Prevalence of Malocclusion in 3- to 5-Year-Old Children in Shanghai, China

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Abstract: The aim of the present study was to obtain the prevalence of malocclusions in preschool children in Shanghai, China. A cross-sectional survey was conducted among 2335 children aged 3–5 years from kindergartens. Several occlusal parameters were clinically assessed, including second deciduous molar terminal plane, canine relationship, degree of overjet and overbite, anterior and posterior crossbite, and the presence or absence of physiologic spaces and crowding. All parents of subjects were asked to fill in the oral health knowledge questionnaires. The prevalence of malocclusion in primary dentition in Shanghai was 83.9%, and no significant differences were found in genders. Data showed that the prevalence of deep overbite (63.7%) was the highest in children with malocclusion, followed by deep overjet (33.9%), midline deviation (26.6%), anterior crossbite (8.0%) and anterior crowding (6.5%). The results revealed a high prevalence of malocclusion in primary dentition in children aged 3–5 years old of Shanghai, especially in vertical anomalies. The need for preventive orthodontic therapy is extremely desired and oral health education about malocclusion should be strengthened.

Keywords: primary dentition; malocclusion; epidemiology; prevalence

1. Introduction

As an improving quality of living, people are hoping to own an aesthetically pleasing appearance. This evolution has driven many industries to satisfy their clients’ aesthetic needs, including dentistry. The rapid development of China’s economy has resulted changes in diet, making people consume more refined food. However, this dietary change results in insufficient jaw growth [1]. Malocclusion is a disorder of the craniofacial complex that affects the development of dental maxillofacial region and masticatory function [2]. Serious malocclusion may cause both psychological and physiological conditions. Therefore, it is important to find out the incidence of various malocclusions and corresponding methods to prevent or correct them.

Early intervention for children in, or before, the peak of growth and development can reduce not only the prevalence of malocclusion or the severity in permanent dentition, but also the psychological impact. A number of studies had investigated the prevalence of malocclusions in the primary dentition in different countries and populations, with prevalence values ranging from 21.0% to 88.1% [3–10]. A study about Chinese people from 1956 to 1960 showed the prevalence ranging from 29.33% to 48.87%. A national survey conducted by Chinese Stomatological Association (CSA) in 2000 concluded the prevalence of malocclusion as 51.84% in Chinese children [11]. Some studies suggested that
malocclusions were also related with bad oral habits, such as mouth-breathing and non-nutritive sucking habits [1,12].

The aim of the present study was to evaluate the prevalence of malocclusion in the primary dentition and bad oral habits of preschoolers in the city of Shanghai, in order to provide an epidemiological reference for the development of early intervention and prevention of the occurrence of malocclusion.

2. Materials and Methods

2.1. Study Design and Study Population

A multistage, stratified sampling method was applied to obtain a representative sample of preschoolers, and we selected four districts (Hongkou District, Putuo District, Pudong District, and Minhang District) by probability proportional to size sampling (PPS) (Figure 1). The sample was composed of 2335 children (1247 boys and 1088 girls) aged 3 to 5 years from 12 kindergartens. The included children were studied in the kindergartens which were sampling surveyed and we also obtained their parents’ or guardians’ informed consent before examination was initiated. The exclusion criteria were the presence of permanent teeth, loss of any primary teeth, dental caries that affected the judgment, orthodontic treatment history, tooth agenesis, and other congenital malformation (such as cleft lip/palate) or severe illness and children unable to cooperation. The survey was conducted from January to June, 2016. This study was approved by the Ethics Committee of Shanghai Stomatological Hospital (2015-0012).

![Figure 1. The locations where the study took place.](image)

2.2. Questionnaire

The investigation was composed by an anamnestic questionnaire and oral examination measurements without radiograms, which were mostly based on the WHO basic methods for conducing oral health surveys [13].

The questionnaires were completed by parents under the dentists’ instruction. The first section was about general information, such as age and gender of the child. The second section contained ten questions about the children’s oral habits and parents’ awareness of oral health.

2.3. Dental Examination

The oral examination was carried out by five calibrated trained orthodontic dentists. A pilot study on 50 children was conducted before beginning the present investigation to ensure the accuracy of diagnosis and to standardize the procedures, and substantial inter-examiner reliability was found (Kappa agreement value >0.9). The children were examined in schools’ infirmaries. Each child was checked with a pair of disposable latex gloves and a disposable mouth mirror.
Following items were included in the oral examination:

### 2.3.1. Sagittal Anomalies
- **Deciduous canine relationship:** Equal to Angel’s classification. The canine relationship was recorded as class II or class III, if it was class I on one side and class II or class III on the other. Children with class II canine relation on one side and class III on the other side were recorded as mixed.
- **Terminal plane relationship of the second primary molars:** The relationship of the distal surface between the upper and lower second deciduous molar including three types (flush type, mesial type and distal type). The relationship of molars and canines were recorded on the basis of bilateral occlusion.
- **Maxillary overjet:** This was measured from the palatal surface of the mesial corner of the most protruded maxillary incisor to the labial surface of the corresponding mandibular incisor. (0 mm: edge-to-edge; >3 mm, ≤5 mm: mild; >5 mm, ≤8 mm: moderate; >8 mm: severe).
- **Mandibular overjet (anterior crossbite):** This was recorded when one or more of the maxillary incisors or canine occluded lingual to the mandibular incisors.

### 2.3.2. Vertical Anomalies
- **Overbite:** This was graded according to coverage of the mandibular incisor by the most protruded fully erupted maxillary incisor. (<1/2: normal; >1/2, ≤3/4: mild; >3/4, <1: moderate; all cover: severe).
- **Open bite, anterior:** (<3 mm: mild; >3 mm, ≤5 mm: moderate; >5 mm: severe).

### 2.3.3. Transversal Anomalies
- **Posterior crossbite:** This was recorded when one or more of the maxillary primary molars occluded the lingual to the buccal cusps of the opposing mandibular teeth.
- **Scissors bite:** This was recorded when one or more maxillary primary molars occluded the buccal to the buccal surfaces or the lingual to the lingual surfaces of the corresponding mandibular teeth.
- **Midline displacement.**

### 2.3.4. Space Discrepancies
- **Crowding (anterior, posterior):** >0, ≤2 mm: mild; >2 mm, ≤4 mm: moderate; >4 mm: severe
- **Spacing:** >0, ≤2 mm: mild; >2 mm, ≤4 mm: moderate; >4 mm: severe

### 2.3.5. Others
- **Dental arch shape:** triangular; U-shape; square-shape
- **Tonsil:** normal; antiadoncus I°; antiadoncus II°; antiadoncus III°
- **Temporomandibular joint disorder**
- **Nasal ventilation**
- **Mandibular plane angle**

Anterior crossbite, posterior crossbite, deep overbite (>1/2), deep overjet (>3 mm), anterior open bite, anterior edge-to-edge, posterior scissor bite, and crowding (>2 mm) all indicated malocclusion. The preschool children who exhibited at least one of these conditions were classified with malocclusion.

### 2.4. Statistical Analysis

Data were recorded in a spreadsheet computer program (Microsoft Excel 2010, Microsoft Corp., Redmond, WA, USA). SPSS 22.0 software (SPSS, Chicago, IL, USA) was used for analyses. The results of intra-examiner reliability were tested using the kappa agreement statistic method.
The prevalence of malocclusion was reported by age and gender, and in total. The chi-square test was applied to determine the statistical associations between the independent variables and the malocclusion variable. For all tests, significant difference was assumed when the \( p \) value is < 0.05. The clinical registrations were based on the method evolved by the Angle’s classification, which has been used in many studies [14].

3. Results

The present study showed that 16.1% of children had dentitions without any irregularity and 83.9% had different degrees of anomaly (Table 1). There was no significant difference found in genders. Data showed that prevalence of deep overbite (63.7%) was the highest in children with malocclusion, followed by deep overjet (33.9%), midline deviation (26.6%), anterior crossbite (8.0%), and anterior crowding (6.5%) (Tables 2–5).

Table 1. Descriptive analyses of demographic characteristics of sample.

| Age & Gender | Normal Occlusion | Malocclusion | \( p \) |
|--------------|------------------|--------------|--------|
|              | \( n \) | % | \( n \) | % |
| Age          |        |    |        |    |        |    |        |    |        |    |
| 3            | 846    | 14.7 | 722    | 85.3 | 0.121  |
| 4            | 728    | 15.4 | 616    | 84.6 |
| 5            | 761    | 18.3 | 622    | 81.7 |
| Gender       |        |    |        |    |        |    |        |    |        |    |
| Boys         | 1247   | 53.1 | 1048   | 53.5 | 0.886  |
| Girls        | 1088   | 46.9 | 912    | 46.5 |
| Total        | 2335   | 16.1 | 1960   | 83.9 |

Chi-square test: \( p > 0.05 \).

Table 2. The composition and prevalence of sagittal occlusal characteristic.

| Sagittal Occlusal Characteristic | Age 3 (Year) | Age 4 (Year) | Age 5 (Year) | Total | \( n \) | % | \( n \) | % | \( n \) | % |
|----------------------------------|--------------|--------------|--------------|-------|-------|----|-------|----|-------|----|
| Canine relationship              |              |              |              |       |       |    |       |    |       |    |
| Normal (class I)                 | 496          | 58.6         | 415          | 57.0  | 419   | 55.1 | 1330  | 57.0|
| Distal (class II)                | 254          | 30.0         | 239          | 32.8  | 264   | 34.7 | 757   | 32.4|
| Mesial (class III)               | 83           | 9.8          | 69           | 9.5   | 75    | 9.9  | 227   | 9.7 |
| Mix 1                            | 13           | 1.5          | 5            | 0.7   | 3     | 0.4  | 21    | 0.9 |
| Second deciduous molar terminal plane |          |              |              |       |       |    |       |    |       |    |
| Bilateral symmetry               | 751          | 88.8         | 643          | 88.3  | 671   | 88.2 | 2065  | 88.4|
| Flush                            | 332          | 39.2         | 265          | 36.4  | 306   | 40.2 | 903   | 38.7|
| Distal                           | 70           | 8.3          | 129          | 17.7  | 65    | 8.5  | 264   | 11.3|
| Mesial                           | 349          | 41.3         | 249          | 32.7  | 300   | 39.4 | 898   | 38.5|
| Deep overjet                     | 294          | 34.8         | 264          | 36.3  | 233   | 30.6 | 791   | 33.9|
| Edge to edge                     | 16           | 1.9          | 15           | 2.1   | 23    | 3.0  | 54    | 2.3 |
| Mild (>3 mm, \( \leq 5 \) mm)    | 222          | 26.2         | 202          | 27.7  | 183   | 24.0 | 607   | 26.0|
| Moderate (>5 mm, \( \leq 8 \) mm) | 61         | 7.2          | 58           | 8.0   | 43    | 5.7  | 162   | 6.9 |
| Severe (>8 mm)                   | 11           | 1.3          | 4            | 0.5   | 7     | 0.9  | 22    | 0.9 |
| Anterior crossbite               | 68           | 8.0          | 49           | 6.7   | 70    | 9.2  | 187   | 8.0 |

Mix 1: Child with class II canine relation on one side and class III on the other side was recorded as mixed.
Table 3. The composition and prevalence of vertical anomalies.

| Vertical Anomalies                  | Age 3 (Year) | Age 4 (Year) | Age 5 (Year) | Total  |
|------------------------------------|--------------|--------------|--------------|--------|
|                                    | n    | %  | n    | %  | n    | %  | n    | %  |
| Deep overbite                      | 532  | 62.9 | 499  | 68.5 | 457  | 60.1 | 1488 | 63.7 |
| Mild (≥1/2, ≤3/4)                  | 204  | 24.1 | 172  | 23.6 | 144  | 18.9 | 520  | 22.3 |
| Moderate (≥3/4, <1)                | 202  | 23.9 | 224  | 30.8 | 185  | 24.3 | 611  | 26.2 |
| Severe (all cover)                 | 126  | 14.9 | 103  | 14.1 | 128  | 16.8 | 357  | 15.3 |
| Open bite                          | 5    | 0.6  | 3    | 0.4  | 2    | 0.3  | 10   | 0.4  |
| Moderate (>3 mm, ≤5 mm)            | 4    | 0.5  | 3    | 0.4  | 1    | 0.1  | 8    | 0.3  |
| Severe (>5 mm)                     | 1    | 0.1  | 0    | 0.0  | 1    | 0.1  | 2    | 0.1  |

Table 4. The composition and prevalence of transversal anomalies.

| Transversal Anomalies              | Age 3 (Year) | Age 4 (Year) | Age 5 (Year) | Total  |
|------------------------------------|--------------|--------------|--------------|--------|
|                                    | n    | %  | n    | %  | n    | %  | n    | %  |
| Midline displacement               | 224  | 26.5 | 190  | 26.1 | 206  | 27.1 | 620  | 26.6 |
| Posterior Teeth Malocclusion       |            |              |              |        |
| Posterior crossbite                | 1    | 0.1  | 5    | 0.7  | 0    | 0.0  | 6    | 0.3  |
| Edge to edge                       | 0    | 0.0  | 0    | 0.0  | 0    | 0.0  | 0    | 0.0  |
| Scissors bite                      | 3    | 0.4  | 2    | 0.3  | 2    | 0.3  | 7    | 0.3  |
| Opposite Scissors bite             | 0    | 0.0  | 1    | 0.1  | 0    | 0.0  | 1    | 0.0  |

Table 5. The composition and prevalence of space discrepancies.

| Anterior Teeth Malocclusion         | Age 3 (Year) | Age 4 (Year) | Age 5 (Year) | Total  |
|------------------------------------|--------------|--------------|--------------|--------|
|                                    | n    | %  | n    | %  | n    | %  | n    | %  |
| Crowding                           | 46   | 5.4  | 33   | 4.5  | 72   | 9.5  | 151  | 6.5  |
| Maxillary                          | 38   | 4.5  | 17   | 2.3  | 23   | 3.0  | 78   | 3.3  |
| >2 mm, ≤4 mm                       | 36   | 4.3  | 15   | 2.1  | 19   | 2.5  | 70   | 3.0  |
| >4 mm                              | 2    | 0.2  | 0    | 0.0  | 4    | 0.5  | 8    | 0.3  |
| Mandibular                         | 59   | 7.0  | 26   | 3.6  | 61   | 8.0  | 146  | 6.3  |
| >2 mm, ≤4 mm                       | 56   | 6.6  | 21   | 2.9  | 55   | 7.2  | 132  | 5.7  |
| >4 mm                              | 3    | 0.4  | 0    | 0.0  | 6    | 0.8  | 14   | 0.6  |
| Spacing                            | 349  | 41.3 | 348  | 47.8 | 349  | 45.9 | 1046 | 44.8 |
| Maxillary                          | 306  | 36.2 | 317  | 43.5 | 297  | 39.0 | 920  | 39.4 |
| >2 mm, ≤4 mm                       | 168  | 19.9 | 173  | 23.8 | 157  | 20.6 | 498  | 21.3 |
| >4 mm                              | 138  | 16.3 | 144  | 19.8 | 140  | 18.4 | 422  | 18.1 |
| Mandibular                         | 211  | 24.9 | 204  | 28.0 | 221  | 29.0 | 636  | 27.2 |
| >2 mm, ≤4 mm                       | 144  | 17.0 | 133  | 18.3 | 152  | 20.0 | 429  | 18.4 |
| >4 mm                              | 67   | 7.9  | 71   | 9.8  | 69   | 9.1  | 207  | 8.9  |

The study revealed that the most common molar relationship at the 3–5 years of age was the flush terminal plane (38.7%), followed by mesial step (38.5%) (Table 2). With respect to the canine relationship, the normal type was observed as 57.0%, and the distal type as 32.4% (Table 2).

There were 63.4% children with bad oral habits, 32.7% of them had sucking habits, and 48.5% parents had no awareness about orthodontic treatments (Figure 2).
Table 4. The composition and prevalence of transversal anomalies.

| Posterior Teeth Malocclusion | Age 3 (Year) | Age 4 (Year) | Age 5 (Year) | Total |
|-----------------------------|-------------|-------------|-------------|-------|
| n %                         | n %         | n %         | n %         |       |
| Midline displacement        | 224 (26.5%) | 190 (26.1%) | 206 (27.1%) | 620 (26.6%) |
| Posterior crossbite         | 1 (0.1%)    | 5 (0.7%)    | 0 (0.0%)    | 6 (0.3%) |
| Edge to edge                | 0 (0.0%)    | 0 (0.0%)    | 0 (0.0%)    | 0 (0.0%) |
| Scissors bite               | 3 (0.4%)    | 2 (0.3%)    | 2 (0.3%)    | 7 (0.3%) |
| Opposite Scissors bite      | 0 (0.0%)    | 1 (0.1%)    | 0 (0.0%)    | 1 (0.0%) |

Table 5. The composition and prevalence of space discrepancies.

| Anterior Teeth Malocclusion | Age 3 (Year) | Age 4 (Year) | Age 5 (Year) | Total |
|-----------------------------|-------------|-------------|-------------|-------|
| n %                         | n %         | n %         | n %         |       |
| Crowding                    | 46 (5.4%)   | 33 (4.5%)   | 72 (9.5%)   | 151 (6.5%) |
| Maxillary                   | 38 (4.5%)   | 17 (2.3%)   | 23 (3.0%)   | 78 (3.3%) |
| >2 mm, ≤4 mm                | 36 (4.3%)   | 15 (2.1%)   | 19 (2.5%)   | 70 (3.0%) |
| >4 mm                       | 2 (0.2%)    | 2 (0.3%)    | 4 (0.5%)    | 8 (0.3%) |
| Mandibular                  | 59 (7.0%)   | 26 (3.6%)   | 61 (8.0%)   | 146 (6.3%) |
| >2 mm, ≤4 mm                | 56 (6.6%)   | 21 (2.9%)   | 55 (7.2%)   | 132 (5.7%) |
| >4 mm                       | 3 (0.4%)    | 5 (0.7%)    | 6 (0.8%)    | 14 (0.6%) |
| Spacing                     | 349 (41.3%) | 348 (47.8%) | 349 (45.9%) | 1046 (44.8%) |
| Maxillary                   | 306 (36.2%) | 317 (43.5%) | 297 (39.0%) | 920 (39.4%) |
| >2 mm, ≤4 mm                | 168 (19.9%) | 173 (23.8%) | 157 (20.6%) | 498 (21.3%) |
| >4 mm                       | 138 (16.3%) | 144 (19.8%) | 140 (18.4%) | 422 (18.1%) |
| Mandibular                  | 211 (24.9%) | 204 (28.0%) | 221 (29.0%) | 636 (27.2%) |
| >2 mm, ≤4 mm                | 144 (17.0%) | 133 (18.3%) | 152 (20.0%) | 429 (18.4%) |
| >4 mm                       | 67 (7.9%)   | 71 (9.8%)   | 69 (9.1%)   | 207 (8.9%) |

The study revealed that the most common molar relationship at the 3–5 years of age was the flush terminal plane (38.7%), followed by mesial step (38.5%) (Table 2). With respect to the canine relationship, the normal type was observed as 57.0%, and the distal type as 32.4% (Table 2).

There were 63.4% children with bad oral habits, 32.7% of them had sucking habits, and 48.5% parents had no awareness about orthodontic treatments (Figure 2).

Figure 2. Composition ratio of inadequate oral habits at each age.

4. Discussion

The results showed that prevalence of malocclusion from 3 to 5 years old was 83.9%, which is much higher than 51.84% for children with primary dentition in China [11]. The prevalence was also different from that reported in studies which were carried out in different countries, such as 26.0% reported in India and 42.0% to 74.7% in Germany [6,7,15]. These differences may be due to the different methodology used by the authors, or different subjects and decades. Race, living environment, and eating habits were different in the various regions, which may affect the incidence of malocclusion.

Our study on the Shanghai population showed that distribution of flush terminal molar relation was 38.7% on both side. A study by Infante pointed out that the distal step molar relationship decreased with the increase of age [16]. Other studies by Nanda et al. and Ravn indicated that the distal step molar relationship was invariably maintained throughout the primary dentition stage and always transferred unchanged to the permanent dentition [3,17]. The research done by Ravn was a longitudinal study, to ensure the result was more reliable. With regard to the flush and mesial terminal plane, Onyeasoet et al. found out most of them developed into Angle class I in the permanent dentition [18]. The present study was a cross-sectional study which inevitably imposed limitations on the estimation. Further longitudinal studies are needed to obtain the changes in occlusal pattern from the deciduous dentition to permanent dentition.

The prevalence of the class I canine relationship in our study was 57.0%. Children with a class II canine relationship reached 32.4%, which was much lower than 45% in British children [19], but was similar to 31.6% in the Danish children [17]. The difference could be caused by small sample size in the former study, which may enlarge the sampling error to misunderstand the actual situation.

Table 2 suggested that the two more prevalent types of anomalies were dental space and deep overbite, which is consistent with previous studies [14,20]. Primate space and leeway space are normal in deciduous dentition. A study published by Center of Human Development at the University of Michigan showed the sum of mesiodistal diameters of primary teeth was 6, shorter than that of permanent teeth in the maxillary [21]. The permanent dentition may be crowded if there are no spaces in the deciduous dentition. However, this theory is questionable since Baume showed that nine of 16 individuals with no interdental spaces in the primary dentition did not exhibit crowding in the permanent dentition [22]. This indicates that leeway space does not necessarily solve the problem of crowding. More longitudinal studies should be conducted to determine this in the future. Hence, dental space was temporarily not classified as malocclusion in our study. The prevalence of
crowding (6.5%) was much lower than in Colombia (52.1%) [14]. This may be due to the cutoff value of the latter article being more than 0 mm.

As interdental space was removed from malocclusion in primary dentition, the most prevalent type of malocclusion became deep overbite (63.7%), followed by deep overjet (33.9%). These results were similar to those reported in previous studies [7,23–25]. The prevalence of deep overbite was high in deciduous dentition and increased to the late mixed dentition, which may be explained by the common use of extraction of deciduous molars, a procedure that will usually result in collapsed dentition. Full eruption of the premolars and second molars could stabilize the occlusion, and the prevalence of deep overbite may decrease in the permanent dentition. During craniofacial growth, the mandible will rotate in a backward direction [26], while the overjet will decrease.

In the present study, 33.9% of the children showed deep overjet, which was higher than 29.7% in Brazil [27] and 26.0% in Finnish subjects [23]. These differences may be caused due to the use of different methodologies by the authors, who considered an accentuated overjet to be greater than 3 mm, in comparison to the 2 mm used in the present study for the determination of this condition.

The prevalence of anterior crossbite was 8.0% in the present study, which was more than the Saudi (1.7%) and the British (1.0%). However, it was similar to the prevalence in the Finnish (8%) [28] and African-Americans (5%) [29]. Previous studies on Americans and Europeans indicated the incidence of posterior crossbite in the primary dentition ranging from 7.2% to 20.81% [5,7]. Another study showed that it was one of the most prevalent malocclusions in the primary and early mixed dentitions [30]. However, in the present study, the prevalence of posterior crossbite was much lower, which meant only 6 in 2334 children had posterior crossbite. Our result was similar to the result found in India (0.4%) [31]. It observed that Caucasians generally showed higher incidence rate of posterior crossbite than Africans and Asians [17,32,33]. The different prevalence of posterior crossbite between different regions may be caused by the difference in prevalence of sucking habits. Three studies on posterior crossbite associated this alteration to finger-/dummy-sucking habits which, in the present study, was 32.7% [5,25,34]. The children who adopted such habits tend to have a greater chance of exhibiting posterior crossbite than those that did not. However, research shows the scientific evidence could not confirm what type of malocclusion is associated with non-nutritive sucking habits [35].

Malocclusion not only destroys aesthetics, but also creates functional problems. Studies suggest that deep overjet and anterior open bite were predisposing factors of dental trauma [36–38]. Young children start to crawl, walk, run, and fall, and take up high-risk activities when they grow up, such that dental injuries and dislocated teeth are common [39]. Cross-bite is unlikely to lead to the development of oral disease, but dysfunction can arise from the resulting impairment of mastication [40].

The definition of early treatment it a treatment which is started in the primary or mixed dentition to enhance the dental and skeletal development before the eruption of permanent dentition [41]. These early therapeutic methods are usually brief and simple, which elicits little cooperation from patients and their parents. Early treatments could prevent the malocclusion from worsening and greatly simplify subsequent orthodontic treatment. Malocclusion caused by bad oral habits, such as open bite caused by tongue protrusion, can be corrected by tongue crib appliance [42]. It seems that some early interventions are needed in order to prevent the malocclusion from worsening and obtain a well-balanced dental and skeletal development.

The present study indicated a high prevalence of malocclusion for 3 to 5-year-old children in Shanghai, which should be taken seriously. However, it is also important to construct a more precise definition of primary dentition malocclusion such that common standards are defined for further studies. The change of malocclusion with increasing age could not be indicated due to our cross-sectional research, and a further longitudinal study is needed to determine this.

5. Conclusions

The present study offers evidence that malocclusion is a remarkable problem in Shanghai’s preschool children. The prevalence of malocclusion was high among the children analyzed and
increased significantly in recent 17 years, suggesting that malocclusion is a public health problem worthy of note in the Chinese population.

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References

1. Kiliaridis, S.; Engström, C.; Thilander, B. The relationship between masticatory function and craniofacial morphology. I. A cephalometric longitudinal analysis in the growing rat fed a soft diet. Eur. J. Orthod. 1985, 7, 273–283. [CrossRef] [PubMed]
2. Peres, K.G.; Barros, A.J.; Peres, M.A.; Victora, C.G. Effects of breastfeeding and sucking habits on malocclusion in a birth cohort study. Rev. Saude Publica 2007, 41, 343–350. [CrossRef] [PubMed]
3. Nanda, R.S.; Khan, I.; Anand, R. Age changes in the occlusal pattern of deciduous dentition. J. Dent. Res. 1973, 52, 221–224. [CrossRef] [PubMed]
4. Frazao, P.; Narvai, P.C.; Latorre, M.R.; Castellanos, R.A. Malocclusion prevalence in the deciduous and permanent dentition of schoolchildren in the city of São Paulo, Brazil. Cad. Saude Publica 2002, 18, 1197–1205. [PubMed]
5. Da, S.F.O.; Ferrari Júnior, F.M.; Aiello, C.A.; Zopone, N. Correction of posterior crossbite in the primary dentition. J. Clin. Pediatr. Dent. 2007, 32, 73–78.
6. Dhar, V.; Jain, A.; Van Dyke, T.E.; Kohli, A. Prevalence of gingival diseases, malocclusion and fluorosis in school-going children of rural areas in Udaipur district. J. Indian Soc. Pedod. Prev. Dent. 2007, 25, 103–105. [CrossRef] [PubMed]
7. Grabowski, M.H.R. Relationship between occlusal findings and orofacial myofunctional status in primary and mixed dentition. J. Orofac. Orthop. 2007, 68, 74–90. [CrossRef] [PubMed]
8. Leite-Cavalcanti, A.; Medeiros-Bezerra, P.K.; Moura, C. Breast-feeding, bottle-feeding, sucking habits and malocclusion in Brazilian preschool children. Rev. Saude Publica 2007, 9, 194–204. [PubMed]
9. Carvalho, A.C.; Paiva, S.M.; Scarpelli, A.C.; Viegas, C.M.; Ferreira, F.M.; Pordeus, I.A. Prevalence of malocclusion in primary dentition in a population-based sample of Brazilian preschool children. Eur. J. Paediatr. Dent. 2011, 12, 107–111. [PubMed]
10. Wagner, Y.; Heinrichweltzien, R. Occlusal characteristics in 3-year-old children—Results of a birth cohort study. BMC Oral Health 2015, 15, 1–6. [CrossRef] [PubMed]
11. Brandao, I.M.; Peres, A.S.; Saliba, N.A.; Moimaz, S.A. Prevalence of dental fluorosis in school children from Marinopolis, Sao Paulo. Cad. Saude Publica 2002, 18, 877–881. [PubMed]
12. World Health Organization. Oral Health Surveys: Basic Methods, 5th ed.; World Health Organization: Geneva, Switzerland, 2013.
13. Thilander, B.; Pena, L.; Infante, C.; Parada, S.S.; De, M.C. Prevalence of malocclusion and orthodontic treatment need in children and adolescents in Bogota, Colombia. An epidemiological study related to different stages of dental development. Eur. J. Orthodont. 2001, 23, 153–167. [CrossRef]
14. Stahl, F.; Grabowski, R. Malocclusion and caries prevalence: Is there a connection in the primary and mixed dentitions? Clin. Oral Investig. 2004, 8, 86–90. [CrossRef] [PubMed]
15. Infante, P.F. An epidemiologic study of deciduous molar relations in preschool children. J. Dent. Res. 1975, 54, 723–727. [CrossRef] [PubMed]
16. Ravn, J.J. Longitudinal study of occlusion in the primary dentition in 3- and 7-year-old children. Eur. J. Oral Sci. 1980, 88, 165–170. [CrossRef]
18. Onyeaso, C.O.; Isiekwe, M.C. Occlusal changes from primary to mixed dentitions in Nigerian children. *Angle Orthod.* 2008, 78, 64–69. [CrossRef] [PubMed]

19. Foster, T.D.; Hamilton, M.C. Occlusion in the primary dentition. Study of children at 2 and one-half to 3 years of age. *Br. Dent. J.* 1969, 126, 76–79. [PubMed]

20. Hegde, S.; Panwar, S.; Bolar, D.R.; Sanghavi, M.B. Characteristics of occlusion in primary dentition of preschool children of Udaipur, India. *Eur. J. Dent.* 2012, 6, 51–55. [PubMed]

21. Moyers, R.E. *Standards of Human Occlusal Development*; University of Michigan CHGD: Ann Arbor, MI, USA, 1976.

22. Baume, L.J. Physiological tooth migration and its significance for the development of occlusion. III. The biogenesis of the successional dentition. *J. Dent. Res.* 1950, 29, 338–348. [CrossRef] [PubMed]

23. Karjalainen, S.; Rönning, O.; Lapinleimu, H.; Simell, O. Association between early weaning, non-nutritive sucking habits and occlusal anomalies in 3-year-old Finnish children. *Int. J. Paediatr. Dent.* 1999, 9, 169–173. [CrossRef] [PubMed]

24. Almeida, E.R.; Narvai, P.C.; Frazão, P.; Guedes-Pinto, A.C. Revised criteria for the assessment and interpretation of occlusal deviations in the deciduous dentition: A public health perspective. *Cad. Saúde Pública* 2008, 24, 10148–10152. [CrossRef]

25. Macena, M.C.; Katz, C.R.; Rosenblatt, A. Prevalence of a posterior crossbite and sucking habits in Brazilian children aged 18–59 months. *Eur. J. Dent.* 2009, 31, 357–361. [CrossRef] [PubMed]

26. Bjoerk, A.; Krebs, A.; Solow, B. A method for epidemiological registration of malocclusion. *Acta Odontol. Scand.* 1964, 22, 27–41. [CrossRef] [PubMed]

27. Katz, C.R.; Rosenblatt, A.; Gondim, P.P. Nonnutritive sucking habits in Brazilian children: Effects on deciduous dentition and relationship with facial morphology. *Am. J. Orthod. Dentofac.* 2004, 126, 53–57. [CrossRef]

28. Kerosuo, H. Occlusion in the primary and early mixed dentitions in a group of Tanzanian and Finnish children. *ASDC J. Dent. Child.* 1990, 57, 293–298. [PubMed]

29. Jones, M.L.; Mourino, A.P.; Bowden, T.A. Evaluation of occlusion, trauma, and dental anomalies in African-American children of metropolitan headstart programs. *J. Clin. Pediatr. Dent.* 1993, 18, 51–54. [PubMed]

30. Petrén, S.; Bonde, M.; Söderfeldt, B. A systematic review concerning early orthodontic treatment of unilateral posterior crossbite. *Angle Orthod.* 2003, 73, 588–596. [PubMed]

31. Bhat, S.S.; Rao, H.A.; Hegde, K.S.; Kumar, B.K. Characteristics of primary dentition occlusion in preschool children: An epidemiological study. *Int. J. Clin. Pediatr. Dent.* 2012, 5, 93–97.

32. Farsi, N.M.A.; Salama, F.S. Characteristics of primary dentition occlusion in a group of Saudi children. *Int. J. Paediatr. Dent.* 1996, 6, 253–259. [CrossRef] [PubMed]

33. Otuyemini, O.D.; Sote, E.O.; Isiekwe, M.C.; Jones, S.P. Occlusal relationships and spacing or crowding of teeth in the dentitions of 3–4-year-old Nigerian children. *Int. J. Paediatr. Dent.* 1997, 7, 155–160. [CrossRef] [PubMed]

34. Góis, E.G.; Ribeirojúnior, H.C.; Vale, M.P.; Paiva, S.M.; Serranegra, J.M.; Ramosjorge, M.L.; Pordeus, I.A. Influence of nonnutritive sucking habits, breathing pattern and adenoid size on the development of malocclusion. *Angle Orthod.* 2008, 78, 647–654. [CrossRef]

35. Hermont, A.P. Breastfeeding, bottle feeding practices and malocclusion in the primary dentition: A systematic review of cohort studies. *Int. J. Environ. Res. Public Health* 2015, 12, 3133–3151. [CrossRef] [PubMed]

36. Carvalho, J.C.; Vinker, F.; Declerck, D. Malocclusion, dental injuries and dental anomalies in the primary dentition of Belgian children. *Int. J. Paediatr. Dent.* 1998, 8, 137–141. [CrossRef] [PubMed]

37. Borzabadi-Farahani, A.; Eslamipour, F. An investigation into the association between facial profile and maxillary incisor trauma, a clinical non-radiographic study. *Dent. Traumatol.* 2010, 26, 403–408. [CrossRef] [PubMed]

38. Borzabadi-Farahani, A. The association between orthodontic treatment need and maxillary incisor trauma, a retrospective clinical study. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod.* 2011, 112, e75–e80. [CrossRef] [PubMed]

39. Bastone, E.B.; Freer, T.J.; McNamara, J.R. Epidemiology of dental trauma: A review of the literature. *Aust. Dent. J.* 2000, 45, 2–9. [CrossRef] [PubMed]

40. Hwang, H.S.; Lee, K.H. Intrusion of over-erupted molars by corticotomy and magnets. *Am. J. Orthod. Dentofac. Orthop.* 2001, 120, 209–216. [CrossRef] [PubMed]
41. Prabhakar, R.R.; Saravanan, R.; Karthikeyan, M.K.; Vishnuchandran, C.; Sudeepthi. Prevalence of malocclusion and need for early orthodontic treatment in children. *J. Clin. Diagn. Res.* **2014**, *8*, ZC60–ZC61. [PubMed]

42. Taslan, S.; Biren, S.; Ceylanoglu, C. Tongue pressure changes before, during and after crib appliance therapy. *Angle Orthod.* **2010**, *80*, 533–539. [CrossRef] [PubMed]

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