Prevalence of Orthodontic Malocclusions in Healthy Children and Adolescents: A Systematic Review

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Abstract: The purpose of this study was to systematically review the literature regarding the prevalence of malocclusion and different orthodontic features in children and adolescents. Methods: The digital databases PubMed, Cochrane, Embase, Open Grey, and Web of Science were searched from inception to November 2021. Epidemiological studies, randomized controlled trials, clinical trials, and comparative studies involving subjects ≤ 18 years old and focusing on the prevalence of malocclusion and different orthodontic features were selected. Articles written in English, Dutch, French, German, Spanish, and Portuguese were included. Three authors independently assessed the eligibility, extracted the data from, and ascertained the quality of the studies. Since all of the included articles were non-randomized, the MINORS tool was used to score the risk of bias. Results: The initial electronic database search identified a total of 6775 articles. After the removal of duplicates, 4646 articles were screened using the title and abstract. A total of 415 full-text articles were assessed, and 123 articles were finally included for qualitative analysis. The range of prevalence of Angle Class I, Class II, and Class III malocclusion was very large, with a mean prevalence of 51.9% (SD 20.7), 23.8% (SD 14.6), and 6.5% (SD 6.5), respectively. As for the prevalence of overjet, reversed overjet, overbite, and open bite, no means were calculated due to the large variation in the definitions, measurements, methodologies, and cut-off points among the studies. The prevalence of anterior crossbite, posterior crossbite, and crossbite with functional shift were 7.8% (SD 6.5), 9.0% (SD 7.34), and 12.2% (SD 7.8), respectively. The prevalence of hypodontia and hyperdontia were reported to be 6.8% (SD 4.2) and 1.8% (SD 1.3), respectively. For impacted teeth, ectopic eruption, and transposition, means of 4.9% (SD 3.7), 5.4% (SD 3.8), and 0.5% (SD 0.5) were found, respectively. Conclusions: There is an urgent need to clearly define orthodontic features and malocclusion traits as well as to reach consensus on the protocols used to quantify them. The large variety in methodological approaches found in the literature makes the data regarding prevalence of malocclusion unreliable.

Keywords: prevalence; malocclusion; orthodontic features; children; adolescents

1. Background

In the 1890s, E. Angle defined normal dental occlusion as follows “the upper and lower molars should be related so that the mesio-buccal cusp of the upper molars occludes in the buccal groove of the lower molars and with the teeth arranged in a smoothly curving line of occlusion” and classified malocclusion in four classes (normal occlusion, Class I, Class II and Class III malocclusion) based on the relationship between the upper and lower first molars.

Furthermore, the World Dental Federation (FDI) states that “malocclusion may affect oral health by increasing the prevalence of dental caries, periodontitis, risk of trauma and...
difficulties in masticating, swallowing, breathing and speaking” and that “orthodontic care has evolved to become an integral part of dentistry helping to prevent oral disease and improve quality of life” [1].

In this context, information regarding the prevalence of malocclusion and the overall need for orthodontic treatment is essential to provide objective information to healthcare stakeholders, to allow for the allocation of healthcare resources based on objective epidemiological data. This information is also crucial for the training of dental and orthodontic healthcare professionals and for the rational planning of all aspects of orthodontic care [2,3].

Despite these facts, large and representative epidemiological studies regarding orthodontic features are hard to find. Proffit et al. argued that the lack of consensus among researchers regarding how much deviation from the ideal should be accepted as normal to be a possible explanation for this [4].

The Third National Health and Nutrition Examination Survey (NHANES III), which was performed in the United States from 1989 to 1994, collected data on the prevalence of malocclusion. A 30% prevalence of Angle “normal occlusion” and a 50–55%, 15%, and <1% prevalence of Angle Class I, II, and III malocclusion were reported, respectively. However, the molar relationship was not examined directly, but rather derived from the overjet measurements, which were claimed to be evaluated more precisely [4,5]. A systematic review on the prevalence of malocclusion in Chinese schoolchildren found 30.1%, 9.9% and 4.8% Angle Class I, II, and III malocclusion, respectively. They also reported deep bite to be the most common malocclusion trait, observed in 16.7% of the sample [6]. Another systematic review reported the prevalence of malocclusion in Iranian children to be 54.6%, 24.7%, and 6.0% for Angle Class I, II, and III, respectively [7]. Knowledge of the prevalence of extensive orthodontic features such as oral clefts, craniofacial syndromes, oligodontia and others is also important in terms of burden of care. According to the World Health Organization (1998), lip, alveolus, and/or palate clefts affect between 1 out of 500 (0.2%) and 1 out of 700 (0.1%) live births in Europe [8].

The aims of this article are firstly to systematically review the existing literature regarding the prevalence of malocclusion and different orthodontic features in children and adolescents and secondly to identify possible inconsistencies in definitions and measurement protocols.

2. Materials and Methods
2.1. Protocol and Registration

The protocol of this systematic review was drafted prior to data collection, and the results are reported according to the PRISMA guidelines (Preferred Reporting Items of Systematic Reviews and Meta-analysis) [9]. The protocol was registered in the international prospective register of systematic reviews (PROSPERO) under protocol registration number CRD42018086464.

2.2. Search Strategy

The digital databases PubMed, Cochrane, Embase, Open Grey, and Web of Science were searched from inception to the 18th of November 2021 by two authors (L.D.R. and M.C.d.L.-P). Specific search strings were developed per database, which were validated by an expert librarian from the Biomedical Library of KU Leuven, Belgium, and are available as supplementary material. Although the search terms ‘cleft lip and/or palate’ and ‘craniofacial syndromes’ were initially included in the search, articles focusing on these patients were kept separately since they are out of the scope of the present review.

2.3. Eligibility Criteria

The inclusion criteria were defined following the PIO format as follows:
Patients: Healthy Subjects ≤ 18 years of age.
Intervention: Assessment of malocclusion and/or dental characteristics.
Outcome: Prevalence and/or incidence of dental malocclusion and dental anomalies,
Epidemiological surveys, randomized controlled trials, clinical trials, and comparative studies were considered. Papers in English, Dutch, French, German, Spanish, and Portuguese were included.

Case reports, conference proceedings, letters to the editors, and unpublished studies as well as studies in other languages than the ones mentioned above and studies involving subjects who had undergone orthodontic treatment were excluded.

2.4. Study Selection

Publications retrieved from the different databases were imported into a reference manager (Mendeley Ltd., London, UK), and duplicates were removed. In a first phase, the titles and abstracts of all of the retrieved articles were screened by two reviewers (L.D.R. and M.C.d.L.-P.). Afterwards, the full texts of the remaining articles were read by three observers (L.D.R., M.C.d.L.-P. and A.A.), who also performed data extraction and scored the risk of bias. Any disagreements that occurred during the first and second selection phase were discussed until consensus was reached.

2.5. Data Collection and Analysis

The following information was extracted from the included studies: the study characteristics (author, publication year, study design, country in which the study was performed, and number of participants), the sample characteristics (type of participant, age, and gender), the type of examination, and a description and assessment of the studied parameters (Angle Class I, Angle Class II,1, Angle Class II,2, Angle Class III, overjet, reversed overjet, open bite, crowding, spacing, crossbite, scissor bite, forced bite (crossbite with lateral or frontal shift), hypodontia, supernumerary teeth, dental anomalies, impacted/retained teeth, ectopic teeth eruption, tooth transposition, and oral habits).

These data were compiled into datasets in Excel files, and—if possible—the weighted means and weighted standard deviations were calculated to consider the prevalence and its standard deviation relative to the number of subjects in the respective studies. Results were afterwards reported in the sagittal, vertical, and transversal dimension in order to offer a more comprehensive explanation.

2.6. Risk of Bias Assessment

The Methodological Index for Non-Randomized Studies (MINORS) from Slim et al., 2003, was used to assess the risk of bias of the included studies [10]. This tool contains 12 items related to comparative studies, the first 8 of which are also applied to non-comparative studies. Each item on the MINORS tool is scored as 0 (not reported), 1 (reported but inadequate), or 2 (reported and adequate), resulting in an ideal total score of 16 for non-comparative studies and 24 for comparative studies.

3. Results

The initial electronic database search identified a total of 6775 articles. After the removal of 2129 duplicates, further title and abstract screening as well as an eligibility assessment resulted in the final inclusion of 123 papers for qualitative analysis. Figure 1 shows the PRISMA flow diagram. The characteristics of the studies population and the methods used in the included studies can be found in Table 1 and will be discussed in the following paragraphs. The exact definitions of all orthodontic terms are available at Proffit et al. [4].
Figure 1. PRISMA flow diagram of the study selection process.
Table 1. Characteristics of and methods used in the included studies.

| Author Year of Publication | Type Study | Population | Subjects | Registration |
|----------------------------|------------|------------|----------|--------------|
|                            |            |            |          |              |
|                            |            |            |          |              |
| Aasheim, 1993 [11]         | ES         | Norway     | Europe   | 1953, 9      | X            | X          | X          | X          | X          | NM         |
| Abu Alhaija, 2005 [12]     | ES         | Jordan     | Saudi    | 1003, 13–15  | X            | X          | X          | X          | ANGLE, BJÖRK |
| Abumelha, 2018 [13]        | CS         | Arabia     | Asia     | 526, 6–12    | X            | X          | X          | ANGLE      |
| Alajlan, 2019 [14]         | CS         | Arabia     | Asia     | 520, 7–12    | X            | X          | X          | ANGLE IOTN |
| Al-Amiri, 2013 [15]        | CS         | USA        | America  | 496, 16 y 3 m * | X          | X          | X          | X          | NM         |
| Alberto, 2006 [16]         | CS         | Italy      | Europe   | 1577, 6–10   | X            | X          | X          | NM         |
| al-Emran, 1990 [17]        | ES         | Saudi      | Arabia   | 500, 13.5–14.5 | X          | X          | X          | BJÖRK      |
| Alkilzy, 2007 [18]         | ES         | Syria      | Asia     | 234, 2–16    | X            | X          | X          | X          | NM         |
| Alsooleihat, 2014 [19]     | CS         | Jordan     | Asia     | 85, 14–18    | X            | X          | X          | NM         |
| Allug-Atac, 2007 [20]      | ES         | Turkey     | Asia     | 3043, 8.5–14.75 | X          | X          | X          | NM         |
| Arabiun, 2014 [21]         | CS         | Iran       | Asia     | 1338, 14–18  | X            | X          | X          | ANGLE IOTN |
| Araki, 2017 [22]           | CS         | Mongolia   | Asia     | 420, 10–16   | X            | X          | X          | NM         |
| Baccetti, 1998 [23]        | CS         | Italy      | Europe   | 5450, 7–14   | X            | X          | X          | NM         |
| Badrov, 2017 [24]          | CS         | Croatia    | Europe   | 4430, 6–15   | X            | X          | X          | NM         |
| Baral, 2014 [25]           | CS         | Nepal      | Asia     | 506, 3–5     | X            | X          | X          | ANGLE, FOSTER & HAMILTON: DAI |
| Baron, 2018 [26]           | CS         | France     | Europe   | 551, 15.23 * | X            | X          | X          | DAI        |
| Baskaradoss, 2013 [27]     | CS         | India      | Asia     | 300, 11–15   | X            | X          | X          | ANGLE      |
| Behbehani, 2005 [28]       | ES         | Kuwait     | Asia     | 1299, 13–14  | X            | X          | X          | ANGLE      |
| Berneburg, 2010 [29]       | CS         | Germany    | Europe   | 2015, 4–6    | X            | X          | X          | DAI        |
| Bhardwaj, 2011 [30]        | CS         | India      | Asia     | 622, 16–17   | X            | X          | X          | ANGLE      |
| Bhayya, 2011 [31]          | CS         | India      | Asia     | 1000, 4–6    | X            | X          | X          | DAI        |
| Bilgic, 2015 [32]          | CS         | Turkey     | Asia     | 2329, 12–16  | X            | X          | X          | ANGLE      |
| Bourzgui, 2012 [33]        | ES         | Morocco    | Africa   | 1000, 8–12   | X            | X          | X          | ANGLE, BJÖRK |
| Calzada Bandomo, 2014 [34] | ES         | Cuba       | America  | 210, 5–11    | X            | X          | X          | ANGLE      |
| Campos-Arias, 2013 [35]    | ES         | Costa Rica | America  | 88, 7.0 *    | X            | X          | X          | ANGLE      |
| Carvalho, 2011 [36]        | CS         | Brazil     | America  | 1069, 5–5 y 11 m | X          | X          | X          | ANGLE, DAI |
| Chauhan, 2013 [37]         | CS         | India      | Asia     | 1188, 9–12   | X            | X          | X          | BJÖRK      |
| Ciuffolo, 2005 [38]        | ES         | Italy      | Europe   | 810, 11–14   | X            | X          | X          | ANGLE      |
| Coetzee, 2000 [39]         | ES         | South Africa | Africa | 214, 3–8     | X            | X          | X          | BJÖRK, FOSTER & HAMILTON: ANGLE |
| Cosma, 2017 [40]           | ES         | Romania    | Europe   | 172, 3–6     | X            | X          | X          | ANGLE      |
| Dacosta, 1999 [41]         | CS         | Nigeria    | Africa   | 1028, 11–18  | X            | X          | X          | ANGLE      |
Table 1. Cont.

| Author Year of Publication | Type Study | Country | Continent | Nr. | Age in Y | Sch. Ch./Ch. | Pat. | Pat. Rec. | Clin. Exam | X-rays | OPT | Study Casts | Photographs | Interv./Quest. | Method |
|----------------------------|------------|---------|-----------|-----|----------|-------------|------|----------|-----------|--------|-----|-------------|------------|--------------|--------|
| Daou, 2019 [42]           | CS         | Lebanon | Asia      | 334 | 7.31 ± 2.17 | X           | X    | X        | X         | X      |     |             |             |               | NM      |
| de Almeida, 2008 [43]     | ES         | Brazil  | America   | 344 | 3.94 *    | X           | X    |          | X         | X      |     |             | FOSTER & HAMILTON |               |        |
| de Araújo Guimarães, 2018 [44] | CS      | Brazil  | America   | 390 | 8–10     | X           | X    |          | X         | X      |     |             | DAI        |               |        |
| de Muniz, 1986 [45]       | ES         | Argentina | America   | 1554 | 12–13   | X           | X    |          | X         | X      |     |             | NM         |               |        |
| Dimberg, 2015 [46]        | LS         | Sweden  | Europe    | 277 | 3, 7 and 11.5 | X           | X    |          | X         | X      |     |             | ANGLE      |               |        |
| Endo, 2006 [47]           | ES         | Japan   | Asia      | 3358 | 5–15    | X           | X    |          | X         | X      |     |             | NM         |               |        |
| Esa, 2001 [48]            | ES         | Malaysia | Asia      | 1519 | 12–13   | X           | X    |          | X         | X      |     |             | DAI        |               |        |
| Eserlik, 2009 [49]        | ES         | Turkey  | Asia      | 2599 | 6–16    | X           | X    |          | X         | X      |     |             | NM         |               |        |
| Fernandes, 2008 [50]      | ES         | Brazil  | America   | 148  | 3–6     | X           | X    |          | X         | X      |     |             | ANGLE      |               |        |
| Ferro, 2016 [51]          | CS         | Italy   | Europe    | 380  | 14      | X           | X    |          | X         | X      |     |             | IOTN       |               |        |
| Ferro, 2016 [52]          | CS         | Italy   | Europe    | 1960 | 3–5     | X           | X    |          | X         | X      |     |             | ANGLE      |               |        |
| Frazao, 2006 [53]         | ES         | Brazil  | America   | 13,801 | 12 and 18 | X           | X    |          | X         | X      |     |             | DAI        |               |        |
| Gábbris, 2006 [54]        | ES         | Hungary | Europe    | 483  | 16–18   | X           | X    |          | X         | X      |     |             | ANGLE, DAI |               |        |
| Gois, 2012 [55]           | LS         | Brazil  | America   | 212  | 8–11    | X           | X    |          | X         | X      |     |             | ANGLE, DAI |               |        |
| Grabowski, 2007 [56]      | CS         | Germany | Europe    | 3041 | 4.5 * and 8.2 * | X           | X    |          | X         | X      |     |             | ANGLE      |               |        |
| Gracco, 2017 [57]         | CS         | Italy   | Europe    | 4006 | 9–16    | X           | X    |          | X         | X      |     |             | NM         |               |        |
| Gudipaneni, 2018 [58]     | ES         | Saudi   | Arabia    | 500  | 7–12    | X           | X    |          | X         | X      |     |             | ANGLE, IOTN |               |        |
| Gutierrez Marin, 2019 [59] | ES         | Costa Rica | America  | 157  | 6–12    | X           | X    |          | X         | X      |     |             | NM         |               |        |
| Harris, 2008 [60]         | RS         | USA     | America   | 1700 | 12–18   | X           | X    |          | X         | X      |     |             | NM         |               |        |
| Harris, 2008 [61]         | RS         | USA     | America   | 1700 | 12–18   | X           | X    |          | X         | X      |     |             | NM         |               |        |
| Hassanali, 1993 [62]      | ES         | Kenya   | Africa    | 412  | 3–16    | X           | X    |          | X         | X      |     |             | ANGLE      |               |        |
| Howell, 1993 [63]         | ES         | Australia | Oceania | 154  | 13–17   | X           | X    |          | X         | X      |     |             | IOTN       | FOSTER & HAMILTON |        |
| Ingervall, 1975 [64]      | ES         | Finland | Europe    | 200  | 8–16    | X           | X    |          | X         | X      |     |             | ANGLE      |               |        |
| Jamilian, 2010 [65]       | ES         | Iran    | Asia      | 350  | 14–17   | X           | X    |          | X         | X      |     |             | ANGLE      |               |        |
| Jerez 2014 [66]           | CS         | Venezuela | America | 120  | 3–6     | X           | X    |          | X         | X      |     |             | BJÖRK     |               |        |
| Johanssdottir, 1997 [67]  | ES         | Iceland | Europe    | 396  | 6       | X           | X    |          | X         | X      |     |             | DAI        |               |        |
| Johnson, 2000 [68]        | ES         | New Zealand | Oceania | 294  | 9.9–11.3 | X           | X    |          | X         | X      |     |             | FOSTER & BJÖRK |               |        |
| Kabue, 1995 [69]          | ES         | Kenya   | Africa    | 221  | 3–6     | X           | X    |          | X         | X      |     |             | ANGLE, IOTN | ANGLE, FOSTER & HAMILTON |        |
| Kalbassi, 2019 [70]       | RS         | Iran    | Asia      | 1208 | 7–15    | X           | X    |          | X         | X      |     |             | ANGLE      |               |        |
| Kasparviciene, 2014 [71]  | CS         | Lithuania | Europe    | 709  | 5–7     | X           | X    |          | X         | X      |     |             | ANGLE      |               |        |
| Author Year of Publication | Type Study | Population | Subjects | Registration |
|-----------------------------|------------|------------|----------|--------------|
| Kielan-Grabowska, 2019 [72] | CS, Poland | Europe | 674 | 6–15 | X | X | X |
| Kolawole, 2019 [73] | CS, Nigeria | Africa | 992 | 1–12 | X | X | DAI |
| Komazaki, 2012 [74] | CS, Japan | Asia | 963 | 12–15 | X | X | ANGLE, IOTN |
| Lagana, 2013 [75] | CS, Albania | Europe | 2617 | 7–15 | X | X | ANGLE, IOTN |
| Lagana, 2017 [76] | CS, Italy | Europe | 4706 | 8–12 | X | X | NM |
| Lara, 2013 [77] | CS, Brazil | America | 1995 | 4–13 | X | X | NM |
| Lux, 2009 [78] | ES, Germany | Europe | 494 | 8–9.6 | X | X | ANGLE, BJÖRK |
| Madiraju, 2021 [79] | CS, Saudi Arabia | Asia | 282 | 8–9 | X | X | ANGLE, IOTN |
| Mail, 2015 [80] | CS, Brazil | America | 50 | 12 | X | X | DAI |
| Martins, 2009 [81] | CS, Brazil | America | 264 | 10–12 | X | X | ANGLE |
| Martins, 2019 [82] | ES, Brazil | America | 1612 | 11–14 | X | X | DAI |
| Medina, 2012 [83] | ES, Venezuela | America | 607 | 5–11 | X | X | X | ANGLE |
| Mohamed, 2014 [84] | CS, Malaysia | Asia | 106 | 8–10 | X | X | ANGLE, IOTN |
| Muya, 2009 [85] | ES, Tanzania | Africa | 1601 | 12–14 | X | X | ANGLE, BJÖRK |
| Muya, 2017 [86] | CS, Tanzania | Africa | 253 | 3–5 | X | X | ANGLE, BJÖRK |
| Murshid, 2010 [87] | CS, Saudi Arabia | Asia | 1024 | 13–15 | X | X | ANGLE, BJÖRK |
| Muyasa, 2012 [88] | CS, Kenya | Africa | 1382 | 12–15 | X | X | DAI |
| Ng’ang’a, 1991 [89] | ES, Kenya | Africa | 251 | 13–15 | X | X | ANGLE, BJÖRK |
| Ng’ang’a, 1996 [90] | ES, Kenya | Africa | 919 | 13–15 | X | X | ANGLE, BJÖRK |
| Ng’ang’a, 2001 [91] | ES, Kenya | Africa | 615 | 8–15 | X | X | ANGLE, BJÖRK |
| Nguyen, 2014 [92] | CS, Vietnam | Asia | 200 | 12 and 18 | X | X | ANGLE, IOTN |
| O’Dowling, 1989 [93] | ES, Ireland | Europe | 3056 | 7–17 | X | X | ANGLE, IOTN |
| O’Dowling, 1990 [94] | ES, Ireland | Europe | 3056 | 7–17 | X | X | ANGLE, IOTN |
| Onyeso, 2004 [95] | ES, Nigeria | Africa | 636 | 12–17 | X | X | ANGLE |
| Oshagh, 2010 [96] | CS, Iran | Asia | 700 | 0–14 | X | X | ANGLE |
| Pagan-Collazo, 2014 [97] | CS, Puerto Rico | America | 1911 | 10–14 | X | X | ANGLE |
| Perillo, 2010 [98] | ES, Italy | Europe | 703 | 12.2 | X | X | ANGLE |
| Perinetti, 2008 [99] | ES, Italy | Europe | 1198 | 7–11 | X | X | ANGLE |
| Pineda, 2011 [100] | CS, Chili | America | 307 | 6–11 | X | X | ANGLE |
| Rapeepattana, 2019 [101] | CS, Thailand | Asia | 202 | 8–9 | X | X | ANGLE, IOTN |
| Rauten, 2016 [102] | ES, Romania | Europe | 147 | 6 and 9 | X | X | ANGLE, IOTN |
| Robke, 2007 [103] | ES, Germany | Europe | 434 | 2–6 | X | X | ANGLE, IOTN |
| Reiling, 1980 [104] | ES, Denmark | Europe | 3325 | 9–10 | X | X | ANGLE |
| Rozsa, 2009 [105] | ES, Hungary | Europe | 4417 | 6–18 | X | X | ANGLE |
| Rwakatema, 2007 [106] | CS, Tanzania | Africa | 289 | 12–15 | X | X | ANGLE |
| Sanadhy, 2014 [107] | CS, India | Asia | 947 | 12–15 | X | X | ANGLE |
Table 1. Cont.

| Author Year of Publication | Type Study | Population | Subjects | Registration |
|----------------------------|------------|------------|----------|--------------|
| Sánchez-Pérez, 2013 [108]  | CS         | Mexico     | 249      | X           | X            | X          | X          | DAI         |
| Seemann, 2011 [109]        | CS         | Germany    | 2975     | 4 and 7.8 * | X           | X          | X          | NM          |
| Sejdini, 2018 [110]        | CS         | Macedonia  | 520      | 7–14        | X           | X          | X          | NM          |
| Sepp, 2017 [111]           | CS         | Estonia    | 392      | 7.1–10.4    | X           | X          | X          | ANGLE, ICON |
| Sepp, 2019 [112]           | CS         | Estonia    | 390      | 4–5         | X           | X          | X          | ANGLE, FOSTER & HAMILTON |
| Shalish, 2013 [113]        | ES         | Israel     | 432      | 7–11        | X           | X          | X          | NM          |
| Singh, 2011 [114]          | ES         | India      | 927      | 12          | X           | X          | X          | DAI         |
| Sola, 2018 [115]           | CS         | Spain      | 2500     | 7–11        | X           | X          | X          | NM          |
| Sonnesen, 1998 [116]       | CS         | Denmark    | 104      | 7–13        | X           | X          | X          | ANGLE       |
| Stahl, 2003 [117]          | CS         | Germany    | 8864     | 2–10        | X           | X          | X          | ANGLE       |
| Stahl, 2003 [118]          | ES         | Germany    | 4208     | 6.7–13.4    | X           | X          | X          | NM          |
| Steinmassl, 2017 [119]     | ES         | Austria    | 157      | 8–10        | X           | X          | X          | ANGLE, IOTN |
| Sundareswaran, 2019 [120]  | CS         | India      | 1554     | 13–15       | X           | X          | X          | ANGLE, BJORK |
| Sunil, 2019 [121]          | ES         | Malaysia   | 100      | 13–17       | X           | X          | X          | ANGLE       |
| Swarnalatha, 2020 [122]    | CS         | India      | 1000     | 12–18       | X           | X          | X          | ANGLE, IOTN |
| Tausche, 2004 [123]        | CS         | Germany    | 1975     | 6–8         | X           | X          | X          | ANGLE, BJORK |
| Thilander, 2001 [124]      | ES         | Colombia   | 4724     | 5–17        | X           | X          | X          | ANGLE       |
| Thomaz, 2013 [125]         | CS         | Brazil     | 2060     | 12–15       | X           | X          | X          | ANGLE       |
| Todor, 2019 [126]          | CS         | Romania    | 960      | 7–14        | X           | X          | X          | ANGLEBJORK  |
| Uematsu, 2012 [127]        | ES         | Japan      | 2378     | 12–13 & 15–16 | X          | X          | X          | NM          |
| Varela, 2009 [128]         | ES         | Spain      | 2108     | 7–16        | X           | X          | X          | NM          |
| Vithanaarachchi, 2017 [129]| CS         | Sri Lanka  | 721      | 8–15        | X           | X          | X          | NM          |
| Wagner, 2015 [130]         | CS         | Germany    | 377      | 3           | X           | X          | X          | NM          |
| Yassin, 2016 [131]         | CS         | Saudi Arabia | 1252  | 5–12        | X           | X          | X          | NM          |
| Yu, 2019 [132]             | CS         | China      | 2810     | 7–9         | X           | X          | X          | ANGLE       |
| Zhou, 2017 [133]           | CS         | China      | 2335     | 3–5         | X           | X          | X          | ANGLE       |

Legend: Characteristics of the included articles are provided in Table 1. Age: Age range, but if no age range was found, the mean age was noted; * Mean, if standard deviation (SD) is not mentioned in article. Abbreviations: ES: epidemiological survey; CS: cross-sectional study; LS: longitudinal study; Nr.: number of subjects; Age in Y: age range in years; Sch. Ch./Ch.: schoolchildren/children; Pat.: patients; Pat. rec.: patient records; Clin. Exam.: clinical examination; OPT: orthopantomogram; Interv.: interviews; Quest.: questionnaires; Method reg.: method of registration; NM: Not mentioned; IOTN: Index of Orthodontic Treatment Need; DAI: Dental Aesthetic Index; ICON: Index of Complexity, Outcome and Need; ANGLE: Angle classification; BJORK: Björk's method; FOSTER AND HAMILTON: method for occlusion in primary dentition.
3.1. Characteristics of the Studied Population

The characteristics of the 123 included articles can be found in Table 1. Most of the studies were performed in a sample of children or schoolchildren (89/123): 9 involved patients and 23 patient records, 1 article included both patients and patient records, and 1 included schoolchildren and patient records. Most of the studies were performed in Europe (42/123), followed by Asia (41/123), America (24/123), Africa (14/123), and Oceania (2/123). X articles did not mention sex distribution. A total of 58 articles found no statistically significant differences in prevalence of malocclusion types between females and males [11–13,15,18,21,22,28,29,31,33,35,37,42,44,46,47,49–52,55–57,59,61,67,69,70,72,73, 77,79,81,83,85,86,88,94–96,98–100,106,110,111,113,115,119,122,125,128–133].

3.2. Methods Used in the Included Studies

The methods used in the included articles can also be found in Table 1. Clinical examinations (94/123), X-rays (39/123), study casts (20/123), intra- and extra-oral photographs (6/123), and interviews or questionnaires (12/123) were the most frequently used diagnostic methods. To assess malocclusion and orthodontic features, the method of Björk (15/123) or the Angle Classification (15/123), the Index of Orthodontic Treatment Need (16/123), or the Dental Aesthetic index (18/123) were explicitly used. However, the vast majority of the included studies used a non-validated method that was specific to the study.

3.3. Prevalence of Malocclusion

3.3.1. Sagittal Occlusion

The terminal plane of the deciduous molar was assessed in 10 of the included studies. A flush terminal plane was found in 41.7 ± 15.2% of the included studies (range 18.2–84.3%); a distal step was found in 12.4 ± 8.1% (range 0.0–33.6%), and a mesial step in 38.5 ± 10.7% (range 6.0–65.9%).

Regarding the permanent molar, 52 studies reported Angle class occlusion. The mean prevalence for Angle Class I “normal occlusion” was 46.3 ± 27.3% (range 1.7–93.6%); for Class I malocclusion, it was 46.5 ± 17.0% (range 7.4–84.0%); for Class II malocclusion, it was 25.0 ± 13.2% (range 0.8–72.1%); for Class II,1 malocclusion, it was 16.7 ± 12.7% (range 1.7–40.0%); for Class II,2 malocclusion, it was 4.7 ± 2.4% (range 1.4–13.2%); and for Class III malocclusion, it was 7.0 ± 7.9% (range 0.5–39.1%). Large variation was observed in the definitions, measurements, and prevalence of overjet and reverse overjet, which can be found in Table 2.

3.3.2. Vertical Occlusion

The prevalence of overbite and open bite varied considerably, as seen in Table 2.
Table 2. Prevalence of overjet, reversed overjet, overbite, and open bite.

| First Author, Year | Subjects | Age Range (Total Sample) | Overjet | Reversed Overjet (Mandibular Overjet) | Overbite | Open Bite | Anterior Open Bite | Posterior Open Bite |
|--------------------|----------|--------------------------|---------|----------------------------------------|----------|-----------|-------------------|---------------------|
| Abu Alhaija, 2005 [12] | 1003 | 13–15 | 4–6 mm: 21.7% >6 mm: 3% | 1.9% | 4–6 mm: 15.9% >6 mm: 1% | 4–6 mm: 1.9% >6 mm: 1.0% |
| Alajlan, 2019 [14] | 520 | 7–12 | <2 mm: 5% 2–4 mm: 71.2% >4 mm: 14.4% edge-edge: 4.2% | 5.2% | 2–4 mm: 83.8% >4–7 mm: 11% >8 mm: 5.2% | 7.7% | 0.6% |
| al-Emran, 1990 [17] | 500 | 13.5–14.5 | 0–1.9 mm: 2.6% >2 mm: 0.6% | 5.2% | 2–4 mm: 91.7% >4–7 mm: 7% >8 mm: 1.5% | 0–1.9 mm: 3.6% >2 mm: 3% |
| Arabiun, 2014 [21] | 1338 | 14–18 | 0–2 mm: 73.0% >2 mm: 27.0% | 1.1% | 0–2 mm: 73.0% >2 mm: 27.0% | 1.0% |
| Bilgic, 2015 [32] | 2329 | 12–16 | 0–4 mm: 73.5% >4 mm: 23.1% | 1.0% | 0–4 mm: 73.5% >4 mm: 23.1% | 1.0% | 8.2% |
Table 2. Cont.

| First Author, Year   | Subjects | Age Range (Total Sample) | Overjet | Reversed Overjet (Mandibular Overjet) | Overbite | Open Bite | Anterior Open Bite | Posterior Open Bite |
|----------------------|----------|--------------------------|---------|---------------------------------------|----------|-----------|-------------------|------------------|
| **Total Number and Groups if Available** | **Age Range, and If no Range, Mean Age ± SD** |
| **Bourzgui, 2012 [33]** | 1000     | 8–12                     | 0 mm: 5.9% | 1–4 mm: 63.9% | 4–6 mm: 17.2% | >6 mm: 10% | 0 mm: 7.1% | 1–4 mm: 65.4% | 4–6 mm: 16.6% | >6 mm: 7% | Indefinite 3.9% | 0 mm: 97.1% | <3 mm: 1.7% | >3 mm: 1.2% |
| **Calzada Bandomo, 2014 [34]** | 210      | 5–11                     | >9 mm: M: 29.1%–F: 27% | increased (no mm): M: 22.7%–F: 15% | M: 6.4%–F: 13% |
| **Carvalho, 2011 [36]** | 1069     | 5–5 Y11M                 | >2 mm: 10.5% | >2 mm: 19.7% | 7.9% |
| **Chauhan, 2013 [37]** | 1188     | 9–12                     | 0–2 mm: 63.7% | >2 mm: 36.3% | ≥1 mm: 1.3% | ≥1 mm: 0.8% |
| **Ciuffolo, 2005 [38]** | 810      | 11–14                    | >3 mm: 19.1% | >5 mm: 6.5% | negative OJ: 1.1% | >3 mm: 41% | >5 mm: 9.6% |
| **Coetzee, 2000 [39]** | 214      | 3–8                      | mean overjet 2.71 mm | 1.9% | deep-3/10 overlap: 18.7% | edge to edge: 18.7% | 10.3% |
| **Cosma, 2017 [40]** | 172      | 3–6                      | OJ > 4 mm: 14% | Abnormal OB: 9% (not defined) | 11.0% |
| **Dacosta, 1999 [41]** | 1028     | 11–18                    | <2 mm: F: 20.4%–M: 17.1% | 2–4 mm: F: 69.7%–M: 72.1% | 5–8 mm: F: 7.5%–M: 7.6% | 8–12 mm: F: 0.4%–M: 0.8% | 12 mm: F: 0%–M: 0.2% | F: 2%–M: 2.1% | F: 1/3 overlap: F: 72.4%–M: 66.1% | >1/3 overlap but does not exceed middle 1/3 of crown: F: 18.9%–M: 26.0% | >overlap middle 1/3 of crown: F: 1.8%–M: 1.5% | F: 4.8%–M: 4.3% |
| **de Almeida, 2008 [43]** | 344      | 3.94 *                   | >3 mm: 16% | >3 mm: 7% | 27.9% |
| **de Araújo Guimarães, 2018 [44]** | 390      | 8–10                     | ≥4 mm: 15.6% | ≥2 mm: 3.1% |
Table 2. Cont.

| First Author, Year | Subjects | Age Range (Total Sample) | Overjet | Reversed Overjet (Mandibular Overjet) | Overbite | Open Bite | Anterior Open Bite | Posterior Open Bite |
|-------------------|---------|--------------------------|---------|--------------------------------------|----------|-----------|------------------|---------------------|
|                   | Total Number and Groups if Available | Age Range, and If no Range, Mean Age ± SD |         | 2/3 overlap: |      | A: 2.1%, B: 1.9% |
| de Muniz, 1986 [45] | 1554 | 12–13 | ≥6 mm | A: 9.9%, B: 2.9% | ≥9 mm A:4.2% B: 2.4% | ≥2/3 overlap: A: 8.1% B: 3.8% | 3/3 overlap: A-3.5%, B-2% |
| Dimberg, 2015 [46] | 3 Y: 457 7 Y: 386 11.5 Y: 277 | 3 to 7 to 11.5 | 4–6 mm: 3 Y: 21.1%, 7 Y: 12.3%, 11.5 Y: 14.8% | >6 mm: 3 Y: 2.9%, 7 Y: 3.7%, 11.5 Y: 6.5% | >2/3: 3 Y: 5.8%, 7 Y: 2.6%, 11.5 Y: 18.4% | complete with gingival trauma: 2.2% (only 11.5 Y) | 3 Y: 54.9%, 7 Y: 9.6%, 11.5 Y: 0.4% |
| Esa, 2001 [48] | 1519 | 12–13 | >4 mm: 41.5% | <0 mm: 3.1% | ≥3 mm: 34.1% | 2.0% |
| Fernandes, 2008 [50] | 148 | 3–6 | ≥4 mm: 33.1% | 35.1% |
| Ferro, 2016 [51] | 380 | 14 | >3 mm: 48% | >5 mm: 15% | >3 mm: 39% | >5 mm: 9% | 1.4% |
| Frazao, 2006 [53] | 13,801 | 12 and 18 | ≥4 mm: A-28.9%–B-21.1% | <0 mm: A-2%–B-2.2% | A-9.2%–B-8.6% |
| Gabris, 2006 [54] | 483 | 16–18 | Ant. max. OJ: 60.8% | Ant. mand. OJ: 1.8% | deep bite: 26.1% | 10.8% |
| Gois, 2012 [55] | 212 | 8–11 | 1–3 mm: 63.7% | 1–3 mm: 19.3% | 1–3 mm: 52.4% | >3 mm: 28.3% |
| Grabowski, 2007 [56] | 3041 | 4.5 and 8.3 | >4–6 mm: A: 9.6%–B: 12% | >6 mm: A: 3.2%–B: 4.2% | >2 mm: A: 33.2%–B: 46.8% | A: 11.4%–B: 9.5% |
| Gudipaneni, 2018 [58] | 500 | 7–12 | >2 mm: 22.2% | <1 mm: 11.4% | >2 mm: 23.4% | <1 mm: 12.2% | 4.6% |
| Hassanali, 1993 [62] | 412 A: Maasai 235 B: Kikuyu 116 C: Kalejin 61 | 3–16 | 0.5–11.5 mm: A: 84.3% B: 99.1% C: 85.2% | 0.5–9.9 mm: A: 78.6% B: 9.3% C: 59.0% | 0.5–8.5 mm: A: 18.3% B: 9.3% C: 24.6% |
Table 2. Cont.

| First Author, Year | Subjects | Age Range (Total Sample) | Overjet | Reversed Overjet (Mandibular Overjet) | Overbite | Open Bite | Anterior Open Bite | Posterior Open Bite |
|--------------------|----------|--------------------------|---------|---------------------------------------|----------|-----------|-------------------|---------------------|
| Howell, 1993 [63]  | 154      | 13–17                    |         | 10–50%: 61%                          |          |           |                   |                     |
| Ingervall, 1975 [64] | 200     | 8–16                     | 6–9 mm: 7% | 0–(-2) mm: 1.5%                     | 5 < 7 mm: 15% | ≥7 mm: 2% |                   |                     |
| Jamilian, 2010 [65] | 350      | 14–17                    | >9 mm: 3.1% | >–3.5 mm: 2.3%                       | 7.7%     |           |                   |                     |
| Jerez, 2014 [66]   | 120      | 3–6                      | >9 mm: 47.1% | 3.9%                                 | 39.2%    |           |                   |                     |
| Johnson, 2000 [68] | 294      | 9.9–11.3                 | >6 mm: 17% | ≥1 mm: 3.4%                          |          |           |                   |                     |
| Kabue, 1995 [69]   | 221      | 3–6                      | 13%      |                                      | deep: 13% |           |                   |                     |
| Kalbassi, 2019 [70]| 1208     | 7–15                     | increased: 20.1% | 9.8%                                 | >4 mm: 17.8% |          |                   |                     |
| Kasparviciene, 2014 [71] | 709 | 5–7                     | edge–edge: 9.3% | 0–2 mm: 40.8% | <0 mm: 3.8% | edge–edge: 9% | 1–3 mm: 57.4% | >3 mm: 31.0% | 2.6% | 3.0% |
| Komazaki, 2012 [74] | 963 | 12–15                   | >6 mm: 9.8% | <-1 mm: 1.2%                         | >5 mm: 8.9% | <-4 mm: 0.5% |                   |                     |
| Lux, 2009 [78]     | 494 M: 237 F: 257 | 8.6–9.6                 | 2–3 mm: 3–4 mm: 6–9 mm: M: 23.4–F: 22.8% | 6–9 mm: M: 6%–F: 4.7% | 3–4 mm: M: 24.7–F: 29.1% | 4–5 mm: M: 20.9–F: 16.5% | 5–6 mm: M: 10.6–F: 3.1% | 6–7 mm: M: 0.9–F: 0.8% | >7 mm: M: 2.1–F: 1.2% | 3.0%–F: 4.3% |
| Madiraju, 2021 [79] | >3.5 mm: 28.4% | >2/3 overlap: 16.3% | >2 mm: 98% | 6.0% | 4.0% | 6.0% |
| Mail, 2015 [80]    | 50       | 12                       | >2 mm: 98% | 6.0% |           |                   |                     |
| Martins, 2009 [81] | 264      | 10–12                    | 0.1–2 mm: 3.4% | 2–3 mm: 33.7% | >3 mm: 50% | edge–edge: 3.8% | 0.1–2 mm: 19.7% | 2–3 mm: 30.3% | >3 mm: 36.7% | edge–edge: 4.2% | 9.1% | 0.6% |
| First Author, Year | Subjects | Age Range (Total Sample) | Overjet | Overbite | Open Bite | Anterior Open Bite | Posterior Open Bite |
|--------------------|----------|--------------------------|---------|----------|-----------|------------------|---------------------|
| **Total Number and Groups if Available** | **Age Range, and If no Range, Mean Age ± SD** | | | | | | |
| Martins, 2019 [82] | 1612 | 11–14 | ≤4 mm: 94.8% >4 mm: 5.2% | 4.9% | | | ≤2 mm: 99.2% >2 mm: 0.7% |
| Mohamed, 2014 [84] | 106 | 8–10 | >6 mm: 17.8% total increased: 42.5% | 4.7% | increased: 55.7% palatal trauma: 0.9% | | 0.9% |
| Mtaya, 2009 [85] | 1601 | 12–14 | 1–4.9 mm: 73.3% 5–8.9 mm: 11.1% ≥9 mm: 0.4% | 0–1.9 mm: 8.2% ≥2 mm: 0.2% | 0.1–2.9 mm: 65.9% 3–4.9 mm: 17.9% ≥5 mm: 0.9% | | 0–1.9 mm: 8.9% ≥2 mm: 6.1%; |
| Mtaya, 2017 [86] | 253 | 3–5 | 1–4.9 mm: 65.6% 5–8.9 mm: 1.2% <0–1.9 mm: 5.5% | 0.1–2.9 mm: 60.9% 3–4.9 mm: 6.3% 0–1.9 mm: 15.8% ≥2 mm: 2.8% |
| Murshid, 2010 [87] | 1024 | 13–15 | 4–6 mm: 24% >6 mm: 5% | 4–6 mm: 27% >6 mm: 13% |
| Muyasa, 2012 [88] | 1382 | 12–15 | ≥4 mm: 36.4% | | | 14.0% |
| Ng’ang’a, 1991 [89] | 251 | 13–15 | >4 mm: 23.1% | >2/3 overlap: 7.6% | | | 9.6% |
| Ng’ang’a, 1996 [90] | 919 | 13–15 | ≥6 mm: 10% | 0.0% | ≥5 mm: 7% | | | 8.0% |
| Nguyen, 2014 [91] | 200 | 12 and 18 | >3.5 mm: 36.3% | | | >3.5 mm: 26.3% |
| Onyeaso, 2004 [94] | 636 | 12–17 | >3 mm: 15.7% | | >middle third: 14.1% | | 7.1% |
| Oshagh, 2010 [96] | 700 | 0–14 | large: 30% | 18.0% | deep bite: 53% | | | 11.0% |
| Perillo, 2010 [98] | 703 | 12.2 ± 0.6 | >4 mm: 16.2% 0–4 mm: 83.2% <0 mm: 0.6% | >4 mm: 20.2% 0–4 mm: 79.2% | | | 0.7% |
| Perinetti, 2008 [99] | 1198 | 7–11 | >3 mm: 45% | | >middle third: 38.1% | | | |
| Pineda, 2011 [100] | 307 | 6–11 | >6 mm: 18.9% | | with gingival/palatal trauma: 11.6% | | | 1.7% |
Table 2. Cont.

| First Author, Year | Subjects | Age Range (Total Sample) | Overjet | Reversed Overjet (Mandibular Overjet) | Overbite | Open Bite | Anterior Open Bite | Posterior Open Bite |
|--------------------|----------|--------------------------|---------|---------------------------------------|----------|-----------|-------------------|---------------------|
| Rapeepattana, 2019 [101] | 202 | 8–9 | 0–3.5 mm: 46.7% 3.5–6 mm with comp lips: 40.5% 3.5–6 mm with incomp.lips: 2.6% 6.0–9.0 mm: 3.1% >9 mm: 1.5% | 5.6% | 0–3.5 mm: 50.3% >3.5 mm without gingival contact: 20.5% >3.5 mm with gingival contact: 21.0% >3.5 mm with gingival trauma: 6.7% | 1.5% |
| Rauten, 2016 [102] | 147 A (6 Y): 69 B: (9 Y): 78 | 6 and 9 | >3 mm: A: 10.1%–B: 55.1% | >1/3 overlap: A: 7.2%–B: 47.4% | A: 17.39%–B: 11.53% |
| Rokke, 2007 [103] | 434 | 2–6 | >3 mm: 30.6% | 2.3% | >3 mm: 16.1% | 14.7% |
| Rwakatema, 2007 [106] | 289 | 12–15 | >4 mm: 12.1% | >0 mm: 0.3% | 6.2% |
| Sanadhya, 2014 [107] | 947 | 12–15 | 0 mm: 1.4% 1 mm: 36.1% 2–3 mm: 49% ≥4 mm: 12.7% | 0 mm: 97.9% ≥1 mm: 2.1% | 0 mm: 97.7% ≥1 mm: 2.3% |
| Sánchez-Pérez, 2013 [108] | 249 | 15 | >2 mm: 39% | 0.3% | 4.5% |
| Sepp, 2017 [111] | 392 | 7.1–10.4 | ≥3.5 mm: 37.5% | 1.0% | ≥3.5 mm: 51.8% |
| Sepp, 2019 [112] | 390 | 4–5 | ≥3.5 mm: 15.6% | 2.3% | ≥3.5 mm: 38.7% | 3.1% |
| Shalish, 2013 [113] | 432 | 7–11 | ≥7 mm: 3.7% | 5.2% (impinging) | 6.5% |
| Singh, 2011 [114] | 927 | 12 | 0–2 mm: 88.3% >2 mm: 11.7% | 0–2 mm: 97.8% >2 mm: 2.1% | 0 mm: 98.2% ≥1 mm: 1.8% |
| Sonnesen, 1998 [116] | 104 | 7–13 | ≥6 mm: 36.5% | 1.9% | ≥5 mm: 30.8% | 3.8% |
| Stahl, 2003 [117] | 8864 A: Deciduous dentition B: Mixed dentition | 2 > 10 | A ≥3 mm: 16.8% B >4 mm: 13.8% A: 1.1% B: 1.2% ≥middle third A: 1.1% B: 1.2% A: 6.7% B: 2.8% |
Table 2. Cont.

| First Author, Year | Subjects | Age Range (Total Sample) | Overjet | Reversed Overjet (Mandibular Overjet) | Overbite | Open Bite | Anterior Open Bite | Posterior Open Bite |
|--------------------|----------|--------------------------|---------|-------------------------------------|----------|-----------|-------------------|---------------------|
| **Total Number and Groups if Available** | Age Range, and If no Range, Mean Age ± SD | | | | | | | |
| Steinmassl, 2017 [119] | 157 | 8–10 | 1 mm: 7.0% 2 mm: 15.9% 3 mm: 27.4% 4 mm: 19.1% 5 mm: 15.9% 6 mm: 9.6% 7 mm: 1.9% 10 mm: 0.6% | 0 mm: 0.6% -0.6% | 0 mm: 1.9% 1 mm: 4.5% 2 mm: 15.3% 3 mm: 27.4% 4 mm: 22.3% 5 mm: 17.8% 6 mm: 8.3% 7 mm: 2.6% | |
| Sundareswaran, 2019 [120] | 1554 | 13–15 | >3 mm: 11.8% edge-edge: 5.5% | 1.6% | >1/2 overlap: 27.5% | 1.6% | |
| Sunil, 2019 [121] | 100 | 13–17 | >3 mm: 26% | | >2 mm: 17% | |
| Tausche, 2004 [123] | 1975 | 6–8 | >0 ≤ 3.5 mm: 60.2% >3.5 ≤ 6 mm: 25.3% >6 ≤ 9 mm: 5.0% >9 mm: 1.1% | <0 ≥ -1 mm: 0.5% | <3.5 mm: 53.8% ≥3.5 mm without gingival contact: 15.8% complete without trauma: 15.9% complete with trauma: 14.5% | NONE: 82.3% 1–3 mm: 14.9% 4–6 mm: 2.4% >6 mm: 0.4% | |
| Thilander, 2001 [124] | 4724 | 5–17 | >4 mm: 25.8% | 5.8% | >4 mm: 21.6% | 9.0% | |
| Todor, 2019 [126] | 960 | 7–14 | >1/3 overlap/28.7% | | | 7.9% | |
| Uematsu, 2012 [127] | 2378 A: 12–13 B: 15–16 12–13 15–16 | >6 mm: A: 9.4%–B: 7.8% | | deep: A: 8.4%–B: 5.8% | | A: 0.6%–B: 1.2% | |
| Wagner, 2015 [130] | 377 | 3 | ≥3 mm: 41.2% | | | | 10.9% | |
| Yu, 2019 [132] | 2810 | 7–9 | >3 ≤ 5 mm: 23.5% >5 ≤ 8 mm: 12.1% >8 mm: 5.2% | >2/3 overlap: 6.2% | | | 4.3% | |
| Zhou, 2017 [133] | 2335 | 3–5 | >3 ≤ 5 mm: 26% >5 ≤ 8 mm: 6.9% >8 mm: 0.9% | >1/2 ≤ 3/4: 22.3% >3/4 < 1: 26.2% | | | | |

Legend: Prevalence of overjet, reversed overjet, overbite, and open bite are noted as in the included article. Y: age range is noted, but if not available, the mean ± SD are noted and * if SD not mentioned in article. Only mandatory if the groups mentioned are under subjects. Abbreviations: Y: years, SD: standard deviation, Yyears, M: months, ant.: anterior, max.: maxillary, mand.: mandibular, incomp.: incompetent.
3.3.3. Transversal Occlusion

The type of crossbite was not specified in 12 studies, and 58 investigated at least one type of crossbite. The mean prevalence of a non-specified crossbite in the studied populations was $6.2 \pm 7.8\%$ (range 1.0–36.0%). Additionally, $7.6 \pm 6.0\%$ presented a posterior crossbite (range 0.3–32.0%), $8.3 \pm 2.9\%$ (range 4.0–13.5%) presented a unilateral crossbite, and $2.5 \pm 1.8\%$ (range 0.0–6.5%) presented a bilateral crossbite. Nine studies dealt with the prevalence of scissor bite, reporting a weighted mean prevalence of $2.2 \pm 3.4\%$ (range 0.0–14.3%). The presence of a forced bite (crossbite with lateral or frontal shift) was assessed in nine studies and was found in $13.7 \pm 7.7\%$ of the included population (range 1.1–22.5%).

3.3.4. Tooth Anomalies

Hypodontia (wisdom teeth excluded) was reported in 44 articles, with a mean reported prevalence of $6.5 \pm 4.2\%$ (range: 0.0–18.6%). Hyperdontia was reported with a mean prevalence of $2.1 \pm 1.2\%$ (range: 0.2–4.5%) in 19 studies, and mesiodens showed a weighted mean prevalence of $1.3 \pm 0.5\%$ (range: 0.3–4.6%). In all of these studies, X-rays were taken. The prevalence of hypo-hyperdontia—the simultaneous occurrence of both abnormalities in the same person—was $0.4 \pm 0.1\%$ (range: 0.3–0.5%).

Only a few studies included other dental anomalies, such as impacted teeth (12 studies), ectopic eruption (8 studies), and transposition of teeth (6 studies). The mean prevalence of impacted teeth, ectopic eruption, and transposition was found in $4.0 \pm 2.4\%$ (range: 0.5–12.9%), $5.3 \pm 3.5\%$ (range: 0.9–11.1%), and $0.9 \pm 0.6\%$ (range: 0.1–1.4%), respectively.

3.3.5. Space Anomalies

Crowding was not defined in the vast majority if the studies assessing this parameter [1, 21, 22, 25, 27, 28, 32, 33, 35, 37, 40, 44–47, 53–55, 63, 65–70, 79, 80, 82, 83, 88, 96, 98, 101, 107–109, 112–114, 116, 117, 119–121, 124, 125, 132, 133]. The remaining studies used the Irregularity Index (Little, 1975) [51], the method of Björk [87, 90, 106], overlapping of erupted teeth due to insufficient space or lack of space for teeth to erupt in the dental arch [41, 58, 81, 127] and others.

In general, crowding represented a mean prevalence of $33.8 \pm 18.1\%$ (range: 0.8–93.4%). When assessed separately for the maxillary and mandibular arch, a weighted mean prevalence for crowding of $20.8 \pm 14.5\%$ (range: 1.7–77.9%) and $19.7 \pm 15.8\%$ (range: 0.3–83.3%) was found, respectively. The mean prevalence of spacing was reported in $18.7 \pm 13.7\%$ of the samples (range: 1.2–59.5%) and demonstrated $23.4 \pm 20.1\%$ (range: 1.8–62.2%) and $12.8 \pm 10.6\%$ (range: 1.3–30.0%) prevalence in the upper and lower jaw, respectively. The weighted mean prevalence of a midline diastema was reported in $13.8 \pm 14.2\%$ (range: 1.0–73.0%).

3.3.6. Oral Habits

A total of 11 articles reported oral habits, with some of them focusing on changes over time, while others just mentioned oral habits in correlation with malocclusion. The prevalence of oral habits ranged from 10.9% to 40.2%. Further details can be found in Table 3.

3.3.7. Geographic Differences

The prevalence of malocclusion and of the studied occlusal traits on the different continents is presented in Tables 4–7. For this, the studies were clustered per continent as follows: Africa, America, Asia, Europe, and Oceania.
Table 3. Prevalence of oral habits.

| First Author, Year | Participants | Age Range in Y (Total Sample) | Location | Oral Habit in General | Non-Nutritive Sucking | Non-Nutritive Biting | Abnormal Tongue Position | Atypical Swallowing | Bruxism |
|--------------------|--------------|--------------------------------|----------|-----------------------|-----------------------|----------------------|-------------------------|---------------------|---------|
|                      | Total Number | Country                        |          | In General Pacifier   | Finger-/Thumb-Sucking| Bottle               | Lip-Sucking             | Lip-Inter-Position     | Nail Biting       | Object Biting | Cheek-/Lip-Biting | In General Tongue Threat | In General Incompetent Lip-Closure |
| Campos-Arias, 2013 [35] | 88           | Costa Rica                     | 7–11     | 10.0%                 | 19.0%                 | 66.0%                | 7.9%                   | 3.7%                | 7.0%              | 21.5%         | 10.2%          |                             |                             |
| Coetzee, 2000 [39]   | 214          | South Africa                   | 3–8      | 12.1%                 | 6.5%                  | 10.0%                | 7.5%                   | 1.7%                | 3.7%              | 14.1%          | 6.5%           | 21.5%          | 14.1%                          |
| Howell, 1993 [63]    | 154          | Australia                      | 13–17    | 5.0%                  | 14.0%                 | 30.0%                | 7.0%                   | 1.4%                | 14.0%             | 7.0%           | 2.0%           | 4.0%           | 14.0%                          |
| Kasparviciene, 2014 [71] | 709        | Lithuania                      | 3–8      | 1.4%                  | 8.7%                  | 30.0%                | 7.0%                   | 1.4%                | 1.4%              | 21.5%          | 14.1%          | 6.5%           | 21.5%                          |
| Kolawole, 2019 [72]  | 992          | Nigeria                        | 1–12     | 13.1%                 | 6.5%                  | 40.0%                | 13.0%                  | 1.4%                | 1.4%              | 1.4%           | 1.4%           | 1.4%           | 1.4%                          |
| Lagana, 2013 [70]    | 251          | Tanzania                       | 7–15     | 81.0%                 | 28.0%                 | 28.0%                | 20.0%                  | 13.0%               | 1.4%              | 21.5%          | 14.1%          | 6.5%           | 21.5%                          |
| Mtaya, 2017 [64]     | 432          | Israel                         | 7–11     | 10.0%                 | 40.0%                 | 30.0%                | 10.0%                  | 4.0%                | 9.0%              | 16.2%          | 1.4%           | 1.4%           | 1.4%                          |
| Nahali, 2013 [113]   | 800          | Brazil                         | 12–15    | 63.3%                 | 1.1%                  | 14.4%                | 3.5%                   | 60.3%               | 55.2%             | 40.3%          | 20.3%          | 40.3%          | 20.3%                          |
| Shalish, 2013 [113]  | 300          | Germany                        | 2 > 10   | 40.2%                 | 28.1%                 | 28.1%                | 20.0%                  | 27.3%               | 28.1%             | 20.2%          | 28.1%          | 28.1%          | 20.2%                          |
| Stahl, 2001 [117]    | 8000         | Germany                        | 2 > 10   | 40.2%                 | 28.1%                 | 28.1%                | 20.0%                  | 27.3%               | 28.1%             | 20.2%          | 28.1%          | 28.1%          | 20.2%                          |
| Thomas, 2013 [120]   | 200          | Brazil                         | 12–15    | 63.3%                 | 1.1%                  | 14.4%                | 3.5%                   | 60.3%               | 55.2%             | 40.3%          | 20.3%          | 40.3%          | 20.3%                          |
| Wagner, 2015 [130]   | 357          | Germany                        | 3        | 60.1%                 | 4.3%                  | 60.1%                | 4.3%                   | 60.1%               | 4.3%              | 60.1%          | 4.3%           | 60.1%          | 4.3%                          |

Legend: The prevalence of different oral habits is noted as provided in the included articles. Age: age range in years (Y) is noted. Abbreviations: Y: years.
Table 4. Prevalence of angle classification and deciduous molar occlusion according to geographical location.

| Continent | Class I | Class I Malocclusion | Class II | Class II, 1 | Class II, 2 | Class III | FTP | DS | MS |
|-----------|---------|----------------------|---------|------------|------------|-----------|-----|----|----|
| Africa    | 58.1 ± 33.9% | 71 ± 16.5% | 9.7 ± 8.6% | 58 ± 52% | 1.4 ± 0.0% | 4.8 ± 4.2% | 35.9 ± 17.4% | 0.9 ± 1.0% | 54.8 ± 11.0% |
| America   | 13.9 ± 4.8% | 50.6 ± 3.2% | 28.4 ± 11.7% | 17 ± 0.0% * | 5.3 ± 0.0% | 13.9 ± 15.8% | 73.9 ± 17.6% | 7.9 ± 3.0% | 15.9 ± 16.7% |
| Asia      | 50.6 ± 26.9% | 41.5 ± 18.5% | 27.4 ± 14.9% | 19.5 ± 15.2% | 4.2 ± 1.9% | 7.8 ± 4.2% | 41.6 ± 6.7% | 10.2 ± 1.4% | 36.4 ± 15.5% |
| Europe    | 47.4 ± 17.2% | 46.6 ± 6.9% | 25.1 ± 8.6% | 16.1 ± 5.7% | 4.9 ± 2.6% | 3.4 ± 2.6% | 28.1 ± 14.7% | 24.9 ± 8.8% | 47.6 ± 4.7% |
| Oceania   | 65.0 ± 0.0% * | NA | 5.0 ± 15.0% | 12.0 ± 0.0% * | 7.0 ± 0.0% * | NA | NA | NA | NA |

Legend: The weighted mean and standard deviation of the prevalence of the class I angle classification and deciduous molar occlusion in noted in %. * If only one study is available. NA (not available): if no data available for the given continent. Abbreviations: Class I: Angle Class I normal molar occlusion (well-aligned dental arches without any anomalies); Class I malocclusion: Angle Class I molar occlusion but with an anomaly; Class II: Angle Class II malocclusion; Crossbite (not specified, posterior crossbite, unilateral- and bilateral crossbite, anterior crossbite, scissor bite, and crossbite with functional shift) according to geographical location given in %. * If only one study is available. NA (not available): if no data available for the given continent.

Table 5. Prevalence of different transversal malocclusions and anterior crossbite according to geographical location.

| Continent | Crossbite (Not Specified) | Posterior Crossbite (Not Specified) | Posterior Crossbite Unilateral | Posterior Crossbite Bilateral | Anterior Crossbite | Scissor Bite | Forced Bite/Crossbite with Frontal/Lateral Shift |
|-----------|---------------------------|-------------------------------------|-------------------------------|-------------------------------|-------------------|-------------|-----------------------------------------------|
| Africa    | 1.2 ± 0.0% * | 5.5 ± 2.8% | 5.5 ± 0.0% * | 1.6 ± 0.0% * | 5.5 ± 1.9% | 10.3 ± 4.8% | 14.7 ± 10.3% |
| America   | NA | 9.3 ± 6.3% | 13.0 ± 12.2% | 3.8 ± 1.4% | 4.9 ± 3.9% | 1.0 ± 0.6% | NA |
| Asia      | 8.9 ± 14.0% | 6.6 ± 7.0% | 5.0 ± 2.1% | 5.0 ± 1.0% | 10.3 ± 6.5% | 1.8 ± 1.6% | 11.9 ± 4.8% |
| Europe    | 5.1 ± 2.9% | 8.9 ± 4.3% | 8.6 ± 1.8% | 1.6 ± 1.1% | 5.6 ± 4.0% | 1.0 ± 1.5% | 13.7 ± 5.5% |
| Oceania   | NA | 13.0 ± 0.0% * | 6.5 ± 0.0% * | 12 ± 0.0% | NA | NA | NA |

Legend: The weighted mean and standard deviation of the prevalence of different transversal malocclusions: crossbite (not specified, posterior crossbite, unilateral- and bilateral crossbite, anterior crossbite, scissor bite, and crossbite with functional shift) according to geographical location are noted in %. * If only one study is available. NA (not available): if no data available for the given continent.

Table 6. Prevalence of tooth anomalies according to geographical location.

| Continent | Agenesis/Hypodontia | Mesiodens | Supernumerary Teeth/Hypodontia | Hypo-Hypodontia | Impacted/Retained Teeth (Impeded Eruption) | Ectopic Eruption | Transposition |
|-----------|--------------------|-----------|-------------------------------|----------------|-----------------------------------------------|-----------------|---------------|
| Africa    | 3.4 ± 2.2% | NA | 0.3 ± 0.2% | NA | 3.0 ± 0.0% * | 9.7 ± 0.0% * | 0.2 ± 0.1% |
| America   | 5.0 ± 3.3% | 15 ± 0.0% * | 1.9 ± 0.4% | NA | 3.9 ± 2.9% | 1.5 ± 0.0% * | NA |
| Asia      | 8.1 ± 63% | NA | 2.7 ± 1.6% | NA | 4.8 ± 4.1% | 6.0 ± 4.0% | 0.5 ± 0.4% |
| Europe    | 6.9 ± 3.2% | 1.3 ± 0.9% | 2.3 ± 1.3% | 0.4 ± 0.1% | 3.8 ± 0.8% | 7.5 ± 0.0% * | 1.3 ± 0.7% |
| Oceania   | 7.0 ± 0.0% * | NA | 1.0 ± 0.0% * | NA | 5.0 ± 0.0% * | NA | NA |

Legend: The weighted mean and standard deviation of the prevalence of different tooth anomalies: hypodontia, hypodontia, impacted/retained teeth, ectopic eruption, and transposition, according to geographical location are provided in percentages. * If only one study is available. NA (not available): if no data available for the given continent.

Table 7. Prevalence of space anomalies according to geographical location.

| Continent | Crowding Maxillary Arch | Crowding Mandibular Arch | Crowding | Spacing Maxillary Arch | Spacing Mandibular Arch | Spacing | Midline Diastema |
|-----------|------------------------|--------------------------|----------|-----------------------|------------------------|---------|-----------------|
| Africa    | 23.8 ± 11.8% | 24.8 ± 10.6% | 24.5 ± 15.9% | 32.2 ± 14.4% | 22.0 ± 8.5% | 32.6 ± 10.7% | 36.8 ± 0.0% * |
| America   | 17.3 ± 4.3% | 12.3 ± 2.7% | 42.1 ± 7.3% | 1.8 ± 0.0% * | 13.0 ± 0.0% * | 23.5 ± 4.7% | 11.1 ± 7.3% |
| Asia      | 35.3 ± 21.3% | 35.4 ± 22.2% | 24.9 ± 17.2% | 10.7 ± 5.9% | 16.7 ± 14.3% | 8.3 ± 4.8% |
| Europe    | 15.6 ± 19.0% | 23.3 ± 19.4% | 28.1 ± 11.2% | 44.0 ± 15.7% | 14.4 ± 2.5% | 7.2 ± 13.5% | 30.9 ± 20.9% |
| Oceania   | 6.0 ± 0.0% * | NA | 77.4 ± 3.9% | NA | NA | 45.1 ± 20.0% | NA |

Legend: The weighted mean and standard deviation of the prevalence of space anomalies: crowding, spacing, and midline diastema, according to geographical location given in %. * If only one study is available. NA (not available): if no data available for the given continent.
3.4. Risk of Bias

The risk of bias of the included articles determined according to the MINORS tool is shown in Table 8. The scores of each article are plotted in Figures 2 and 3 for non-comparative and comparative studies, respectively, and are sorted by publication year, from oldest to newest. The lowest score for non-comparative studies was 2, and the highest was 10, with a possible maximum score of 16. For comparative studies, the lowest score was 5, and the highest was 13, with a possible maximum of 24. A very discrete tendency to better article quality over time can be found in both comparative and non-comparative studies.

Table 8. Risk of bias assessment according to the MINORS tool.

| Author, Year | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 | M9 | M10 | M11 | M12 | T |
|--------------|----|----|----|----|----|----|----|----|----|-----|-----|-----|---|
| 1 Rolling, 1980 [104] | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 3 |
| 2 O'Dowling, 1989 [93] | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 2 |
| 3 Al-Emran, 1990 [17] | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 5 |
| 4 O'Dowling, 1990 [94] | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 2 |
| 5 Ng'ang’a, 1991 [89] | 2 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 4 |
| 6 Aasheim, 1993 [11] | 2 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 5 |
| 7 Howell, 1993 [63] | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 4 |
| 8 Kabue, 1995 [69] | 2 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 5 |
| 9 Ng’ang’a, 1996 [90] | 2 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 7 |
| 10 Johannsdottir, 1997 [67] | 2 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 5 |
| 11 Sonnesen, 1998 [116] | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 5 |
| 12 Coetzee, 2000 [39] | 2 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 7 |
| 13 Johnson, 2000 [68] | 2 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 7 |
| 14 Ng’ang’a, 2001 [91] | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 4 |
| 15 Stahl, 2003 [118] | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 3 |
| 16 Onyeaso, 2004 [95] | 2 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 7 |
| 17 Abu Alhaija, 2005 [12] | 2 | 0 | 1 | 2 | 1 | 1 | 0 | 0 | NC | NC | NC | NC | 8 |
| 18 Behbehani, 2005 [28] | 1 | 0 | 2 | 1 | 2 | 0 | 0 | 1 | NC | NC | NC | NC | 7 |
| 19 Alberti, 2006 [16] | 2 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 7 |
| 20 Frazao, 2006 [53] | 1 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 6 |
| 21 Gabris, 2006 [54] | 2 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 6 |
| 22 Alkilzy, 2007 [18] | 2 | 0 | 2 | 2 | 2 | 0 | 0 | 0 | NC | NC | NC | NC | 8 |
| 23 Altug-Atac, 2007 [20] | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 5 |
| 24 Graboswki, 2007 [56] | 2 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 5 |
| 25 Rwakatema, 2007 [106] | 2 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 7 |
| 26 de Almeida, 2008 [43] | 2 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 8 |
| 27 Fernandes, 2008 [30] | 2 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 6 |
| 28 Perinetti, 2008 [99] | 2 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 7 |
| 29 Robke, 2008 [103] | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 3 |
| 30 Martins, 2009 [81] | 2 | 0 | 2 | 2 | 2 | 0 | 0 | 0 | NC | NC | NC | NC | 10 |
| 31 Lux, 2009 [78] | 2 | 0 | 2 | 2 | 2 | 0 | 0 | 0 | NC | NC | NC | NC | 8 |
| 32 Rozsa, 2009 [105] | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 5 |
| 33 Varela, 2009 [128] | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 4 |
| 34 Jamal, 2010 [65] | 2 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 4 |
| 35 Murshid, 2010 [87] | 2 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 7 |
| 36 Oshagh, 2010 [96] | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 4 |
| 37 Perillo, 2010 [98] | 2 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 9 |
| 38 Bhardwaj, 2011 [30] | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 5 |
| 39 Campos-Arias, 2013 [35] | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 6 |
| 40 Carvalho, 2011 [36] | 2 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 9 |
| 41 Pineda, 2011 [100] | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 4 |
| 42 Singh, 2011 [114] | 2 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 7 |
| 43 Bourzgui, 2012 [33] | 2 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 7 |
| 44 Medina, 2012 [83] | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 3 |
| 45 Muyasa, 2012 [127] | 2 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | NC | NC | NC | NC | 6 |
| 46 Thomaz, 2013 [125] | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | NC | NC | NC | NC | 5 |
Table 8. Cont.

| Author, Year | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 | M9 | M10 | M11 | M12 | T |
|--------------|----|----|----|----|----|----|----|----|----|-----|-----|-----|---|
| 48 Al-Amiri, 2013 [15] | 2 0 0 2 1 0 0 0 NC NC NC 5 |
| 49 Baskaradoss, 2013 [27] | 2 0 2 1 1 0 0 1 NC NC NC 7 |
| 50 Chauhan, 2013 [37] | 2 0 2 2 1 0 0 0 NC NC NC 7 |
| 51 Lagana, 2013 [75] | 2 0 1 1 1 0 0 1 NC NC NC 6 |
| 52 Lara, 2013 [57] | 2 0 0 1 1 0 0 0 NC NC NC 4 |
| 53 Sánchez-Pérez, 2013 [108] | 2 0 1 1 1 0 0 1 NC NC NC 6 |
| 54 Shalish, 2013 [115] | 2 0 1 1 1 0 0 1 NC NC NC 6 |
| 55 Alsoleihat, 2014 [19] | 2 0 1 1 1 0 0 0 NC NC NC 6 |
| 56 Baral, 2014 [25] | 2 0 1 2 1 0 0 0 NC NC NC 6 |
| 57 Calzada Bandomo, 2014 [34] | 2 0 1 2 1 0 0 0 NC NC NC 6 |
| 58 Jerez, 2014 [66] | 1 0 1 1 0 0 0 0 NC NC NC 3 |
| 59 Kasparviciene, 2014 [71] | 2 0 1 2 1 0 0 1 NC NC NC 7 |
| 60 Mohamed, 2014 [84] | 1 0 1 1 1 0 0 0 NC NC NC 4 |
| 61 Nguyen, 2014 [92] | 2 0 1 1 1 0 0 1 NC NC NC 7 |
| 62 Sanadhy, 2014 [107] | 2 0 1 1 1 0 0 1 NC NC NC 7 |
| 63 Mail, 2015 [80] | 1 0 1 1 0 0 0 0 NC NC NC 3 |
| 64 Wagner, 2015 [130] | 2 0 2 1 1 0 0 0 NC NC NC 6 |
| 65 Ferro, 2016 [51] | 2 0 1 2 0 0 0 0 NC NC NC 7 |
| 66 Rauten, 2016 [102] | 2 0 0 1 0 0 0 0 NC NC NC 3 |
| 67 Araki, 2017 [22] | 2 0 2 1 1 0 0 0 NC NC NC 6 |
| 68 Badrov, 2017 [24] | 1 0 0 1 1 0 0 0 NC NC NC 3 |
| 69 Cosma, 2017 [40] | 2 0 0 2 1 0 0 0 NC NC NC 5 |
| 70 Gracco, 2017 [57] | 2 0 0 2 0 0 0 0 NC NC NC 4 |
| 71 Sepp, 2017 [111] | 2 0 1 1 1 0 0 1 NC NC NC 7 |
| 72 Steinmassl, 2017 [119] | 2 0 2 2 1 0 0 2 NC NC NC 9 |
| 73 Vitanaarchchi, 2017 [129] | 2 0 1 1 1 0 0 0 NC NC NC 5 |
| 74 Zhou, 2017 [133] | 2 0 1 1 1 0 1 1 NC NC NC 7 |
| 75 Abumelha, 2018 [13] | 2 0 0 2 1 0 0 0 NC NC NC 5 |
| 76 Baron, 2018 [26] | 2 0 0 2 1 1 0 0 NC NC NC 5 |
| 77 de Araújo Guimarães, 2018 [44] | 2 0 2 1 1 0 0 2 NC NC NC 8 |
| 78 Gutierrez Marin, 2019 [59] | 2 0 0 2 1 0 0 0 NC NC NC 5 |
| 79 Mtaya, 2017 [86] | 2 0 2 2 1 0 0 0 NC NC NC 7 |
| 80 Sejini, 2018 [110] | 2 0 1 1 1 0 0 0 NC NC NC 6 |
| 81 Sola, 2018 [115] | 2 0 0 2 1 0 0 0 NC NC NC 5 |
| 82 Alajlan, 2019 [14] | 2 0 1 1 1 0 0 0 NC NC NC 5 |
| 83 Daou, 2019 [42] | 2 0 2 2 1 0 0 0 NC NC NC 5 |
| 84 Kalbassi, 2019 [70] | 2 0 0 2 1 0 0 0 NC NC NC 5 |
| 85 de Araújo Guimarães, 2018 [44] | 2 0 2 1 1 0 0 2 NC NC NC 8 |
| 86 Rapeepattana, 2019 [101] | 2 0 2 1 1 0 0 2 NC NC NC 8 |
| 87 Sepp, 2019 [112] | 2 0 1 1 1 0 0 1 NC NC NC 7 |
| 88 Todor, 2019 [126] | 2 0 2 2 1 0 0 0 NC NC NC 7 |
| 89 Yu, 2019 [132] | 2 0 1 1 1 0 0 0 NC NC NC 5 |
| 90 Madiruja, 2021 [79] | 2 0 1 1 1 0 1 2 NC NC NC 8 |
| 91 Engervall, 1975 [64] | 2 0 1 2 1 0 0 0 0 0 0 1 7 |
| 92 de Muniz, 1986 [45] | 2 0 2 1 1 0 0 0 0 1 0 1 8 |
| 93 Hassanalil, 1993 [62] | 2 0 2 2 1 0 0 0 0 0 0 0 7 |
| 94 Bacetti, 1998 [23] | 2 0 0 2 1 0 0 0 1 0 0 1 7 |
| 95 Dacosta, 1999 [41] | 2 0 0 1 1 0 0 0 0 1 0 1 6 |
| 96 Esa, 2001 [46] | 2 0 2 1 1 0 0 2 1 1 0 2 12 |
| 97 Thlander, 2001 [124] | 2 0 2 2 1 0 0 0 0 0 0 0 7 |
| 98 Stahl, 2003 [117] | 1 0 1 1 1 0 0 0 0 0 0 2 6 |
| 99 Tausche, 2004 [123] | 2 1 0 1 1 0 0 2 0 0 0 2 9 |
| 100 Ciuffolo, 2005 [38] | 2 0 0 2 1 0 0 0 0 0 0 2 7 |
Table 8. Cont.

| Author, Year | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 | M9 | M10 | M11 | M12 | T |
|--------------|----|----|----|----|----|----|----|----|----|-----|-----|-----|---|
| Endo, 2006 [47] | 2 0 0 2 1 0 0 0 0 0 0 2 7 |
| Esenlik, 2007 [49] | 2 0 1 2 1 0 0 0 0 0 0 1 7 |
| Harris, 2008 [60] | 2 0 0 1 1 0 0 0 1 0 0 2 7 |
| Harris, 2008 [61] | 2 0 0 1 1 0 0 0 1 0 0 2 7 |
| Mtaya, 2009 [85] | 2 0 2 2 1 0 0 0 0 0 0 2 9 |
| Berneburg, 2010 [29] | 2 0 2 2 2 0 0 1 0 0 0 2 11 |
| Bhayya, 2011 [31] | 2 0 2 2 1 0 0 0 0 0 0 0 7 |
| Seemann, 2011 [109] | 2 0 2 2 1 1 0 0 0 0 0 0 7 |
| Gois, 2012 [55] | 2 0 2 2 1 1 0 0 0 0 0 0 7 |
| Komazaki, 2012 [74] | 2 1 2 2 1 0 0 1 0 1 1 2 13 |
| Arabiun, 2014 [21] | 2 0 2 2 1 0 0 0 0 0 0 0 7 |
| Pagan-Collazo, 2014 [97] | 2 0 2 2 1 0 0 2 0 0 0 0 2 11 |
| Bilgic, 2015 [32] | 2 0 0 2 1 0 0 0 0 0 0 2 7 |
| Dimberg, 2015 [46] | 2 0 1 1 1 0 0 0 0 1 0 2 8 |
| Ferro, 2016 [51] | 2 0 1 2 1 0 0 2 0 1 0 0 9 |
| Yassin, 2016 [131] | 2 0 1 1 1 0 0 0 0 1 0 2 8 |
| Lagana, 2017 [76] | 2 0 0 1 1 0 0 0 0 1 1 1 7 |
| Gudipaneni, 2018 [58] | 2 0 2 2 1 0 0 2 0 1 0 0 12 |
| Kolawole, 2019 [73] | 2 0 2 2 1 0 0 2 0 1 1 2 13 |
| Martins, 2019 [82] | 2 0 2 2 1 0 0 2 0 1 0 2 12 |
| Sundareswaran, 2019 [119] | 2 0 1 1 1 0 0 1 0 1 1 1 9 |
| Sunil, 2019 [120] | 2 0 1 1 1 0 0 0 0 1 1 0 7 |
| Swarnalatha, 2020 [121] | 2 0 0 1 1 0 0 0 0 0 0 1 5 |

Legend: 1–87: the included non-comparative studies sorted by ascending year of publication; 88–123: the included comparative studies sorted by ascending year of publication. Abbreviations: M: MINORS item; M1: clearly stated aim; M2: inclusion of consecutive sample; M3: prospective collection of data; M4: end point appropriate to aim; M5: unbiased assessment of endpoints; M6: follow up period appropriate to aim; M7: loss to follow up less than 5%; M8: prospective calculation of study size; M9: adequate control group; M10: contemporary groups; M11: baseline equivalence; M12: adequate statistical analysis; T: total; NC: non-comparative; C: comparative studies.

Figure 2. Risk of bias assessment for non-comparative studies.
4. Discussion

This systematic review was performed to identify, synthesize, and assess the available evidence on the prevalence of malocclusion and other orthodontic features in subjects younger than 18 years old.

According to the WHO, before an epidemiological survey can be carried out, the investigators need to decide the following: whether to perform it at a local, regional, or national level; what variables to examine; which age groups to include [134]. Prior to the start, clear definitions should be provided to the study variables and measurement protocols and how to record the results should be defined. Ethnicity and geographical data are also indispensable [134], and performing a prospective calculation of the sample size and eventual subsamples is advised [10], since diagnostic criteria need to be based on comparable data in a representative sample. When reporting the results, all of the materials and methods should be described in detail to be able to evaluate possible selection and/or design bias.

Sample size is an important factor. Only 32 of the 123 studies included in this systematic review reported sample size estimation prior to the start. Size differences ranging from 50 to 13,801 individuals can be found in the included studies, which can partially explain the large ranges found in the prevalence of some of the studied malocclusion traits. The use of patient samples can also introduce additional bias over random samples since patients seek dental or orthodontic treatment for a reason. In this sense, it is preferable to conduct an epidemiological study on a population-based sample rather than on patient populations.

It is hard to draw solid conclusions regarding different orthodontic parameters due to the large variety of methods used to assess the different orthodontic features. Some examples of this inconsistency can be found in the description of overjet. The included studies defined increased overjet as >2.5 mm [29], >3 mm [81], >4 mm [14], and >6 mm [22], which makes it impossible to compare the data. Due to this heterogeneity in reporting,
it was impossible to distinguish prevalence of occlusion according to age or dental stage, since most articles report groups with a large age range and do not provide this distinction.

The Dental Aesthetic Index (DAI) was used to report the findings of several studies, which is in accordance with the methods recommended by the WHO to standardize epidemiological data on malocclusion and treatment need [134]. However, the DAI is not a complete measure of malocclusion, but rather an aesthetic treatment need index since it does not measure occlusal parameters such as crossbite, asymmetry, midline deviation, missing molars, or impacted teeth [114].

Other studies used the Dental Health Component of the Index ofOrthodontic Treatment Need to assess different orthodontic features (Table 1). Araki et al. stated that only the IOTN can diagnose the type of malocclusion, such as increased or reverse overjet, overjet, deep bite, open bite, and crowding [22]. Although they score some orthodontic features, neither the IOTN nor DAI were developed to perform epidemiological surveys on the prevalence of orthodontic features, but rather to assess orthodontic treatment need [135,136]. Thirty-nine of the studies included in this Systematic Review used X-rays, ten of which were performed in schoolchildren. The British Orthodontic Society states that each radiograph must be clinically justified because the prescription of a radiograph is a procedure with a low but nevertheless inferred risk [137]. In this context, the assessment of some orthodontic features such as the presence of hypodontia, impacted, or retained teeth, etc., remains a problem since taking radiographs for epidemiological studies is not initially indicated.

Oral habits can influence the development of malocclusion [71]. Thumb and finger sucking can cause an open bite in preadolescent children, and when such oral habits are persistent, increased overjet, decreased overbite, and crossbite can be observed [138]. The use of pacifiers has been linked to an increased prevalence of an anterior open bite and posterior crossbite [139]. Furthermore, tongue thrust at swallowing or rest can cause malocclusions such as open bite [4]. Stahl et al. found a decrease in oral habits from 40.2% in deciduous dentition to 26.1% in mixed dentition [118]. The protocols to diagnose infantile swallowing, sucking habits, and tongue position are rarely mentioned in the studies and are mostly based on subjective data. Often, the assessment of a child’s current and previous oral habits is based on information obtained from the parents, either informally or through non-validated questionnaires [71]. Therefore, there is an urgent need to develop methods that allow for the objective quantification of oral habits. The geographical differences in the prevalence of malocclusion traits are also worth mentioning. For instance, the prevalence of Angle Class II malocclusion was reported to be around 25% in America, Asia, and Europe, while the mean prevalence in Africa was 8.80 ± 10.36%. The weighted mean prevalence for Class III malocclusions for Europe, America, Africa, and Asia is 3.4 ± 1.4%, 4.1 ± 1.4%, 4.8 ± 4.2%, and 7.8 ± 4.2%, respectively, which is in accordance with the conclusions of Proffit that Class III malocclusions are more prevalent in Asian populations [4]. The mean prevalence of anterior crossbite was the highest in Asia (10.3 ± 6.5%) and the lowest in America (1.0 ± 0.6%).

Regarding transversal discrepancies, while posterior crossbites were more prevalent in America (13.0 ± 1.2%) than in Africa (5.5 ± 2.8%), a forced bite was the most prevalent in Africa (14.7 ± 10.3%) followed by Europe (13.7 ± 5.5%), and a scissor bite was the most prevalent in Africa (10.3 ± 4.8%). The prevalence of tooth anomalies ranged from 3.4 ± 2.2% in Africa to 8.1 ± 6.3% in Europe for hypodontia and from 0.3 ± 0.2% in Africa to 2.7 ± 1.6% in Asia for hyperdontia.

The geographical differences found in this systematic review are in accordance with the findings reported by Cenzato et al., which suggest that genetic and environmental factors that typically influence malocclusion traits in each population [140]. However, these differences could also be accounted for by the large heterogeneity in study designs, classifications for tooth anomalies, and a lack of clear international terminology, as previously reported by Anthonappa et al. [141]. Specifically, for the articles included in this review, the large ranges reported and the disparity in the number of studies per continent could have also played a role in the observed geographical differences.
5. Conclusions

A plethora of methods to determine the prevalence of malocclusion and orthodontic features was found across the included studies, which makes the data regarding prevalence of malocclusion unreliable. The mean prevalence of Angle Class I, Class II and Class III malocclusion was 51.9% (SD 20.7), 23.8% (SD 14.6) and 6.5% (SD 6.5), respectively. The prevalence of anterior crossbite, posterior crossbite and crossbite with functional shift was 7.8% (SD 6.5), 9.0% (SD 7.34) and 12.2% (SD 7.8), respectively. The prevalence of hypodontia and hyperdontia were reported to be 6.8% (SD 4.2) and 1.8% (SD 1.3), respectively. For impacted teeth, ectopic eruption and transposition, a mean of 4.9% (SD 3.7), 5.4% (SD 3.8) and 0.5% (SD 0.5) was found, respectively. There is an urgent need to establish methodological protocols for epidemiological studies in orthodontics, which should be reached in consensus with academia and professional societies. Only this will allow objective data to be obtained on which recommendations to the healthcare sector and involved stakeholders can be based.

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Abbreviations

| Abbreviation | Description |
|--------------|-------------|
| SD           | Standard deviation |
| ES           | Epidemiological survey |
| CS           | Cross-Sectional study |
| LS           | Longitudinal study |
| Nr.          | Number of subjects |
| Sch.Ch.      | Schoolchildren |
| Ch.          | Children |
| Pat.         | Patients |
| Pat. rec.    | Patient records |
| Clin. Exam.  | Clinical examination |
| OPT          | Orthopantomogram |
| Interv.      | Interviews |
| Quest.       | Questionnaires |
| IOTN         | Index of Orthodontic Treatment Need |
| DAI          | Dental Aesthetic Index |
| ICON         | Index of Complexity, Outcome and Need |
| ANGLE        | Angle classification |
| BJÖRK        | Björk’s method |
| Y            | Years |
Class I “normal occlusion” Angle Class I normal molar occlusion with well aligned dental arches without any anomalies.
Class I malocclusion Angle Class I molar occlusion but with an anomaly
Class II Angle Class II malocclusion
Class II, 1 Angle Class II,1 malocclusion
Class II, 2 Angle Class II,2 malocclusion
Class III Angle Class III malocclusion
FTP Flush distal plane second deciduous molars
DS Distal step second deciduous molars
MS Mesial step second deciduous molars
M MINORS item
T Total
NC Noncomparative study
C Comparative study
%
Percentage, noted as noted in the article; in most of the cases, two decimals are reported, and if not possible, one or no decimals are reported

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