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Infraoccluded first permanent molars and their association with facial and skeletal development

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Introduction: Permanent molar infraocclusion, usually caused by ankylosis, has been scarcely studied. Unilateral first molar infraocclusion (UFMI) restricts alveolar bone development locally, leading to asymmetrical dental arches and occlusion. This study investigates whether its effect extends beyond dental structures to affect facial and skeletal asymmetries. **Methods:** A retrospective analysis was conducted on consecutively recruited patients with UFMI in comparison with age- and gender-matched controls. The percentage of patients with occlusal cant (OC), chin deviation (CD), and the mean vertical asymmetry index (VAI), rami length difference ratios (RLD), and condyle length difference ratios were evaluated. For clinical significance, the percentage of patients with VAI and RLD values >3% was compared. The effect of age and jaw were studied. **Results:** The UFMI group consisted of 29 patients, 16 males and 13 females, mean age of 13.4 ± 3.8 years. Patients with UFMI displayed significantly more CD and OC and higher VAI and RLD ratios vs the controls (59.0% vs 14.0%, 38.0% vs 7.0%, 3.2% vs 1.0%, and 4.0% vs 2.0%, respectively). VAI >3% was found in 34.5% of patients with UFMI and none of the controls (P <0.001). RLD ratios >3% were found in 51.7% of UFMI vs 24% controls (P = 0.030). CD and OC prevalence significantly increased with age in the UFMI group. Maxillary UFMI influenced more than mandibular UFMI. **Conclusions:** UFMI is linked to significant facial and skeletal asymmetry, particularly in older age groups. These findings highlight the potential relevance of early diagnosis and intervention to mitigate potential long-term influence on facial growth and development. (Am J Orthod Dentofacial Orthop 2025;■:■-■)

Permanent first molar infraocclusion is a result of the cessation of tooth eruption.[1] It can arise because of a physical barrier in the path of eruption, dental trauma, infection, or genetic factors; however, ankylosis plays a pivotal role in its pathogenesis.[1]

Ankylosis refers to a condition in which a tooth becomes fused to the surrounding bone, resulting in a lack of mobility or movement.[2] It occurs when the periodontal ligament, which normally attaches the tooth to the bone, is replaced by bone tissue, causing a direct connection between the tooth and the bone, which prevents normal tooth eruption and occlusal development,[3] leading to infraocclusion or submergence, in which the affected tooth is positioned lower than the surrounding teeth.[4-6]

Ankylosis can affect both primary and permanent dentitions and is twice as common in the mandible than in the maxilla.[2] The primary molars are the most commonly affected, with prevalence rates ranging 1%-30% depending on the population and the specific definition used by the authors.[7,8] Although there is a lack of data on its prevalence in permanent dentition, it is estimated to be 10 times less than in deciduous dentition, with the most affected tooth being the permanent molar.[2,3,9]

The etiology of ankylosis is not fully understood, but several theories and mechanisms have been suggested,[2,3,9-11] including impaired local bone and periodontal ligament metabolism, impaired eruption

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All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
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Submitted, September 2024; revised and accepted, February 2025.
0889-5406/$36.00

https://doi.org/10.1016/j.ajodo.2025.02.004

force, local infection, chemical or thermal insult, local trauma, and improper tongue pressure. A clear genetic influence has also been demonstrated.[8,10,12,13] Therefore, etiology is diverse and includes both intrinsic and extrinsic factors.

Diagnosis is performed through both clinical examination and radiographic imaging.[1,14-16] Clinically, the ankylosed tooth will generally be infraoccluded and exhibit a dull sound during the percussion examination. However, a definitive diagnosis can only be obtained through a histologic test after the extraction of the affected tooth.[14] Therefore, unless proved histologically, the most appropriate clinical term for these teeth is infraocclusion.

Molar infraocclusion may cause local malalignment, with neighboring teeth tipping toward the affected tooth.[3,4,17] This can also affect other teeth in the same arch, causing the midline to deviate toward the affected tooth and the adjacent distal molar, which remains located further distally.[6] The opposite arch may also be affected, as the opposing tooth tends to overerupt.[5] Wider effects include underdevelopment of the alveolar bone, leading to a reduction in bone height and canting of the occlusal plane toward the affected side.[3,9,18-20]

The implications differ significantly between permanent and primary ankylosed teeth as most infraoccluded primary molars with permanent successors will exfoliate normally, and normalization of the bone level will occur during the eruption of the successors.[21,22]

In contrast, if the permanent molar becomes ankylosed during growth, a noticeable vertical defect may occur.[18] The severity of the defect will depend on the patient's remaining growth.[19] If ankylosis occurs early in the tooth's eruption and there is still expected growth for the patient, the effect will be more pronounced, and the prognosis will be worse as the submergence of the affected tooth in relation to the adjacent erupting teeth and the subsequent bone level discrepancy will increase fast during the remaining growth period.[11,18]

Although not explicitly mentioned in the literature, it can be assumed that severe instances of unilateral ankylosis and infraocclusion, associated with impaired asymmetrical alveolar bone development, could also affect facial and skeletal growth. Consequently, our aim in this study was to investigate whether unilateral permanent first molar infraocclusion (UFMI) is associated with skeletal or facial asymmetries.

MATERIAL AND METHODS

This study is a retrospective analysis of the pretreatment records of patients with UFMI, consecutively recruited from the Department of Orthodontics, Hebrew University-Hadassah School of Dental Medicine, Jerusalem. The research was approved by the institutional review board of the Hadassah Medical Organization (HMO-0131-22).

The inclusion criteria for the study group were healthy subjects diagnosed with UFMI by clinical and radiographical evaluation on panoramic views.

The inclusion criteria for the matched control group were healthy subjects with normally erupted molars and symmetrical Class I or II malocclusion.

To maintain consistent standards in patient positioning and quality of radiographs, all photographs and radiographs were taken within the same institute inside the hospital with standardized protocols for both the study and matched control groups.

The exclusion criteria for both groups were subjects who had functional shift because of dental crossbites, and for the UFMI group, patients with first permanent molars unerupted because of primary failure of eruption, cysts, odontomas, or other obstructions in the path of eruption, craniofacial syndromes, cleft lip or palate or severe malocclusions that require orthognathic surgery.

All of the measurements were done by one of the authors (Z.G.F.). Randomly selected 8 patients were assessed twice during at least 2 weeks, with repeated evaluations by another examiner (A.L.). To evaluate reproducibility and accuracy, both interobserver and intraobserver assessments were performed using intraclass correlation coefficients.

Facial and dentoalveolar asymmetry were assessed clinically and radiographically as follows:

1. Frontal facial photograph examination (Fig 1, *A*): (1) occlusal cant (OC) was assessed by determining the parallelism between the occlusal plane and the interpupillary line; (2) chin deviation (CD) was evaluated by determining the position of soft-tissue menton (Me) in relation to the facial vertical midline, determined as a vertical line passing through the soft-tissue glabella and soft-tissue subnasale; and (3) vertical asymmetry between the right and left sides of the face was determined using the vertical asymmetry index (VAI), calculated as the ratio between the distances of the right vs left soft-tissue gonial angles relative to the interpupillary lines as was described by Lee et al[23]:

VAI (%) = ([right vertical gonial length − left vertical gonial length]/[average right and left lengths]) × 100

2. Panoramic examination (Fig 1, *B*): (1) rami length difference ratio (RLD) was calculated by dividing the condyle-ramus unit heights of the right and

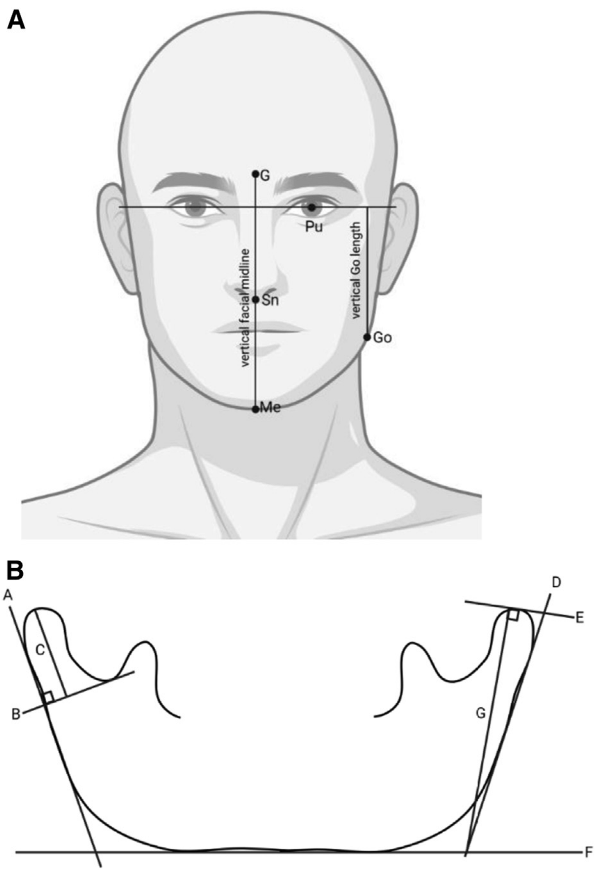

Fig 1. Clinical and radiographic measurements: **A,** Facial soft-tissue landmarks and reference lines: *G,* soft-tissue glabella; *Sn,* soft-tissue subnasalle; *Me,* soft-tissue menton; *Go,* soft-tissue gonion; *Pu,* pupil; *G-Sn*, facial vertical midline; *right Pu-left Pu*, interpupillary line; *Go⊥ interpupillary line*, vertical Go length; **B,** Skeletal measurements on a panoramic radiograph illustration: *A-line*, tangent to vertical ramus; *B-line*, perpendicular line passing through the mandibular notch; *C-line*, condylar height; *D-line*, tangent to vertical ramus; *E-line*, tangent to condylar head; *F-line*, tangent to inferior border of the mandible; *G-line*, ramus-condyle unit height – the perpendicular distance to line E from the insertion of lines D and F.

left side, according to Troulis et al[24]; and (2) condyle length difference ratio (CLD) was assessed by dividing the heights of right and left condyles, according to Nicot et al.[25]

The impact of age was examined by categorizing the experimental groups into 2 age subgroups according to the median: a young group, consisting of patients aged 9-13 years, and an older group, consisting of patients aged 13-27 years.

The possible connection to the affected jaw was also studied by comparing the asymmetry in patients with UFMI in the maxilla vs the mandible.

Power analysis was conducted to determine the minimum sample size required for a study based on parameters derived from previous studies[25,26] and an unpublished pilot study of early constitutive patients that was done in the department >5 years ago. The following parameters were considered: Comparing 2 paired means, significance level (α): 0.05, desired power ($1 - \beta$): 0.80 (80%), effect size (Cohen's d): 0.6 (medium to large effect), and type of test: 2-tailed. On the basis of these parameters, the power analysis has determined that a minimum sample size of 24 participants per group is necessary.

Statistical analysis

Continuous variables were compared using the Wilcoxon signed-rank test for matched pairs. When comparing 2 unmatched groups, such as the upper and lower jaws, the Mann-Whitney test was applied. The chi-square test was used to analyze dichotomous variables. In addition, the chi-square test was employed to determine the clinical significance of continuous variables above and below the threshold level of 3% (see below). Correlations were identified using the Spearman *r* test. When analyzing the correlation of dichotomous variables, the results obtained were from point-biserial correlation tests. Significance was attributed to all test findings with a P value of <0.05. All analyses were performed using Prism (version 10.2.2; GraphPad, Boston, Mass).

RESULTS

Reliability of the measurements within the same examiner (intraexaminer) showed high values (0.962). Consistency between examiners (interexaminer) also showed a high value of 0.917. Thus, all measurements were considered highly reliable.

The UFMI group consisted of 29 patients, 16 males and 13 females (Table I). The average age was 13.5 years, ranging 9-27 years (Table I). The younger group (aged <13 years) included 14 patients (mean age 10.8 years), and the older group (aged >13 years) included 15 patients (mean age 15.8 years) (Table I). The control group was matched for age, gender, general malocclusion, and severity.

The most frequently affected molar was the mandibular left first molar, comprising 59% of all examined UFMIs.

The UFMI group showed a significantly higher prevalence of CD than the control group (59% vs 14% of patients, respectively; $P<0.001$; Table II), a significantly

Table I. Patient characteristics

Groups	*n*	*Mean age (range), y*
UFMI	29	13.5 (9.0-27.0)
Aged >13 y	15	15.9 (13.0-27.0)
Aged <13 y	14	10.7 (9.0-12.9)
Control	29	13.4 (9-27)
Aged >13 y	15	15.8 (13-27)
Aged <13 y	14	10.8 (9-12.9)
Groups	*Male, n*	*Female, n*
UFMI	16	13
Aged >13 y	10	5
Aged <13 y	6	8
Control	16	13
Aged >13 y	10	5
Aged <13 y	6	8
Infraoccluded molar		*n*
Maxilla		12
Mandible		17
Right		12
Left		17

Table II. Comparison between UFMI and control groups

Variables	*Control, %*	*UFMI, %*	P *value*
OC	6.88%	37.92%	0.005
CD	13.78%	58.62%	<0.001
VAI	1.01 ± 0.68	3.23 ± 2.67	<0.001
RLD	1.96 ± 1.50	4.26 ± 4.30	0.003
CLD	5.68 ± 3.55	6.01 ± 4.08	0.900

higher prevalence of OC (38% vs only 7% of patients, respectively; P = 0.005; Table II) and a significantly higher mean VAI compared with the controls (3% and 1%, respectively; P <0.001; Table II).

RLD ratios were significantly higher among the UFMI patients, with a mean of 4% compared with 2% in the controls (P = 0.003) (Table II). However, CLD ratios were not different between the study and control groups, with both groups having a CLD ratio of 6% (Table II).

In the young UFMI group, CD was more prevalent than in the age-matched controls (54% vs 21%, respectively; P = 0.04; Table III). Similarly, among the UFMI older subgroup, a higher incidence of CD was evident compared with the controls (63% vs 7%, respectively; P = 0.001; Table III). The prevalence of CD decreased with age in the control group (21% in younger subjects and 7% in older patients, whereas in the UFMI subgroups, it increased significantly (from 54% to 63%; P = 0.006; Fig 2).

The prevalence of OC was 8% in the UFMI younger group vs 14% in the controls; however, this difference was not statistically significant. In contrast, a significant

Table III. Comparison of age subgroups between UFMI and control groups

Variables	*Control, %*	*UFMI, %*	P *value*
Aged >13 y			
OC	0.00	62.50	<0.001*
CD	6.67	62.50	0.001*
VAI	1.04 ± 0.66	3.55 ± 3.49	0.029*
RLD	2.61 ± 1.64	4.20 ± 5.10	0.260
Aged <13 y			
OC	14.29	7.69	0.580
CD	21.43	53.85	0.040*
VAI	0.98 ± 0.70	3.10 ± 1.60	<0.001*
RLD	1.26 ± 0.95	4.32 ± 3.48	0.004*

difference was observed among the older subgroups, with 62.5% of the older UFMI patients exhibiting OC vs 0% of the older control subjects exhibiting OC (P = 0.0002). No age-related differences were found in the control subjects, which showed low prevalences of OC in all subgroups (Fig 2, *A*). In contrast, within the UFMI age subgroups, a significant difference in the prevalence of OC was observed, with 8% in the young age group compared with 62.5% in the older group (P = 0.006) (Fig 2, *B*).

The VAI values were significantly higher in all UFMI compared with control age subgroups (Table III). Younger patients in the UFMI group had 2% higher mean VAI values than their age-matched controls (3% vs 1% respectively; P <0.001; Table III). Similarly, this difference was observed in older subgroups, with UFMI older subjects having 2.5% higher average VAI values vs controls (3.5% vs 1%; P = 0.029; Table III). In contrast, RLD ratios showed a significant difference only among the younger subgroup (4% vs 1%, respectively; P = 0.004; Table III).

VAI, RLD, and CLD were higher when the affected molar was in the upper vs the lower jaw (Table IV); however, only the CLD ratios were statistically significantly different (7% vs 5% respectively; P = 0.04; Table IV). No differences were found in the prevalences of OC and CD (Table IV).

To better understand the clinical impact of these findings, a threshold of 3% was established for VAI and RLD measurements, based on Habets et al[26] and Nicot et al.[25] Specifically, Habets et al[26] found that a 1-cm change in head position during panoramic imaging could result in up to a 6% difference between the measured sizes of the left and right condyles. Using their asymmetry formula, this 6% difference translates to a 3% asymmetry index. Therefore, they suggested that asymmetry values of 3% or less could be due to technical errors in imaging rather than true anatomic asymmetry. Thus, our results were further analyzed for the presence of values above and below this threshold (Table V).

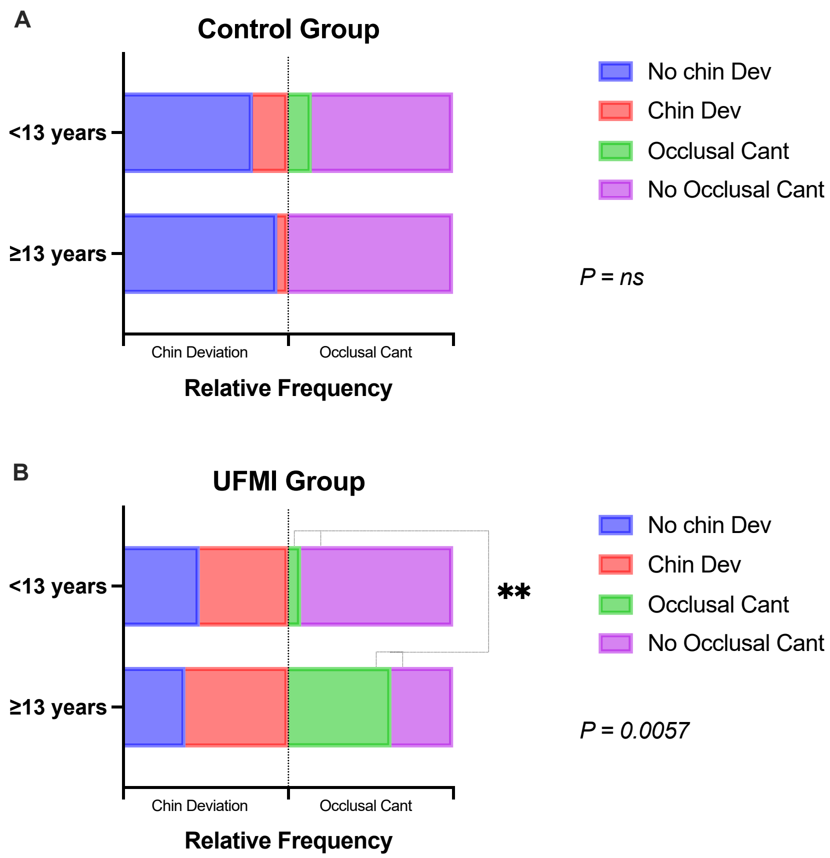

Fig 2. Relative frequency of CD and OC in the control **(A)** and UFMI **(B)** groups. *NS*, not significant. **P* <0.05; ***P* <0.01; ****P* <0.001; **** *P* <0.0001.

Table IV. Comparison between maxillary and mandibular infraoccluded teeth

Variables	*Maxillary, %*	*Mandibular, %*	P *value*
OC	33	41	0.660
CD	66	53	0.450
VAI	4.37 ± 3.54	2.41 ± 1.49	0.086
RLD	5.16 ± 5.58	3.63 ± 3.26	0.580
CLD	7.49 ± 4.37	4.97 ± 3.64	0.043*

In the control group, none of the subjects had a VAI larger than 3%. In contrast, 35% of the UFMI group had VAI bigger than 3% (*P* <0.001; Table V). The differences were statistically significant in all age subgroups as well (Table V).

In contrast to the VAI measurements, RLD ratios exceeding 3% were also found in the controls. However, the UFMI group exhibited a significantly higher proportion of patients with RLD ratios above the threshold than the controls (52% vs 24%, respectively; *P* = 0.030; Table V). Interestingly, within age subgroups of control subjects, the percentage of patients with RLD >3% was significantly higher among older subjects compared with younger subjects (Fig 3, *A*), but not significantly different in the UFMI age subgroups (Fig 3, *B*). Consequently, the differences between UFMI and controls were statistically significant only in the young subgroups (46% vs 7%; *P* = 0.016; Table V).

Table V. Comparing clinical significance (threshold 3%)

Variables	*Control, %*	*UFMI, %*	P *value*
Total			
VAI ≥3%	0	34.5	<0.001*
RLD ≥3%	24.0	51.7	0.030*
Aged >13 y			
VAI ≥3%	0	25.0	0.038*
RLD ≥3%	40.0	56.0	0.290
Aged <13 y			
VAI ≥3%	0	46.0	0.003*
RLD ≥3%	7.0	46.0	0.016*

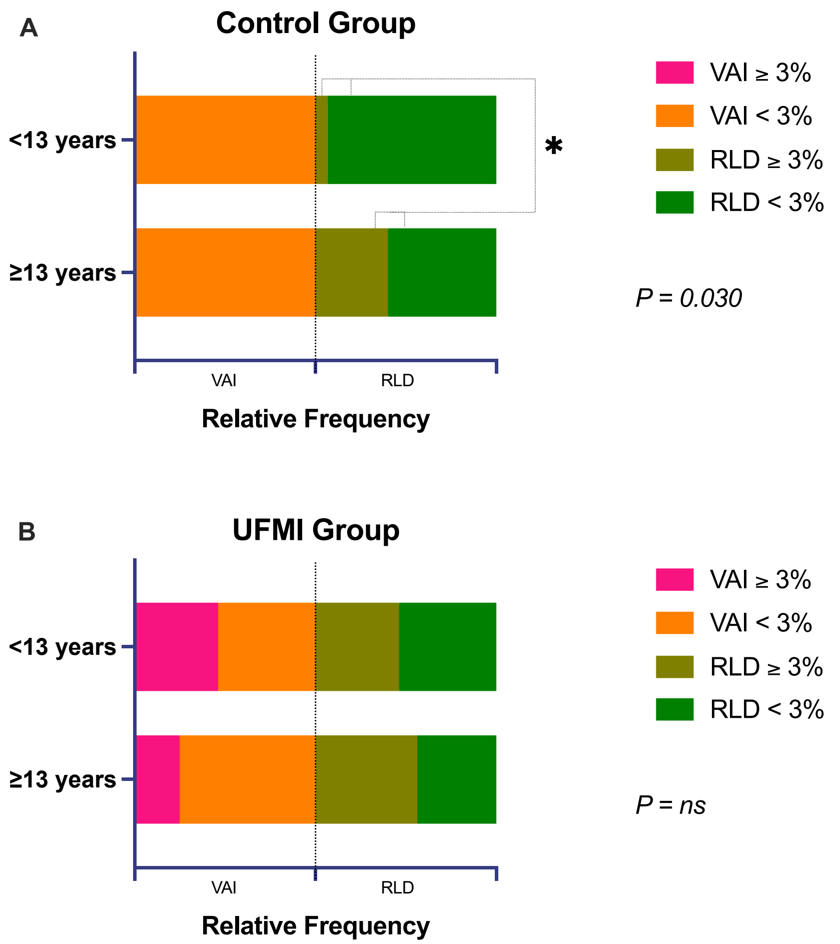

Fig 3. Relative frequency of values above the clinical significance level (set to 3%) of VAI and RLD in the control **(A)** and UFMI **(B)** groups. *NS*, not significant. **P* <0.05; ***P* <0.01; ****P* <0.001; **** *P* <0.0001.

In the initial analysis, we compared the entire control group with the UFMI group, irrespective of age (Fig 4). In the control group, we observed a moderate positive but significant correlation between VAI and RLD (0.42; $P = 0.024$; Fig 4, *A*), as well as between RLD and age (0.48; $P = 0.008$; Fig 4, *A*). However, we did not find any significant correlations between OC or CD and the other measured variables (Fig 4, *A*). In contrast, in the UFMI group, we found moderate positive but significant correlations between the prevalence of OC and age, as well as between the OC and CD (0.43 [$P = 0.019$] and 0.51 [$P = 0.004$], respectively; Fig 4, *B*). In addition, we observed a moderate positive and significant correlation between the incidence of CD and RLD (0.38; $P = 0.039$; Fig 4, *B*).

The effect of age on the correlations was also examined. In the older groups, a moderate yet significant positive correlation (0.62; $P = 0.015$; Fig 4, *C*) was observed between RLD and VAI in the controls, and significant positive correlations were found in UFMI patients between CD and OC (0.73; $P = 0.008$; Fig 4, *D*) and VAI and RLD (0.53; $P = 0.037$; Fig 4, *D*). In contrast, no correlations with age were found in the young patients in both the control and UFMI groups (Fig 4, *E* and *F*).

DISCUSSION

This study comprised a relatively large group of patients with UFMI, which failed to erupt, likely because of ankylosis. The sample distribution showed a preponderance for the lower jaw, similar to infraoccluded deciduous molars.[7,27] A left-sided predominance was found, which has also been observed in other dental anomalies, such as tooth transposition,[28,29] impacted

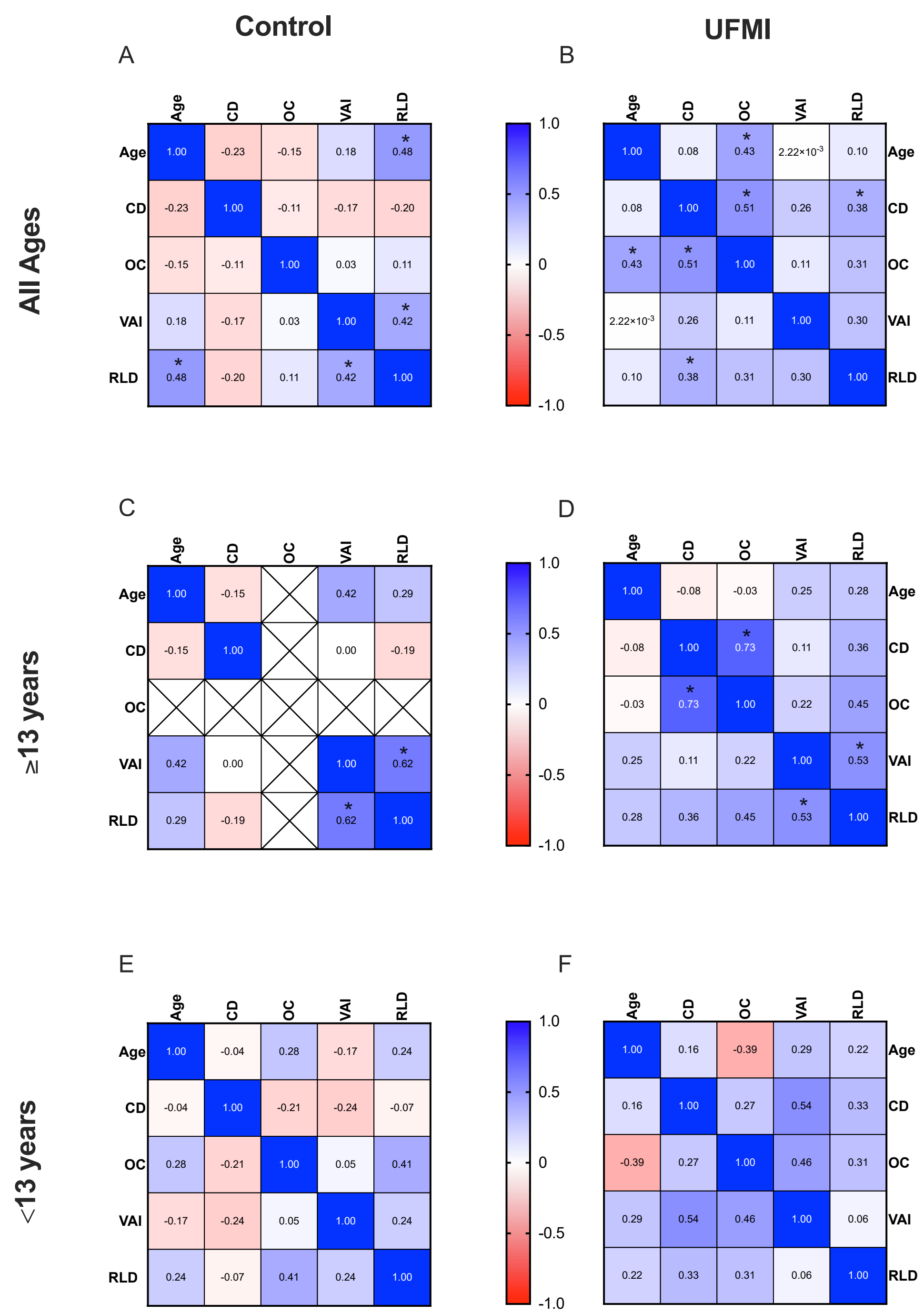

Fig 4. The correlation matrix heat map showing the relationships between different variables, including age, occurrence of OC and CD, and measurements such as VAI and RLD in the control **(A)** and UFMI **(B)** groups. A similar analysis was done according to age subgroups aged <13 years and >13 years in the control **(C** and **E)** and UFMI **(D** and **F)** groups. *NS*, not significant. **P* <0.05; ***P* <0.01; ****P* <0.001; *****P* <0.0001.

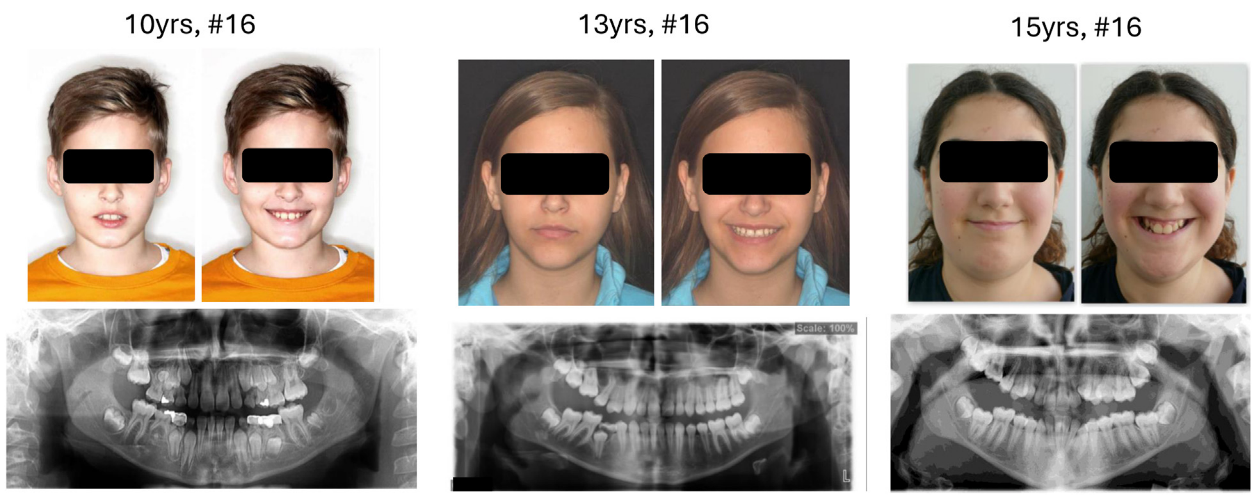

Fig 5. Examples illustrating patients from 3 different age groups with UFMI (maxillary right first molar): preadolescents (aged 9-11 years), adolescents (aged 11-15 years), and young adults (aged >15 years).

palatal canine,[30] maxillary lateral incisor agenesis,[31] peg-shaped maxillary lateral incisors,[32] and cleft lip and palate and lateral facial cleft.[33]

The results clearly demonstrate an increased prevalence of facial and skeletal asymmetry in patients with UFMI when compared with age and gender-matched patients with normally erupted molars. The asymmetry increased with age (Fig 5). As far as we know, this broader effect of molar infraocclusion on facial and skeletal development has never been reported.

The possible explanation relies on understanding the effect of tooth eruption on facial development. When a molar fails to erupt and remains infraoccluded in a growing individual, it impedes the development of the surrounding bone and the normal vertical skeletal growth.[5,20] A correlation between the infraocclusion of deciduous molars and mandibular growth has previously been reported by Leonardi et al[34] and Lanteri et al.[35] However, even if such a correlation is true, the effect of a deciduous molar on growth is temporary and resolves once it sheds and its successor erupts.[21,22] In contrast, in permanent dentition, a unilateral molar infraocclusion will potentially lead to unbalanced development of the 2 sides of the jaw and permanent asymmetry. The jaw will shift to accommodate the infraoccluded molar with the underdeveloped surrounding alveolar bone process, triggering compensatory changes to adapt to the imbalanced occlusion, consequently affecting also the muscles.

The UFMI group had significantly higher VAI values than the control group (Table II). This trend was also seen in both age subgroups (Table III).

Using the threshold of 3% difference for clinical relevance,[25] the difference between the groups was even more prominent, as more than one-third of the patients in the UFMI group vs none of the patients in the control group had VAI values over the threshold (Table V). VAI values >3% were also observed in both UFMI age subgroups (Table V). These findings suggest that VAI values >3% threshold can discriminate and serve as a tool in the early diagnosis of asymmetrical facial development. Similarly to VAI, the RLD ratios were significantly higher in the UFMI group than in the control group (Table II). However, when considering age, statistically significant RLD ratios were only observed in the younger group (Table III). A similar pattern was observed when examining RLD values >3% cutoff value (Table V). This suggests that RLD values >3% can also be used as a tool for detecting asymmetry in younger patients (Tables III and V).

OC and CD are important clinical manifestations of developing asymmetries. Patients with UFMI showed a significantly higher prevalence of CD and OC compared with controls. It is noteworthy to mention that patients exhibiting OC or CD were also found in the young control group. However, among older control patients, none displayed OC, and the prevalence of CD was low. This may imply that OC and CD may appear during the transition from mixed to permanent dentition; however, they are transient and subsequently resolved in the permanent dentition.

A statistically significant positive correlation between OC and CD was present only in the UFMI group. This correlation was moderate in patients aged <13 years and became stronger in those aged >13 years (Fig 4).

On the basis of these data, CD and OC can serve as valuable indicators for asymmetry at a later stage. The CD was specifically shown to have the biggest impact on assessing facial asymmetry.[23] It is important to understand that once these indicators are noticeable, orthodontic correction of asymmetry may become challenging.

Our findings hold significant implications for treatment timing. The moderate but significant increase in the prevalence of OC and CD with age and the strong positive correlation between OC and CD in the older age UFMI group undermine the importance of timely diagnosis of molar infraocclusion.

Early intervention may help to restore balance to the dental arch and prevent the unwanted development of dentoalveolar and skeletal asymmetry. If asymmetry is already developed, early treatment can take advantage of the remaining growth to encourage alveolar bone development and symmetrical skeletal growth.

In contrast, if diagnosed late, correction of asymmetry by orthodontic means alone may prove challenging, if not impossible. In these instances, treatment outcomes must be sometimes compromised or asymmetry corrected by surgical means. These limitations must be understood by the practitioner and explained to the patient and parents at the beginning of treatment to avoid frustration when a symmetrical outcome cannot be achieved.

The study has several limitations that should be considered when interpreting the results. Firstly, the retrospective design and use of a convenience sample, because of the rarity of this condition, may introduce selection bias. Moreover, the age range of participants (9-27 years) is broad, encompassing children, adolescents, and adults, which may complicate the interpretation of results across different developmental stages. Finally, because of local health regulations, the study did not include advanced imaging techniques such as cone-beam computed tomography, which could have provided more accurate measurements of asymmetry. Nevertheless, panoramic x-rays have been shown to be reliable in assessing asymmetries,[25,26] because distortions predominantly manifest in the horizontal rather than the vertical dimension.[36,37]

CONCLUSIONS

This study reveals that UFMI is linked with facial and skeletal asymmetry.

1. The facial and skeletal asymmetry associated with UFMI worsens with age. Therefore, early diagnosis is crucial to allow the initiation of orthodontic intervention to avoid these unwanted effects and encourage symmetrical growth. Pediatric dentists, who are the first to meet these patients, should be aware of the early signs of infraocclusion and its skeletal implications.
2. If UFMI is diagnosed late and asymmetry has already developed, a compromise in treatment outcome must be anticipated and shared with the patients. Alternatively, more complex approaches, including the use of skeletal anchorage or orthognathic surgery, may be considered.

AUTHOR CREDIT STATEMENT

Zehava Geller Fishman contributed to methodology, investigation, validation, and manuscript review and editing; Avi Leibovich contributed to methodology, investigation, validation, manuscript review and editing, and formal analysis; Heli Rushinek contributed to conceptualization, methodology, and investigation; Roberta Lione contributed to investigation; Paola Cozza contributed to investigation; Adrian Becker contributed to methodology and original draft preparation; Stella Chaushu contributed to conceptualization, methodology, investigation, validation, manuscript review and editing, supervision, project administration, and formal analysis.

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