The Relationship between Caries and Malocclusion in Chinese Migrant Workers' Children in Shanghai

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Objective: *To evaluate the relationship between caries and malocclusion in the early and late mixed dentition in a population of children of Chinese migrant workers in Shanghai.*
Methods: *Dental charts were obtained for 646 children in the mixed dentition, aged between 6 and 13 years old. The decayed, missing, and filled teeth (DMFT) index and interproximal tooth structure lost due to caries (ITSLC) were evaluated.*
Results: *In the early mixed dentition, overbite was more likely to be ideal in subjects with DMFT > 0. In the late mixed dentition, crowding in both arches was greater in subjects with DMFT > 0. In the total sample, crowding in the lower arch only was greater in subjects with DMFT > 0. In the early mixed dentition, upper crowding was lower in subjects with ITSLC in the upper arch and in both arches and the rate of anterior crossbite was higher in subjects with ITSLC in the upper arch. In the late mixed dentition, overjet was more likely to be ideal in subjects with ITSLC in the upper arch and upper crowding was greater in subjects with ITSLC in both arches. In the total sample, overjet was more likely to be ideal in subjects with ITSLC in the upper arch and lower crowding was greater in subjects with ITSLC in both arches.*
Conclusion: *A relationship exists between caries and malocclusion, and between ITSLC and malocclusion, and some relationships may change with dental age.*

Key words: *Dental caries, DMFT, early mixed dentition, late mixed dentition, malocclusion*

The relationship between caries and malocclusion has been debated for decades. Despite ongoing research, no definitive studies have been performed[1,2]. The relationship between caries and specific types of malocclusion is even more poorly defined. Many articles argue both for and against the association between caries and malocclusion[3-17]. A better understanding of this potential relationship would be beneficial to orthodontists, paediatric dentists and general dentists. It would aid in the diagnosis and treatment of malocclusion, identification of patients that require early interceptive orthodontic treatment, and when evaluating a patient's caries risk.

The primary weakness of many of these studies is the use of the DMFT (decayed, missing, and filled teeth) index as a caries measure. With limited exceptions[5], most studies evaluating the potential relationship between caries and malocclusion use some variation of the DMFT index[3,4,6,8-10,12-16]. DMFT however, does not distinguish between a small, non-cavitated lesion and a large cavitated lesion with loss of tooth structure. While the DMFT index is a useful statistic for many studies, it is inadequate when comparing caries and malocclusion because the index includes many lesions that are non-cavitated and therefore can have no more effect on malocclusion than a healthy tooth. If caries does have a significant effect on malocclusion, they can only do so if tooth structure is lost, particularly interproximally.

The purpose of this study is to compare caries and malocclusion rates in the early and late mixed dentitions in a sample of children of Chinese migrant workers in Shanghai to see if a relationship exists and if this relationship changes with dental age. This study will also utilise a new variable for calculating caries that is specifically designed to identify a possible relationship

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This research was funded by the University of Illinois at Chicago College of Dentistry.

between caries and malocclusion, which is called the ITSLC (interproximal tooth structure lost due to caries). The DMFT index will also be used to remain consistent and comparable to the existing literature.

Materials and methods

This research was approved by the University of Illinois at the Chicago Institutional Review Board (Research Protocol #2013-0181), and it was determined that this research does not involve human subjects.

During a period of 6 months, a single operator provided complimentary dental treatment for 646 Chinese children in the mixed dentition, aged between 6 and 13 years old. The operator was a US trained and licensed dentist. All children were students at an elementary school located in Southeast Pudong in Shanghai, China, which catered to the children of migrant workers. The children were a mixture of Han Chinese and other ethnic minorities. They all came from low socioeconomic backgrounds and generally could not afford routine dental care other than the treatment provided to them by the volunteer. The children had minimal or no previous dental treatment and no history of orthodontic treatment.

The volunteer performed all treatment at the children's school. As a component of providing dental treatment, paper charts were recorded for each child treated. These charts were the sole source of data for this study and permission to use the de-identified charts for research purposes was obtained from the school principal. Subjects were selected for the study based on dental age. Only subjects in the early and late mixed dentition were included. Early mixed dentition was defined as the presence of at least one permanent tooth, including central incisors, lateral incisors and first molars. Late mixed dentition was defined as the presence of at least one canine, premolar, or second molar and at least one primary tooth. If a primary tooth was retained in situations where the succedaneous tooth had erupted ectopically, the primary tooth was not considered to fulfil the inclusion criteria. Subjects with craniofacial anomalies were excluded.

The presence or absence of specific features of malocclusion was determined for each subject and characteristic. Whether a particular characteristic was deemed ideal or non-ideal was based on the American Board of Orthodontics discrepancy index[18]. All measurements were recorded to within 0.5 mm with a periodontal probe. The following characteristics were evaluated:

- Angle molar classification- this was measured at half a cusp on both the right and left sides. The ideal characteristic was defined as Class I occlusion. A distinction was then made between symmetric and asymmetric classification.
- Overjet- this was measured from the most anterior point on the central incisors to the facial surface of the tooth, which was immediately posterior. Overjet was defined as ideal if it was between 1 and 3 mm.
- Overbite- this was measured from the incisal edge of the maxillary central incisors to the incisal edge of the most adjacent mandibular incisor at the point of greatest overbite. Overbite was considered ideal if it was between 0 and 3 mm.
- Dental midline deviation measured as a deviation between the maxillary dental midline and the mandibular dental midline and was considered ideal if it was between 0 and 2.5 mm.
- Maxillary midline diastema- this was measured at the mesial height of the contour of the maxillary central incisors. It was considered ideal if it was between 0 and 2 mm.
- Crossbite- this was recorded for each mandibular tooth that was buccally displaced in relation to an adjacent maxillary tooth, or a maxillary tooth in the full buccal crossbite. Absence of a crossbite was considered as ideal.
- Upper and lower crowding/spacing- this was measured as the overlap or gap between the heights of the contour of adjacent misaligned teeth. Crowding was considered ideal if it was between 0 and 3 mm. Total crowding was calculated as crowding minus spacing. In subjects with missing teeth, the amount of space remaining at the site of the missing tooth was recorded as part of the spacing measurement. In order to determine the approximate mesial-distal width of the missing tooth, the mesial-distal width of the same tooth on the opposite side of the arch was measured, if available. If unavailable, the averages for the mesial-distal width of teeth in Southern Chinese children were taken from the study by Yuen et al[19]. The approximate mesial-distal width of the missing tooth was then subtracted from the spacing measurement.
- Caries- this was identified through visible inspection and palpation with a periodontal probe utilising the criteria outlined in Helm[20]. No radiographs were taken and therefore carious lesions that were visible by radiograph alone were excluded from the study.
- Dental restorations- tooth number, site, surface and material used were recorded for each restoration.
- Absent teeth were differentiated from teeth that exfoliated due to normal development and teeth that were lost prematurely due to caries.

Table 1 Division of sample into testing categories.

Entire sample n = 646	Descriptive statistics	Early mixed dentition	Male: n = 242 Female: n = 149 Total sample: n = 391
		Late mixed dentition	Male: n = 155 Female: n = 100 Total sample: n = 255
		Entire sample	Male: n = 396 Female: n = 249 Total sample: n = 646
	DMFT score	DMFT = 0 (Caries-free)	Early mixed dentition: n = 61 Late mixed dentition: n = 27 Total sample: n = 88
		DMFT > 0 (Caries)	Early mixed dentition: n = 330 Late mixed dentition: n = 255 Total sample: n = 558
	ITSLC	No ITSLC	Early mixed dentition: n = 172 Late mixed dentition: n = 139 Total sample: n = 311
		ITSLC upper arch only	Early mixed dentition: n = 36 Late mixed dentition: n = 32 Total sample: n = 68
		ITSLC lower arch only	Early mixed dentition: n = 83 Late mixed dentition: n = 43 Total sample: n = 126
		ITSLC both Arches	Early mixed dentition: n = 99 Late mixed dentition: n = 41 Total sample: n = 140

- The decayed, missing, and filled teeth (DMFT) index was calculated for each subject. No distinction was made between primary teeth and permanent teeth when calculating DMFT index, so DMFT and dmft were added together in the final DMFT index.
- Interproximal tooth structure lost due to caries (ITSLC) was measured in the upper and lower arches. Interproximal caries that resulted in a change in the contour of the carious surface was recorded as loss of tooth structure if the tooth was visibly cavitated resulting in a decrease in the mesial-distal width. The space remaining after premature loss of a primary tooth due to caries was measured. If the width of the space was less than the estimated mesial-distal width of the original tooth[18], the teeth distal to the space were assumed to have migrated mesially, resulting in loss of arch circumference. This loss was included in the ITSLC measurement.

All statistics were calculated using SPSS version 20 (IBM, Illinois, USA). Significance was set at $P < 0.05$ for all tests. Subjects were divided into various groups as listed in Table 1. Either one-way ANOVA tests followed by Scheffé pairwise comparisons or chi-square tests were used to evaluate the overall differences in malocclusion characteristics within the four groups of early mixed dentition males, early mixed dentition females, late mixed dentition males and late mixed dentition females. No tests were run to evaluate posterior crossbite or anterior open bite due to the small sample size. Chi-square tests were run to evaluate the relationship between the DMFT groups and between the ITSLC groups for symmetric/asymmetric Angle classification, overjet, overbite, crowding and anterior crossbite. All other characteristics lacked sufficient sample size to run chi-square tests.

Table 2 Average mean with standard deviation for malocclusion characteristics, DMFT and ITSLC.

	Early mixed dentition males	Early mixed dentition females	Early mixed dentition total	Late mixed dentition males	Late mixed dentition females	Late mixed dentition total	Total sample
Number of subjects	241	149	390	155	100	255	646
Overjet (mm)	3.2 ± 1.9	2.7 ± 1.7	3.0 ± 1.8	3.5 ± 1.8	3.3 ± 1.8	3.4 ± 1.8	3.2 ± 1.8
Overbite (mm)	2.6 ± 2.0	2.5 ± 2.0	2.6 ± 2.0	3.1 ± 1.9	3.0 ± 1.9	3.1 ± 1.9	2.7 ± 2.0
Dental midline meviation (mm)	0.9 ± 1.0	0.9 ± 0.9	0.9 ± 1.0	1.1 ± 1.2	0.9 ± 0.9	1.0 ± 1.1	0.9 ± 1.0
Maxillary midline diastema (mm)	0.6 ± 0.9	0.5 ± 0.8	0.6 ± 0.9	0.2 ± 0.5	0.1 ± 0.2	0.1 ± 0.4	0.4 ± 0.7
Upper crowding (mm)	-0.3 ± 3.6	0.1 ± 3.7	-0.2 ± 3.7	1.9 ± 3.6	1.7 ± 3.5	1.8 ± 3.5	0.6 ± 3.7
Lower crowding (mm)	1.8 ± 3.2	2.1 ± 3.0	1.9 ± 3.1	2.5 ± 4.1	2.3 ± 3.8	2.4 ± 4.0	2.1 ± 3.5
DMFT	5.4 ± 4.1	5.0 ± 3.6	5.2 ± 3.9	4.2 ± 3.4	4.6 ± 3.0	4.8 ± 3.2	5.1 ± 3.7
ITSLC upper (mm)	0.5 ± 0.9	0.6 ± 1.0	0.5 ± 1.0	0.5 ± 1.1	0.3 ± 0.8	0.4 ± 1.0	0.5 ± 1.0
ITSLC lower (mm)	0.7 ± 1.2	0.7 ± 1.0	0.7 ± 1.1	0.6 ± 1.0	0.6 ± 1.3	0.6 ± 1.1	0.7 ± 1.1

Results

Descriptive statistics

The averages for overjet, overbite, midline deviation, diastema, crowding, DMFT, ITSLC Upper and ITSLC Lower are reported in Table 2. The numbers of subjects with different angle classifications are reported in Table 3. The number of subjects with crossbite and open bite are reported in Table 4.

Comparison between groups

Overjet was significantly larger in late mixed dentition males than in early mixed dentition females ($P = 0.001$). Maxillary midline diastemas were significantly larger in the early mixed dentition than the late mixed dentition, regardless of sex ($P = 0.000$). Upper crowding was significantly worse in the late mixed dentition compared to the early mixed dentition, regardless of sex ($P = 0.000$). No significant differences were found for the other malocclusion characteristics, DMFT index or ITSLC.

Relationship between DMFT and malocclusion

Percentages of the sample that were determined to be ideal and non-ideal for each malocclusion characteristic, presence of caries, and ITSLC are reported in Table 5. In the early mixed dentition, overbite was more likely to be ideal in subjects with DMFT > 0 than in subjects with DMFT = 0 ($P = 0.007$). In the late mixed dentition, crowding in the upper arch ($P = 0.010$) and lower arch ($P = 0.003$) was greater in subjects with DMFT > 0 than in subjects with DMFT = 0. In the total sample, crowding in the lower arch only was greater in subjects with DMFT > 0 than in subjects with DMFT = 0 ($P = 0.004$).

Relationship between ITSLC and malocclusion

In the early mixed dentition, upper crowding was lower in subjects with ITSLC in the upper arch ($P = 0.039$) and in both arches ($P = 0.040$) than in subjects with no ITSLC, and the rate of anterior crossbite was higher in subjects with ITSLC in the upper arch than in subjects with no ITSLC ($P = 0.011$). In the late mixed dentition, overjet was more likely to be ideal in subjects with ITSLC in the upper arch than in subjects with no ITSLC ($P = 0.000$), and upper crowding was greater in subjects with ITSLC in both arches than in subjects with no ITSLC ($P = 0.011$). In the total sample, overjet was more likely to be ideal in subjects with ITSLC in the upper arch than in subjects with no ITSLC ($P = 0.037$), and lower crowding was greater in subjects with

Table 3 Number of subjects in each group with each angle classification.

	Class I	Class II	Class III	Class I/II	Class I/III	Class II/III	Total
Early mixed dentition males	81	62	18	41	11	6	219
Early mixed dentition females	46	43	14	21	10	1	135
Late mixed dentition males	56	29	17	29	21	3	155
Late mixed dentition females	35	30	11	14	8	2	100
Total sample	218	164	60	105	50	12	609
Percentage of sample	36%	27%	10%	17%	8%	2%	100%

Table 4 Number of subjects in each group with anterior crossbite, posterior crossbite and anterior open bite.

	Anterior crossbite		Posterior crossbite			Anterior open bite	
	Absent	Present	Absent	Unilateral	Bilateral	Absent	Present
Early mixed dentition males	197	43	238	2	1	232	9
Early mixed dentition females	126	24	142	7	1	144	5
Late mixed dentition males	124	31	149	6	0	153	2
Late mixed dentition females	81	19	98	2	0	96	2
Total sample	528	117	627	17	2	625	18

ITSLC in both arches than in subjects with no ITSLC ($P = 0.039$).

Discussion

Descriptive statistics

The average DMFT found in this study is most closely related to that found by Chen[21] in Guangdong Province, but disagrees with that found by Wang et al[22] in the second national survey of oral health status of children and adults in China. The high rate of caries may be due to the low socioeconomic status of the sample[13] or the lack of formal dental education in the Chinese population[23].

The rate of Angle Class I found in this study was less than that reported by both Chu et al[24] and Fu et al[25], but the rate of Angle Class III found in this study is consistent with those studies. This may be due to a discrepancy in reporting Angle Class I/II and I/III since the classification of subjects with a subdivision was not specified. Overjet and overbite were found to be non-

Table 5 Percentages of the sample that are ideal and non-ideal for each malocclusion characteristic, DMFT and ITSLC.

	Early mixed dentition		Late mixed dentition		Total sample	
	Ideal	Non-ideal	Ideal	Non-ideal	Ideal	Non-ideal
Overjet	48%	52%	43%	57%	46%	54%
Overbite	61%	39%	49%	51%	56%	44%
Dental midline deviation	96%	4%	93%	7%	> 99%	< 1%
Maxillary midline diastema	97%	3%	> 99%	< 1%	98%	2%
Upper crowding	38%	62%	51%	49%	43%	57%
Lower crowding	51%	49%	48%	52%	49%	51%
Anterior crossbite	83%	17%	80%	20%	82%	18%
Posterior crossbite	97%	3%	97%	3%	97%	3%
Open bite	96%	4%	98%	2%	97%	3%
DMFT	16%	84%	11%	89%	14%	86%
ITSLC upper	48%	35%	63%	45%	77%	32%
ITSLC lower	48%	47%	63%	33%	77%	41%
ITSLC both	48%	37%	63%	23%	77%	22%

ideal in a much higher percentage of subjects than has been reported in some studies[26], but is consistent with others[24,27]. It is possible that the definition of non-ideal overjet and overbite differs between the studies. The rate of anterior crossbite found in this study is consistent with that found in several studies[24,27], but significantly higher than that found in other studies[26,28]. Chu et al[24] found a much higher rate of posterior crossbite than that found in this study. No explanation is offered for the different rates of crossbites.

Relationship between DMFT and malocclusion

In this cross-sectional study, greater upper and lower crowding were found in the late mixed dentition, and greater lower crowding was found in the total sample in subjects with caries. This is consistent with the findings of Ben-Bassat et al[5], Buczkowska-Radlinska et al[7], Gabris et al[8] and Hixon et al[10] who also found an association between crowding and caries.

This study also found a more normal overbite in the early mixed dentition in subjects with caries. This is in disagreement with Mtaya et al[13], who found that subjects with caries were more likely to have an open bite.

Relationship between ITSLC and malocclusion

Studies evaluating the relationship between ITSLC and malocclusion are rare. Ben-Bassat et al[5] did study this relationship, but did not distinguish between ITSLC in the upper and lower arches. Additionally, they only differentiated between the early mixed dentition and the late mixed dentition when evaluating the relationship between ITSLC and crowding. The current study agrees with findings from the Ben-Bassat et al[5] study, that upper crowding is increased in the late mixed dentition. However whilst Ben-Bassat et al[5] found that in the early mixed dentition, upper crowding was more prevalent in subjects with ITSLC, the current study found that upper crowding improved in subjects with ITSLC.

The current study found that overjet was more likely to be ideal in subjects with ITSLC in the upper arch for subjects in the late mixed dentition and in the total sample. A higher rate of anterior crossbite was found

Table 6 Chi-square test *P* value results comparing ideal vs non-ideal malocclusion characteristics for DMFT = 0 vs DMFT > 0, No ITSLC vs ITSLC Upper, No ITSLC vs ITSLC Lower, and No ITSLC vs ITSLC. Results are shown for the early mixed dentition, late mixed dentition and the total sample.

		Overjet	Overbite	Upper crowding	Lower crowding	Anterior crossbite	Symmetric/ asymmetric angle class
DMFT= 0 vs DMFT> 0	Early mixed dentition	0.356	0.007	0.088	0.154	0.218	0.280
	Late mixed dentition	0.561	0.360	0.010	0.003	0.858	0.927
	Total sample	0.734	0.159	0.890	0.004	0.405	0.545
No ITSLC vs ITSLC upper	Early mixed dentition	0.464	0.180	0.039	0.440	0.011	0.207
	Late mixed dentition	0.000	0.220	0.703	0.797	0.823	0.131
	Total sample	0.037	0.209	0.208	0.707	0.083	0.068
No ITSLC vs ITSLC lower	Early mixed dentition	0.264	0.790	0.508	0.215	0.876	0.129
	Late mixed dentition	0.827	0.308	0.146	0.137	0.586	0.824
	Total sample	0.232	0.404	0.420	0.065	0.890	0.279
No ITSLC vs ITSLC both	Early mixed dentition	0.307	0.074	0.040	0.172	0.044	0.076
	Late mixed dentition	0.876	0.626	0.011	0.073	0.091	0.963
	Total sample	0.223	0.192	0.742	0.039	0.315	0.261

in subjects with ITSLC in the upper arch in subjects in the early mixed dentition. No other studies reported this result.

The possible explanation for the decreased rate of crowding and improved overjet in subjects with ITSLC is comparable to Begg's theory of interproximal attrition[29]. As the subjects lost tooth structure, crowding was able to be resolved due to the increased space available to the teeth. Loss of interproximal tooth structure in the upper arch led to a decrease in overjet, causing an increase in anterior crossbite in subjects that may have begun with ideal overjet, and an improvement in overjet in subjects that may have begun with increased overjet. This loss of tooth structure however, inevitably leads to loss of arch circumference, which is why the crowding rate is higher in the late mixed dentition, as full size adult teeth erupted into a shortened arch. This explanation however, is simply conjecture.

Limitations

This study was limited by the small sample size, which prevented a more complete analysis. The sample size available for each group, as listed in Table 1, is highly variable. This skewed data may have had an adverse effect on the statistical analysis. Data such as oral habits, diet or other behaviours that can alter a subject's caries rate or occlusion were not collected, and therefore were not available for use in this study.

There are inherent limitations comparing caries rate between subjects in the early mixed dentition and the late mixed dentition groups in a cross-sectional study.

The presence or absence of primate space and leeway space affects the crowding measurement. Since the data were collected at a single time point, it is impossible to know how much of the primate space and leeway space was lost, or how much the presence or absence of these spaces affects the crowding measurement. Additionally, the DMFT index and ITSLC that were recorded, were from a single time point. Each subject's past caries history is unknown. Subjects may have had primary teeth with carious lesions that were no longer in the mouth at the time of the study, so they were not recorded. A subject's DMFT index or ITSLC measurement may therefore decrease over time despite a history of caries. This creates inaccuracy in comparing DMFT and ITSLC between the early mixed and the late mixed dentition groups and is an inherent limitation in a cross-sectional study of this nature.

Conclusion

According to this retrospective, cross-sectional study on the relationship between caries and malocclusion in a sample of children of Chinese migrant workers in Shanghai, a relationship exists between caries and malocclusion, and between ITSLC and malocclusion, and some of these relationships may change with dental age. Longitudinal studies with large sample sizes and additional documentation, such as photographs and radiographs, are required to fully understand the relationship between caries and malocclusion. ITSLC is a useful measurement for these types of studies and should be utilised in future research.

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