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An investigation into the association between facial profile and maxillary incisor trauma, a clinical non-radiographic study

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Abstract – *Objectives*: To explore the association between maxillary incisor trauma (MIT) and facial skeletal forms (sagittal and vertical), overjet (OJ), lip coverage, and gender. *Subjects and methods*: Five hundred and two subjects (253 females and 249 males, aged 11–14 years) were examined. Sagittal (Class I, II or III) and vertical skeletal pattern (average, increased or decreased Frankfort-Mandibular Plane Angle (FMPA)) were recorded. Samples were categorized into four groups according to OJ severity: OJ ≤ 3.5 mm, 3.5 mm < OJ ≤ 6.0 mm with competent lips, 3.5 mm < OJ ≤ 6.0 mm with incompetent lips and OJ > 6 mm. Samples were also subdivided into two groups: OJ ≤ 3.5 mm and OJ > 3.5 mm. Chi-square test was performed to determine any gender differences in trauma experience. Logistic regression was performed to test for any differences in risk of MIT in different groups, and to estimate the predictive value of facial skeletal pattern (sagittal), FMPA, gender, OJ, and lip competence for MIT. *Results*: Nine percent had incisor trauma (8.4% MIT). Boys had greater odds of receiving MIT than girls (OR = 2.16; 95% CI, 1.11–4.21). Subjects with Class II skeletal patterns had greater odds of MIT than those with Class I skeletal patterns (OR = 3.98; 95% CI, 1.98–8.00). Subjects with decreased FMPA had greater odds of MIT than subjects with average FMPA (OR = 4.55; 95% CI, 2.28–9.06). Lip competence was not associated with MIT ($P > 0.05$). Subjects with OJ > 3.5 mm had greater odds of MIT than subjects with OJ ≤ 3.5 mm (OR = 2.83; 95% CI, 1.49–5.37). *Conclusion*: Compared with children with normal OJ (≤3.5 mm), Class I skeletal pattern (Straight profile) and average FMPA, the odds of MIT increased significantly in children with OJ > 3.5 mm (OR = 2.83), Class II skeletal pattern (OR = 3.98) and decreased FMPA (short face profile) (OR = 4.55), respectively.

In Iran, based on a recent cross-sectional study in the city of Yazd (1), the prevalence of children with some accidental damage to permanent maxillary incisor teeth was relatively high (27.5%) and the maxillary central incisors was reported as the teeth most at risk from trauma (1). Based on the available evidence, the risk factors for incisor trauma can be broadly classified into anatomic and socio-behavioral factors. The anatomic factors consistently reported to increase the risk of occurrence of anterior teeth injuries are: substantial maxillary incisor overjet (2–7) and inadequate lip coverage of the anterior teeth (2–5, 8).

Some researchers suggested that overjet is of minimal significance as a risk factor for maxillary incisor trauma (2, 8–10). However, other investigators observed higher trauma risk in subjects with overjet larger than 3.5 mm (3–5). There is also some evidence that individuals with overjet > 6 mm or 7 mm are more at risk, and this risk increases with higher overjet values (2, 6, 7). Information regarding the increased risk of maxillary incisor injury in subjects with inadequate lip coverage is contradictory. Although some researchers demonstrated a higher risk of maxillary incisor injury in subjects with inadequate lip coverage, (2–5, 8) others observed no association between maxillary incisor trauma and inadequate lip coverage (2, 6, 11). These findings suggest that an increased overjet may contribute to the higher risk of experiencing maxillary incisor trauma owing to the protrusion of maxillary incisors.

Gender is one of the socio-behavioral factors reported to increase the predisposition toward traumatic injuries. Males tend to suffer more incisor trauma than females (4, 5, 11–17). However, two studies failed to detect a gender difference in dental trauma experience (3, 8). Burden (3) suggested a high participation rate in sports and other risk activities of the girls in their samples as a likely explanation for their unusual finding.

While all of these studies have repeatedly identified some risk factors, no study assessed the relationship between the maxillary incisor trauma and facial forms, such as sagittal and vertical skeletal patterns. Therefore, the aim of the present study was to investigate the association between maxillary incisor trauma and variables such as facial skeletal forms (sagittal and vertical skeletal patterns), overjet, lip coverage and gender.

Subjects and methods

The present investigation forms only part of a multipurpose cross-sectional study which aimed at assessing the prevalence of malocclusions (18), orthodontic treatment needs and relationship between two occlusal indices (19, 20). After approval by the ethical committee at Isfahan University of Medical Sciences, Faculty of Dentistry, we selected the present sample of 11–14-year-old Iranian school children according to a stratified cluster sampling method, defining the students in six public schools as six strata. A total of 249 boys and 253 girls were examined, including six subjects (one female and five male) who were wearing an orthodontic appliance at the time of the survey. To our knowledge, the sample did not include any subjects with learning delay or disabilities. The examinations were performed in a well-lit room. Each maxillary and mandibular incisor was scored for presence and type of traumatic injury according to the following criteria:

0 = No evidence of trauma.
1 = Trauma limited to enamel.
2 = Trauma involving enamel and dentin.
3 = Trauma involving enamel, dentine and pulp.
4 = Discoloration due to trauma (verified by interview).
5 = Avulsed tooth due to trauma (verified by interview).

The above scoring system was based on clinical non-radiographic evidence of tooth injury. Age at injury was recorded in number of years from 6 to12 or more (with 2-year intervals) or as not known. One examiner (Ali Farahani) performed the clinical examinations. A mouth mirror, ruler, and a digital sliding caliper were used during examination. The examination comprised an extra-oral examination of skeletal relationship and an intra-oral examination of the teeth and occlusion. To assess the examiner's reliability, five percent repeat examination (25 subjects) was carried out 1 week apart. The results showed a good level of agreement (Kappa Statistics > 0.80) between the two assessments of different variables investigated. The following variables were recorded in the present study

Assessment of anterior-posterior (sagittal) skeletal pattern

This was carried out with the subjects sitting upright or standing and looking at the horizon or a distant object (Frankfort Horizontal Plane parallel to the floor). While in that position, the relationship between the lines dropped from the bridge of the nose to the base of the upper lip, and a second one extending from the base of the upper lip to the chin was assessed. These two lines should form a nearly straight line, and the angle between them indicating either profile convexity or profile concavity (21). This is the description of the relationship of the maxillary and mandibular apical bases to each other. To avoid any misinterpretation of the mentioned technique (e.g. prominent chin can give the impression of Class III skeletal relationship), the relationship between the deepest soft tissues points on upper and lower jaws were also taken into consideration (22). Skeletal relationship was recorded as follows:

1 Straight (Class I skeletal pattern).
2 Convex (Class II skeletal pattern).
3 Concave (Class III skeletal pattern).

Assessment of vertical skeletal pattern

The Frankfort-Mandibular Plane Angle (FMPA) was assessed and recorded (22). Prominent orthodontist Charles Tweed was the first to describe the importance of FMPA (or FMA as Charles Tweed described it) in orthodontics (23). This is the angle between the mandibular plane and the Frankfort plane (inferior orbital rim to the upper border of the external auditory meatus). The mandibular plane can be visualized by placing a finger or mirror handle along the lower border of mandible (21). The FMPA can be assessed clinically or measured using the lateral cephalograms. An increased FMPA usually indicates a skeletal open bite tendency, while a decreased FMPA often correlates with short anterior facial height and deep bite malocclusions. In an average or well-proportioned face, these planes intersect at the occiput region (22), posterior part of the head above the base of the neck. The FMPA was recorded as follows:

1 Average.
2 Increased.
3 Decreased.

Assessment of overjet (OJ)

This was measured to the nearest half millimeter as the distance parallel to the occlusal plane from the incisal edge of the most labial maxillary central incisor to the most labial mandibular central incisor with a ruler. The sample was categorized into four groups using the following criteria according to OJ severity:

1 OJ ≤ 3.5 mm.
2 3.5 mm < OJ ≤ 6.0 mm with competent lips.
3 3.5 mm < OJ ≤ 6.0 mm with incompetent lips.
4 OJ > 6 mm.

To perform certain statistical analyses, the sample was also subdivided into two groups according to OJ values:

1 OJ ≤ 3.5 mm.
2 OJ > 3.5 mm.

Assessment of soft tissue (lip competence)

Lip competence was evaluated with the lips in rest position and recorded as competent even though kept apart during the examination if the subject could close the lips without any noticeable strain. If lip strain was evident on closure, the lips were recorded as incompetent.

In those subjects who received orthodontic treatment at the time of examination (six subjects), an estimate of overjet and lip coverage were used and if available overjet was measured on pretreatment study models.

Statistical analysis

The data for this investigation was collected and entered into the SPSS 17 program for statistical analysis (Statistical Package for Social Sciences, SPSS Inc., Chicago, IL, USA). The percentages and types of dental trauma in subjects were calculated for both genders. Descriptive analysis including the frequency distribution was used. A chi-square test was performed to determine any gender differences in trauma experience. Logistic regression was performed to test for any differences in risk of MIT in the different groups and to estimate the predictive value of facial skeletal pattern (sagittal), vertical skeletal pattern (FMPA), gender, OJ and lip competence for maxillary incisor trauma. Any P value <0.05 was interpreted as statistically significant.

Results

A total of 45 of the 502 subjects examined (nine percent) had at least one tooth with a positive score for incisor trauma. The observed prevalence was higher in boys (12 percent) than in girls (5.9 percent) ($P < 0.05$). Incisor trauma occurred primarily in the maxillary arch (93.4) and only 6.6 percent (three subjects) had injuries to the mandibular incisors. Overall, 8.4 percent experienced maxillary incisor trauma. Only 1 traumatized incisor was found in 88.8 percent (40 subjects) and 11.2 percent had 2 or more injured incisors. Enamel fracture was the most common type of incisor trauma (6.2 percent) (Table 1).

The odds of experiencing trauma to the maxillary incisors in subjects with Class II skeletal pattern was nearly four times higher when compared with subjects with Class I skeletal pattern (OR = 3.98; 95% CI, 1.98–8.00) (Table 2). We did not record any subject with maxillary incisor trauma among those with Class III skeletal pattern. When we considered the FMPA, subjects with decreased FMPA had greater odds of trauma to the maxillary incisors when compared with subjects with average FMPA (OR = 4.55; 95% CI, 2.28–9.06) (Table 3). The univariate logistic regression showed that the male gender increased the risk of maxillary incisor trauma, with an effect of 0.77 (SE = 0.34) and with OR = 2.16 (95% CI 1.11–4.21) (Table 4). As it can be seen in Table 4, lip competence was not associated with maxillary incisor trauma ($P > 0.05$). Subjects with overjet of more than 3.5 mm had greater odds of trauma to the maxillary incisors when compared with those with overjet of ≤3.5 mm (OR = 2.83; 95% CI, 1.49–5.37) (Table 4). Similar trend was observed for individual with overjet between 3.5 and 6 mm and competent lips (OR = 2.72; 95% CI, 1.36–5.43) (Table 5).

Table 1. Gender distribution (%) of subjects with incisor traumatic injuries to the maxillary and mandibular incisors

Incisor trauma severity	Gender		
	Male	Female	Total
Trauma*	(12) 30	(5.9) 15	(9) 45
Enamel fracture	(8.4) 21	(4) 10	(6.2) 31
Dento-enamel fracture	(2) 5	(0.8) 2	(1.4) 7
Fracture of enamel, dentine and pulp	(0.8) 2	(0.8) 2	(0.8) 4
Discoloration due to trauma	(0.4) 1	(0.4) 1	(0.4) 2
Tooth avulsed	(0.4) 1	0	(0.2) 1

*Chi-square test, n = 502, P < 0.05.

Table 2. Percentages of subjects with traumatic injuries to maxillary incisors in population-based sample of 502, 11–14-year-old school children categorized into different groups. Odds ratio (OR) and 95% confidence interval (CI) are relative to group with Class I skeletal pattern

Skeletal pattern	n	% Trauma	Effect (SE)	P	OR	95% CI
Straight (Class I)	280	4.3			1	
Convex (Class II)	198	15.2	1.38 (0.35)	0.008	3.98	1.98–8.00
Concave (Class III)	24	0		0.998	0	

Table 3. Percentages of subjects with traumatic injuries to maxillary incisors in population-based sample of 502, 11–14-year-old school children categorized into different groups. Odds ratio (OR) and 95% confidence interval (CI) are relative to the group with average Frankfort-Mandibular Planes Angle (FMPA)

FMPA	n	% Trauma	Effect (SE)	P	OR	95% CI
Average	315	4.8			1	
Increased	63	6.3	0.30 (0.58)	0.60	1.35	0.43–4.23
Decreased	124	18.5	1.51 (0.35)	0.00	4.55	2.28–9.06

Table 4. Effect of gender, lip competence and increased overjet on maxillary incisor trauma in 11–14-year-old children (results according to univariate logistic regression, n = 502)

	Effect (SE)	P	OR	95% CI
Gender (Male/Female)	0.77 (0.34)	0.023	2.16	1.11–4.21
Lip coverage (Incompetent/Competent)	0.54 (0.77)	0.486	1.71	0.37–7.88
OJ > 3.5 mm vs OJ ≤ 3.5 mm	1.04 (0.32)	0.001	2.83	1.49–5.37

Table 5. Percentages of subjects with traumatic injuries to maxillary incisors in population-based sample of 502, 11–14-year-old school children categorized into four groups. Odds ratio (OR) and 95% confidence interval (CI) are relative to the group with OJ ≤ 3.5 mm

Groups	n	% Trauma	P	OR	95% CI
OJ ≤ 3.5 mm	361	5.8		1	
3.5 mm < OJ ≤ 6 mm with competent lips vs OJ ≤ 3.5 mm	111	14.4	0.004	2.72	1.36–5.43
3.5 mm < OJ ≤ 6 mm with incompetent lips vs OJ ≤ 3.5 mm	12	16.7	0.145	3.23	0.66–15.73
OJ > 6 mm vs OJ ≤ 3.5 mm	18	16.7	0.080	3.23	0.86–12.06
Total	502	8.4			

Discussion

The prevalence of incisor trauma in our study was nine percent which is within the reported range of 6–50% in previous studies (11). However, the trauma rate was considerably lower than the previously reported figure of 27.5% (1) for 9–14-year-old Iranian children in the city of Yazd. The differences in prevalence could be due to the different classification system and different age range that authors investigated (1). The comparison of characteristics of incisor trauma in the present study with previous studies would be beyond the scope of this paper and will be presented elsewhere (24). The prevalence of maxillary incisor trauma was considerably higher than mandibular incisor trauma. This is similar to the findings of previous studies (25–29). The non-rigid connection of mandible to the cranial base dissipates the blows to the mandible (30) and this combined with the low prevalence of Class III malocclusions that offer natural protection to the mandibular incisors (31) explains why maxillary incisor trauma is more frequent than mandibular incisor trauma. The classification system differs among previous studies, but it was clear that the most prevalent dental trauma type in 11–14-year-old Iranian children was a fracture of enamel only, representing 69 percent of injured teeth. This is in agreement with the findings of O'Brien (32) in the United Kingdom survey and the reports of several previous studies (1, 32–36).

The main aim of the present data analysis was to assess the association between incisor trauma and facial forms (sagittal and vertical skeletal pattern). Obtaining cephalometric views of an untreated population could not be justified ethically for the present study; therefore, we resorted to clinical and visual examination. To our knowledge, very few studies have investigated the association between facial forms and incisor trauma (2, 11, 37). In the present investigation we evaluated the sagittal skeletal relationship by assessing the relationship between the two lines connecting the bridge of the nose to the base of the upper lip (soft tissue A point), and from the base of the upper lip to the chin (soft tissue pogonion). This method has been used previously to assess the sagittal skeletal relationship (38). To assess the sagittal skeletal pattern, the patient has to be postured carefully with the head in a neutral horizontal position (Frankfort horizontal plane should be parallel to the floor). Different head postures can mask the true skeletal relationship. If the head is tipped back, the chin tends to come further forward and makes the patient appear to be more Class III. Also a prominent chin can give the impression of Class III type of skeletal relationship. Conversely, if the head is tipped down, the chin moves back and the patient appears to be more Class II. Obviously, the soft tissue thickness may vary and mask the sagittal skeletal pattern to some degree, but generally, the thickness of the upper and lower lips is similar (39). We found a significant association between Class II skeletal pattern and maxillary incisor trauma. This is in agreement with the work of Kania et al. (11). They found significantly higher percentages of incisor trauma in Class II skeletal profiles and subjects with prognathic maxillas. In contrast to our work, Kania and coworkers (11) have not investigated the association between maxillary incisor trauma and skeletal profile types and the findings include both maxillary and mandibular incisor trauma.

To the best of our knowledge, the association between the facial vertical dimension and maxillary incisor trauma is yet to be investigated. We assessed the vertical dimension measuring the FMPA. The Frankfort-Mandibular Plane Angle (FMPA or FMA) can be measured clinically (40) or extracted using the cephalometric radiographs: according to our findings, the odds of receiving maxillary incisor trauma were 4.55 times higher in subjects with reduced FMPA (short faces). A possible explanation for this finding is the fact that subjects with reduced FMPA (short faces) are more likely to represent the Class II type of malocclusion and consequently experience more maxillary incisor trauma. Within this context, perhaps more vigilant screening (clinical examination, pre-treatment radiographs, etc.) and preventive interventions (e.g. reducing the excessive overjet) should be aimed at individuals presenting with Class II skeletal profile and reduced FMPA (short face). This is reflected with the highest odds of experiencing maxillary incisor injuries in these groups.

To assess the relationship between the overjet severity and maxillary incisor trauma, we initially split the samples into four categories which was based on the overjet severity. Excluding the category of subject with $3.5 < OJ \leq 6$ mm and competent lips; other categories with increased overjet did not show a significant increase in experiencing maxillary incisor trauma. This is contrary to the findings of Årtun et al. (7). Although there was a tendency for higher prevalence of maxillary incisor trauma in subjects with overjets > 6 mm or $3.5 < OJ \leq 6$ mm (with incompetent lips), it was not significant at a 95% confidence interval. In different overjet subgroups, our representative sample of subjects with large overjets was small, and may have limited further sub-analysis. Perhaps larger study samples can identify the disparity in experiencing maxillary incisor trauma in different overjet severity groups. However, when we combined different groups into two groups of $OJ > 3.5$ mm and $OJ \leq 3.5$ mm, the difference between the groups reached significance. Compared with subjects having an overjet of ≤3.5 mm (normal overjet), the odds of experiencing maxillary incisor trauma was 2.83 times higher in subjects with an overjet of more than 3.5 mm. This confirms the findings of previous studies (3–5). We also observed a similar trend in individuals with an overjet between 3.5 and 6 mm (with competent lips). It is worthwhile mentioning that the present study provided preliminary information on the prevalence of incisor trauma and its relationship with facial forms in Iranian population and the current findings can be used for sample size calculation in testing the hypothesis of future studies.

Lip incompetence can be caused by either a lack of lip tissue or an adverse skeletal pattern. If the skeletal pattern is unfavorable in either the vertical or sagittal position, then even with normal lip length, the soft tissues are still widely separated. Some researchers demonstrated an increased risk of maxillary incisor injury in subjects with inadequate lip coverage (2–5, 8); however, we did not find any statistically significant association between lip competence and maxillary incisor trauma. This is consistent with other investigators who observed no association between maxillary incisor trauma and inadequate lip coverage (2, 6, 11). Whilst many young children have incompetent lips, this is often just a normal stage of development. As they pass through puberty, the lip length increases relative to the size of the face and the degree of lip competence gradually improves (41).

Like many studies on this topic, the present study is cross-sectional in nature and it is impossible to infer a casual relationship. Additional experimental and longitudinal studies are needed to probe further the underlying mechanisms of these associations. A possible limitation of the present study is the lack of diagnostic aides and using non-radiographic clinical scale for classification of dental trauma that might mask root fracture or periapical pathology, if it existed. The classification system we used unfortunately did not allow us to record the full spectrum of trauma related problems including; craze lines on the enamel, displacement, intrusion or extrusion due to injury, and this can potentially affect the final result. A retrospective nature of the present study, unfortunately, does not allow investigating and recording some oral injuries, such as alveolar fractures and soft tissue injuries, if they are not present at the time of the clinical examination. If the injury occurred sometime beforehand, it could be missed if signs and symptoms do not exist at the time of the examination. Another shortcoming of retrospective studies is the accuracy of a patient's recall of the injury, if the accident occurred months or even years before the examination.

As Glendor et al. (40) pointed out that the prevalence rate of dental injuries is usually higher than the reported ones by cross-sectional studies and these studies tend to underestimate its occurrence, which is related to the retrospective nature of these studies (40). A further potential limitation of our study is that we evaluated a relatively younger population of 11–14 years old. It is not clear if our findings can be applied to the older population. Younger patients are likely to have more dental trauma risk factors, such as the level of activity and hence our findings are not necessarily applicable to the general population. Therefore, due to inability of this study (and similar cross-sectional studies) to adjust for unrecognized confounders, it is possible that dental trauma is a surrogate for one or more unmeasured variables that may be causally linked to facial forms or increased overjet.

Within the above discussed limitations, the findings in the current study suggest that children with convex profile (Class II skeletal pattern), reduced FMPA (short face), and increased overjet are involved in susceptibility to receive maxillary incisor trauma.

Conclusion

Compared with children with normal OJ (≤3.5 mm), Class I skeletal pattern (straight profile) and average FMPA angle, the odds of maxillary incisor trauma increased significantly in children with OJ > 3.5 mm (OR = 2.83), Class II skeletal pattern (OR = 3.98), and decreased FMPA (short face profile) (OR = 4.55), respectively. Lip competence was not associated with maxillary incisor trauma.

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