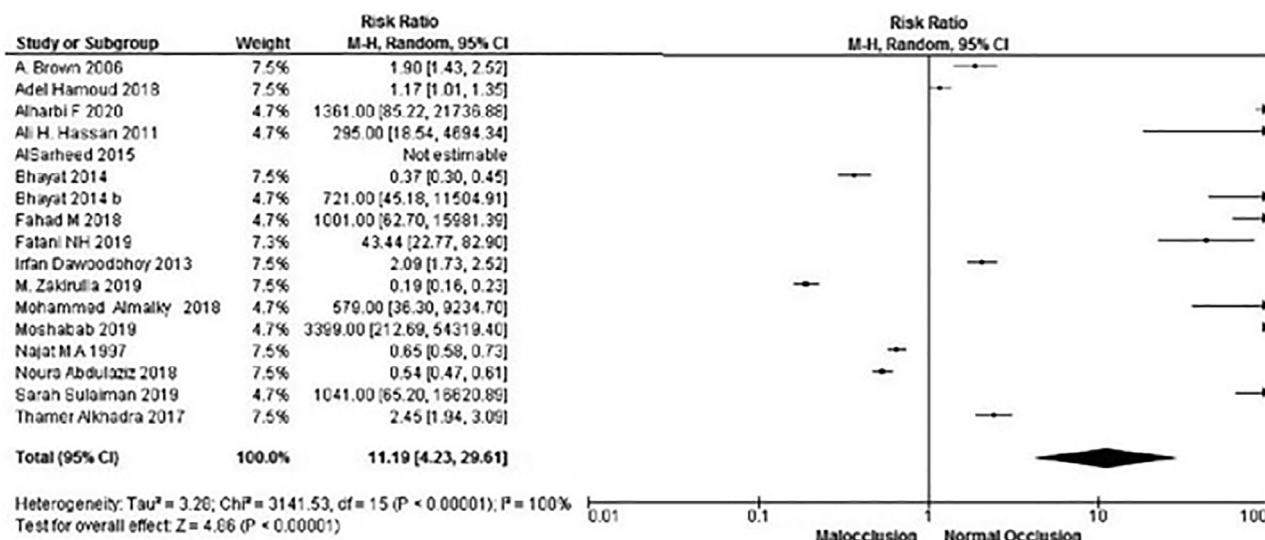
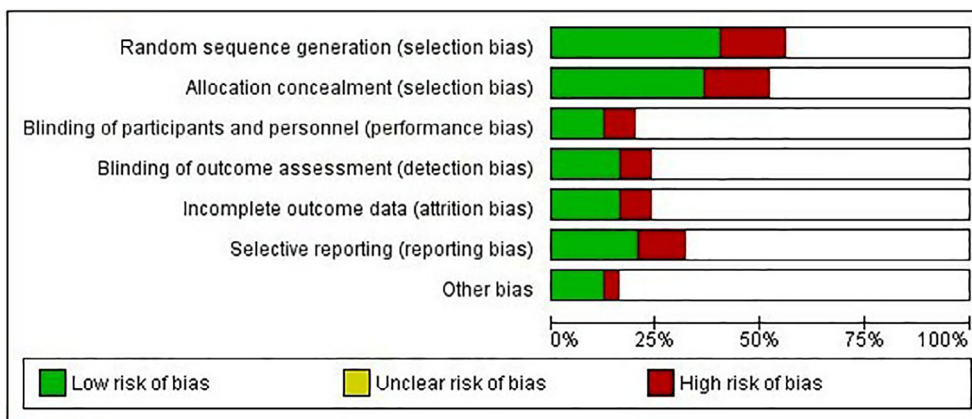**Fig. 3** Cases of Malocclusion and Normal Occlusion among Saudi Children.

Fig. 4 Risk of bias analysis Parameter.

3.4. Assessment of quality of evidence

The risk of bias of all the included studies is depicted in Fig. 5. Due to non-reporting of proper malocclusion classes and sample size the studies Bhayat 2014 & M. Zakirulla 2020 were not included in the bias analysis. The rest of 21 studies were analysed for their bias. More detail studies on the theme of malocclusion in the target group is required.

The analysis of Risk of individual studies demonstrates that only a handful of studies have significant risk of bias. The risk of bias analysis across the studies demonstrates that selection bias in terms of random sequence generation and allocation concealment is just above 50% and significantly less than 75% bias. Rest of the 5 parameters were significantly low in terms of bias and its just 25% (Figs. 4 and 5). Figure Supplementary figures 6–9

4. Discussion

The present study summarizes the current status of dental malocclusion in children below the age of 18 years, in Saudi Arabia. A total of 1825 Saudis (1007 males and 818 females) of 12–16 years old were randomly selected in the study and about 60.11% of Saudis presented with Class I molar relationship while 7.12% and 10.13% of the subjects had Class II and Class III molar relationships, respectively.

In this research paper the statistical analyses were performed using the Rev Man 5.3 software with 95% confidence intervals (CIs) for the dichotomous variables. Among the included reports, one was regarding the records of 700 patients (391 girls and 309 boys) aged 6–14 years attending the undergraduate Department of Orthodontics at Shiraz University of Medical Sciences. The prevalence of Angle class I, II and III malocclusion of first molars was 52.0%, 32.6% and 12.3% respectively. Skeletal class I, II and III malocclusion was found in 18.0%, 70.0% and 12.0% respectively (Asiry, 2015).

In meta-analysis, representation in terms of heterogeneity Tau, Chi2, df and I2to investigate the degree of statistical heterogeneity among studies is vital. It is because diverse study designs are generally followed by scientists. For example the cross-sectional study that recruited non-T21 and T21 children between the ages of 7–15 years who were studying at the Saudi Society (Oshagh et al., 2010). A total of 8% of control children (47 females and 52 males, with a mean age of 10.75 years) had a Class III incisor relationship. According to a study, there
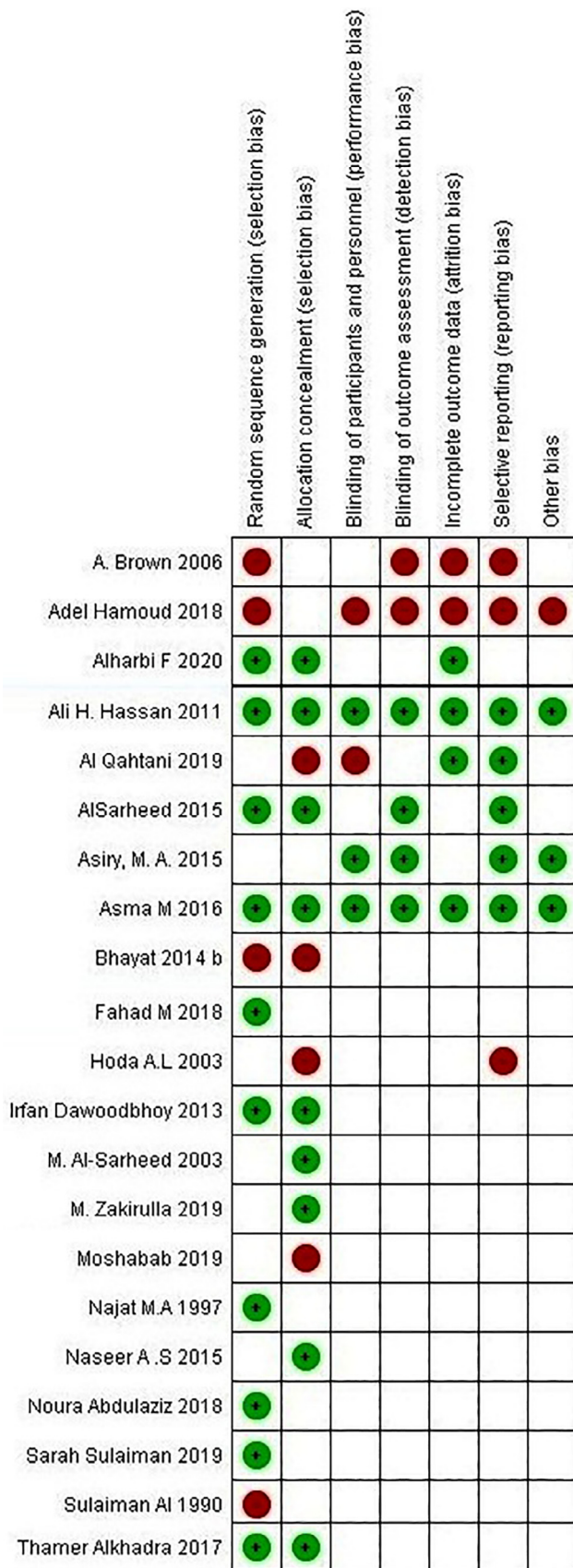
Fig. 5   Risk of bias analysis across the studies.

were no malocclusion (n = 40), moderate or severe malocclusion (n = 76) (AlSarheed, 2015). The study population consisted of 174, 11–14-year-old children (65% healthy and 35% medically compromised). Clinical data on caries status and malocclusion were collected for 138 of the children.

A cross-sectional study based on a convenience sample of hospital volunteers included a total of 278 (139 boys and 139 girls) children aged 11–14 years old those attending the Dental and Maxillofacial Centre of the Almana General Hospital (Alkhobar, Saudi Arabia) (Brown and Al-Khayal, 2006). The children were asked to fill out the Arabic version of the Child Perception Questionnaire for 11-to 14-year-old children (CPQ11–14) and were then clinically examined to determine the severity of their malocclusion using the Dental Aesthetic Index (DAI).

Our study objective was also to find out gender variations if any among the three malocclusions. It was found that many included study did not aim for this objective. For example an observational, cross-sectional study included 307 male children only aged 9–11 years old (Dawoodbhoy et al., 2013). Clinical examinations were performed using a disposable sharp explorer, a UNC periodontal probe and a dental mirror.

In this meta-analysis, Risk differences, Risk ratios and Odd ratios are analyzed depending on the objectives of the analysis. The results are generally represented in the form of forest plots. Some primary studies focused on clear cut demarcation of study sample to enable a good meta-analysis. For example in a study there were 690 male and 1080 female candidates, age ranging from 9 to 17 years with the median age being 13 years old (Al-Shahrani et al., 2015). There were 1379 subjects of the sample who responded to whether proper occlusion is important. A total of 69.4% participants reported that correcting malocclusion was important while the remaining were in different as to the importance. Among the above a larger percentage of females (71%) considered correcting malocclusion as an important factor as compared to males (67%) (p = 0.1188).

In the forest plot analysis on the side lines show the confidence interval of 95%. Weights from random effect analysis were also estimated in the analysis. The ultimate graphical representation of the canopy in the forest plot indicates the favorable factor in the comparability study. However the following five studies do not aid to this kind of comparison using forest plots (Latif and Abdel, 2003; Zakirulla et al., 2020; Hassan, 2011; Bhayat and Ali, 2014; Bhayat and Ahmad, 2014).

In the present study, the prevalence of Class I Malocclusion was found to be 66.51%, whereas prevalence of Class II Malocclusion was 17.70% and the prevalence of Class III malocclusion was 15.79%. In one study five hundred male school children in Riyadh city, Saudi Arabia with an age of 12–15 years participated. The Molar Class I relation involved the highest percentage of the sample (71.2%) while Class 2 relation involved only 23% which was four times of Class III (5.8%) (Alharbi, 2020).

As per the best knowledge no study has reported the intra class comparative analysis of malocclusion in Saudi Arabian population. In the present study the percentage wise occurrence of dental malocclusion observed in children below the age of 18 years in Saudi Arabia was about 60.11% for Class I molar relationship while 7.12% and 10.13% for Class II

and Class III molar relationships, respectively. However, Oshagh et al., 2010 reported in a population of children between the ages of 7–15 years, with a mean age of 10.75 years that only 8% of the children had a Class III incisor relationship. In another study done in Saudi children by Al Sarheed, 2015, it was observed that 40 children had no malocclusion whereas 76 had moderate or severe malocclusion. In a similar context Alharbi, 2020 reported that the molar Class I relation involved the highest percentage of the sample (71.2%) while Class II relation involved only 23% which was four times of Class III (5.8%) in Saudi children with an age of 12–15 years. Several studies have attempted to explore the prevalence of malocclusion in Saudi Arabian children such as Latif and Abdel, 2003; Zakirulla et al., 2020; Hassan, 2011; Bhayat and Ali, 2014; Bhayat and Ahmad, 2014. In the present study the prevalence of Class I malocclusion was found to be 66.51%, whereas prevalence of Class II malocclusion was 17.70% and the prevalence of Class III malocclusion was 15.79%. Asiry, 2015 on the other hand reported the prevalence of Angle class I, II, and III malocclusion of first molars to be 52.0%, 32.6%, and 12.3% respectively. Skeletal class I, II, and III malocclusion was found to be 18.0%, 70.0%, and 12.0% respectively.

5. Strength and limitations of this systematic review

For complete assessment of the phenomenon of malocclusion among Saudi Children, a comparative analysis was executed through meta-analysis. For example, other than the comparative account of Gender Differences in the Included Studies regarding malocclusion, this study reports (1) Cases of Malocclusion and Normal Occlusion among Saudi Children, (2) Class I Malocclusion w.r.t Gender differences among Saudi Children (3) Class II Malocclusion w.r.t Gender differences among Saudi Children, (4) Class III Malocclusion w.r.t Gender differences among Saudi Children, (5) Class I Malocclusion compared to all other Malocclusion and control among Saudi Children, (6) Class II Malocclusion compared to all other Malocclusion and control among Saudi Children and (7) Class III Malocclusion compared to all other Malocclusion and control among Saudi Children. To the best of our knowledge this approach is novel and is demonstrated in this study for the first time. Moreover, the study reports the results with (a) Year wise distribution of selected papers included in the final study and (b) Map of the Locations Covered in the Overall Study which enhances the scientific temper of research work for the readers.

All relevant studies that could be included in the present meta-analysis in the specific geographic location reported the patients / participants age from 3 to 17 years. Therefore, technically the study population is belongs to a Children data set. However, this age range consists of subjects with various dentition such as primary dentition, mixed and permanent. This is a limitation of the study. Among the male and female participants in all studies included in this research, the female candidates were favored. The heterogeneity indices were as follows: Tau2 − 0.93 and Z − 1.20. These tests were used to investigate the degree of statistical heterogeneity among studies and it was significantly high. Similarly, in the analysis on Cases of Malocclusion and Normal Occlusion among Saudi Children, it is seen that the analysis have significant limitation of

heterogeneity among studies. Whereas it was observed that the Class I Malocclusion was favored among female participants, although there was significant heterogeneity among the studies.

6. Conclusion

According to the 26 studies included in the systematic review, there were 72% of the candidates with malocclusion in Saudi Arabia. Prevalence of Class I, Class II and Class III malocclusion were 66.51%, 17.70%, and 15.79% respectively. In both male and female participants, the prevalence of Class I malocclusion was the highest followed by class II and III malocclusion.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sdentj.2021.09.005.

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