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The association between incisor trauma and occlusal characteristics in individuals 8–50 years of age

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Abstract – To explore the association between incisal trauma and occlusal characteristics using oral examination and health interview data from the Third National Health and Nutrition Examination Survey 1988–1994 (NHANES III). Incisal trauma examinations were performed on 15 364 individuals 6–50 years of age using an ordinal scale developed by the National Institute of Dental and Craniofacial Research. Occlusal examinations were performed on 13 057 individuals 8–50 years of age. We fitted separate multivariate logistic regression models for maxillary and mandibular incisor trauma adjusting for socio-demographic variables (age, gender, race-ethnicity) and occlusal characteristics (overbite, overjet, open bite). 23.45% of all individuals evidenced trauma on at least one incisor, with trauma more than four times more prevalent on maxillary (22.59%) than on mandibular incisors (4.78%). Males (OR = 1.67) had greater odds of trauma than females; Whites (OR = 1.37) and non-Hispanic Blacks (OR = 1.37) had greater odds of trauma than Mexican–Americans. The odds of trauma increased with age, peaked from age 21 to 30 (OR = 2.92), and declined. As overjet increased, so did the odds of trauma. Compared to individuals with ≤0-mm overjet, odds of trauma increased from 1–3 mm (OR = 1.42) to 4–6 mm (OR = 2.42) to 7–8 mm (OR = 3.24) to >8 mm (OR = 12.47). Trauma to incisors is prevalent but mostly limited to enamel. Trauma to maxillary incisors is associated with overjet, gender, race-ethnicity, and age, while trauma to mandibular incisors is associated with gender, age, and overbite.

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Incisor trauma of one or more teeth may result in pain, disfigurement, poor esthetics, speech, and psychological effects (1). Usually in children, incisal trauma is attributed to sport injuries, playground injuries, or those injuries related to bicycling, skateboarding, or roller blade accidents. When trauma results in loss of pulp vitality, the tooth is in further jeopardy of enamel-dentin crown fracture because of future dental trauma (2), the attendant dental morbidity that occurs, substantial costs to the injured person and community arise, indicating the continued need for research toward the prevention of facial trauma.

Çelenk et al. (3) found that dental fractures in early permanent teeth were primarily caused by falls and collisions. Marcenes et al. (4) reported that 45% of injuries to permanent incisors of 9–12-year-old Syrian schoolchildren were caused by violence (42.5%). Recently, Nicolau et al. (5) found that adolescents who experienced adverse psychosocial environments suffered more traumatic dental injuries than their counterparts who experienced more favorable environments.

Overall, the preponderance of incisor trauma occurs to children 8–13 years of age (1, 3, 4, 6–12).

Caliskan & Turkun (13) found that patients aged 11–15 years exhibited the highest number of injuries (34.4%) followed by the 6–10-year-old group (24.5%). Furthermore, males tend to suffer more incisor trauma injuries (64.8%) than females (35.2%). Males suffer predominately more often from incisor trauma than females (3, 6, 10, 12, 14–20). This is not an uncommon conclusion based on the type of activity boys participate in compared to girls of this age. Yet, Alonge et al. (1) and Burden (21) did not find a statistically significant difference in the prevalence of incisor fracture among male and female schoolchildren.

The maxillary central incisor is most often affected in both primary and permanent dentition injuries (10, 17, 22). Most injuries involved one tooth (60%), and maxillary central incisors are the most often affected teeth (66.2%) depending upon the severity of the blow to the anterior face (13). This finding in multiple studies suggests that an overbite or an overjet may contribute to a higher risk of dental injury to the maxillary incisor because of the relationship of the malocclucded incisor jutting away from the face (10, 15, 21, 23, 24).

Further, inadequate lip coverage may provide less protection to the malocclucded incisors and thus easily contribute to the increased risk of dental injury depending on the severity of the trauma. Kania et al. (19) found that incisor injury was greater for children who had a prognathic maxilla, were male, and had greater overjet. According to Järvinen (11), the frequency of injuries was 14.2% in children with normal overjet (0–3 mm), 28.4% in children with increased overjet (3.1–6.0 mm), and 38.6% in children with extreme overjet (>6 mm). He also determined that the range of injuries increaseed in relation to the overjet. Research reports that children with untreated overjet, overbite, and inadequate lip coverage suffer from a higher incidence of incisor trauma. Burden (21) found that both inadequate lip coverage and increased overjet were significant risk factors for maxillary incisor trauma, with inadequate lip coverage (OR = 2.62) the most important. Children who suffer from malocclusion compounded by inadequate lip coverage are at greater risk than those suffering incisor trauma (13, 21, 24). This population may need special preventive strategies to protect them from the morbidity suffered incisor trauma.

Brin et al. (8) found that increased overjet and inadequate lip coverage of the maxillary incisors are not fully capable of predicting the likelihood of dental injury. Furthermore, Stokes et al. (25) showed that overjet is not a positively correlated with traumatic dental injury in Singapore schoolchildren. Marcenes et al. (16) also found that children with incisor overjet greater than 5 mm and inadequate lip coverage are not more likely to experience dental injuries in Brazil. Table 1 summarizes studies of risk factors associated with incisor trauma.

While most studies of incisor trauma used individuals' orofacial characteristics as covariates, some focused on demographic and socio-economic characteristics. Kania et al. (19) found that 'non-Caucasians' had a higher prevalence of incisor trauma than Caucasians in a univariate analysis, but the association was not strong enough for it to be included in the multivariate logistic model. Alonge et al. (1) found that the prevalence of incisor trauma was higher in non-Hispanic Blacks and Hispanics than Whites.

Some studies used income and measures of social status. The findings, however, were equivocal. Hamilton et al. (20) and Alonge et al. (1) found children in lower socio-economic groups had a higher prevalence of incisor trauma than those in higher socio-economic groups while Cortes et al. (9) found that Brazilian children from higher socio-economic groups had greater odds of incisor trauma than children from lower socio-economic groups. Nicolau et al. (5) found that being in a non-nuclear family and having a high level of paternal punishment were associated with incisor trauma in Brazilian adolescents. Marcenes & Murray (15) found that living in an overcrowded household was associated with incisor trauma in British adolescents. Marcenes et al. (16) did not find parents' education level, employment status, or family income to have a statistically significant association with incisor trauma in Brazilian adolescents.

Kaste et al. (22) presented a summary of the incisor trauma data from the phase one (1988–1991) of the Third National Health and Nutrition Examination Survey, 1988–1994 (NHANES III). NHANES III collected data using a trauma index developed by the National Institute of Dental Research for large-scale epidemiologic surveys (22) applied to each of the eight permanent incisors or tooth spaces, with scores ranging from 0 (no evidence of trauma) to 6 (tooth missing because of trauma). Based on an analysis of 7569 clinical examinations on individuals between 6 and 50 years of age, they found that 24.9% of those examined had evidence of incisor trauma, with enamel fracture the predominant condition accounting for 45.8% of the traumatized teeth.

While Kaste et al. (22) described data from the first 3 years of NHANES III, this paper analyzes the full 6 years of data and explores the association between incisor trauma and potential risk factors suggested by the literature and occlusal characteristics from NHANES III. While most studies of incisor trauma focused on children and youth, NHANES III allows us to examine factors associated with maxillary and mandibular incisor trauma in individuals 8–50 years of age.

Table 1. Summary of studies of risk factors associated with incisal trauma

Study	Country	Age group (years)	Sample size	Source of sample	Risk factors associated with trauma
Çelenk et al. (3)	Turkey	9–15	208	Dental school	Males > females 9–11 >12–15
Şarog . . lu & Sönmez (17)	Turkey	3–15	147	Dental school	Males > females
Cortes et al. (9)	Brazil	9–14	3702	Schoolchildren	High SES > low SES Males > females Overjet >5 mm Inadequate lip coverage
Alonge et al. (1)	USA	8–9	1039	Schoolchildren	Males > females Low SES > high SES Non-Whites > Whites
Marcenes & Murray (15)	UK	14	2242	Schoolchildren	Males > females Overjet >5 mm Living in an overcrowded household
Al-Majed et al. (23)	Saudi Arabia	5–14	1216	Schoolchildren (boys)	Overjet ≥6 mm
Brin et al. (8)	Israel	Mean = 11.7 SD = 1.37	154	Orthodontic practice	Overjet
Marcenes et al. (16)	Brazil	12	476	Schoolchildren	Males > females
Marcenes et al. (4)	Syria	9–12	1087	Schoolchildren	Inadequate lip coverage
Hamilton et al. (20)	UK	11–14	2022	Schoolchildren	Males > females Low SES > high SES
Petti & Tarsitani (18)	Italy	6–11	519	Schoolchildren	Males > females
Kania et al. (19)	USA	7–12	3396	Elementary school children	Males > females Older > younger Whites > non-Whites Overjet
Burden (21)	Northern Ireland	11–12	1113	Schoolchildren	Inadequate lip coverage Overjet
Otuyemi (6)	Nigeria	12	1016	Schoolchildren	Males > females Inadequate lip coverage Overjet
Forsberg & Tedestam (24)	Sweden	7–15	1610	Schoolchildren	Overjet >4 mm Inadequate lip coverage
Zerman & Cavalleri (12)	Italy	6–21	2798	Dental school patients	Males > females
Dearing (10)	New Zealand	7–15	186	Orthodontic patients	Males > females Overjet Inadequate lip coverage
Järvinen (11)	Finland	7–16	1445	Schoolchildren	Overjet

Methods

We used pubically available data from NHANES III, a periodic survey conducted by National Center for Health Statistics. The survey used a complex, multistage sample plan and was designed to provide national estimates of the health and nutritional status of the United States civilian, non-institutionalized population aged 2 months and older (26). From 19 528 randomly selected households, 33 994 subjects were interviewed, 30 818 were examined in mobile examination centers, and 493 were examined at home. Examinations were performed by calibrated dentists and physicians; extensive health, social, and nutritional histories were obtained by interviewing the subjects or their parents; and blood specimens were drawn. A detailed discussion of the survey methods is presented by Drury et al. (27)

Assessment of incisor trauma, performed on all dentate subjects between the ages of 6 and 50 years with at least one permanent incisor, was based on 'clinical, non-radiographic evidence of tooth injury and treatment received by the eight permanent incisors, including a positive history of injury obtained from the examinee'. Incisors were classified as having: (i) no history of trauma; (ii) untreated enamel fracture not involving dentin; (iii) unrestored fracture involving dentin; (iv) untreated injury evidenced by dark discoloration, swelling, and/or fistula; (v) restored fracture; (vi) endodontic therapy following traumatic injury; (vii); tooth missing because of trauma; and (viii) could not be assessed (26).

To explore the association between incisal trauma and potential risk factors suggested by the literature (socio-demographic variables: age, gender, and race-ethnicity) and occlusal characteristics. Race-ethnicity was categorized as non-Hispanic White, non-Hispanic Black, Mexican–American, and other. Subjects classified as 'other' were excluded from analyses using the race-ethnicity variable resulting in the removal of 684 (8.9%) subjects categorized as 'other' from some analyses.

Occlusal characteristics were measured on subjects 8–50 years of age. Occlusal characteristics used in this

study are overjet, overbite, and open bite (28). Overjet was 'measured to the nearest whole millimeter by use of a periodontal probe from the midpoint of the labial surface of the most anterior lower central incisor to the midpoint of the labial surface of the most anterior upper central incisor, parallel to the occlusal plane' (28). Overbite was assessed on the maxillary right central incisor to the nearest whole millimeter using a periodontal probe. If the right maxillary or mandibular central incisor were missing or fractured, the left central incisors were used. Open bite was the distance in millimeters from the edge of the mandibular central incisor to the edge of the maxillary central incisor with the posterior teeth in occlusion (28).

As the survey uses complex, multistage sampling, we used Statistical Analysis System® (SAS 9.0)-callable SUDAAN 8.0 to compute standard errors for all variables adjusting for the survey design (design effect) as well, providing the (weighted) population size to which the prevalence data can be projected. For example, the 15 364 subjects 6–50 years of age who received an incisor trauma examination represent 159 481 882 individuals in the US population (weighted count).

To explore the risk factors associated with incisor trauma, we recoded the 6-level trauma scale to a binary variable. We performed bivariate logistic regressions on maxillary and mandibular incisor trauma with the previously described covariates. Table 3 presents the results of the logistic regression models. Variables with a Wald F-statistic with a P-value of <0.10 were fitted to a multivariate logistic models using forward selection. Covariates and interactions with $P < 0.05$ were retained in the final models.

Results

Table 2 shows that 23.45% of the 15 364 individuals evidenced trauma on at least one incisor, with trauma more than four times more prevalent on maxillary (22.59%) than on mandibular incisors (4.78%). Trauma prevalence is higher in subjects aged 21–50 years (27.09%) than those aged 6–20 years (15.98%); higher in males (28.09%) than in females (18.98%); higher in Whites (24.81%) than in non-Hispanic Blacks (23.33%) or in Mexican–Americans (19.42%).

Table 3 shows the distribution of trauma by tooth. Trauma was more prevalent on maxillary than on mandibular incisors. Maxillary right central incisors had the highest trauma prevalence (15.17%) followed by maxillary left central incisors (14.72%), left lateral incisors (3.63%), and right lateral incisors (1.58%). Among the mandibular incisors, left centrals had higher prevalence (2.70%) than right centrals (2.60%), right laterals (1.60%), or left laterals (1.43%). Enamel trauma was the predominant type of trauma on all teeth.

Table 4 shows bivariate logistic regression models for maxillary incisor trauma. Males had greater odds of trauma than females (OR = 1.71; $P < 0.0001$); and Whites (OR = 1.39; $P < 0.0001$) and non-Hispanic Blacks (OR = 1.35; $P < 0.0001$) had greater odds of trauma than Mexican–Americans. The odds of trauma generally increased with age (compared to the referent), but differences between the age groups were not statistically significant. The association between overjet and trauma was statistically significant beyond 3 mm with the odds ratios increasing

Table 2. Percentage of subjects 6–50 years of age with trauma to permanent incisors

	Sample size	All incisors	SE	Maxillary incisors	SE	Mandibular incisors	SE
Age (years)	15364	23.45	0.665	22.59	0.615	4.78	0.421
6–20	6558	15.98	0.782	15.80	0.802	3.06	0.452
21–50	8806	27.09	0.651	25.87	0.774	5.63	0.525
Gender	15364	23.45	0.665	27.19	1.084	6.45	0.627
Male	7209	28.09	1.068	27.19	1.084	6.45	0.627
6–20 years	3179	20.06	1.127	19.80	1.194	4.95	0.734
21–50 years	4030	32.14	1.385	30.79	1.362	7.20	0.777
Female	8155	18.98	0.854	18.08	0.884	3.17	0.374
6–20 years	3397	11.84	0.873	11.84	0.888	1.13	0.296
21–50 years	4776	22.29	1.090	21.08	1.153	4.13	0.514
Race-ethnicity	14680	24.17	0.693	23.29	0.613	4.81	0.460
White	4368	24.81	0.890	23.78	0.780	4.92	0.564
6–20 years	1704	16.99	0.985	16.82	1.041	3.44	0.602
21–50 years	2664	28.28	1.071	26.83	0.932	5.58	0.703
Black	5150	23.33	0.760	23.32	0.748	4.17	0.386
6–20 years	2287	16.32	0.836	16.08	0.837	2.07	0.417
21–50 years	2863	27.68	1.243	27.90	1.273	5.47	0.472
Mexican–American	5162	19.42	0.943	18.38	1.005	4.93	0.530
6–20 years	2264	13.90	1.034	13.37	1.000	3.69	0.532
21–50 years	2898	23.02	1.174	21.53	1.259	5.73	0.700

Table 3. Percentage distribution and standard error of incisors by trauma score

Trauma score	Total (SE)	Maxillary				Mandibular			
		Left lateral (SE)	Left central (SE)	Right central (SE)	Right lateral (SE)	Left lateral (SE)	Left central (SE)	Right central (SE)	Right lateral (SE)
No trauma	94.38 (0.35)	96.32 (0.37)	85.28 (0.55)	84.83 (0.46)	96.42 (0.36)	98.57 (0.22)	97.30 (0.30)	97.40 (0.31)	98.49 (0.21)
Trauma	5.62	3.68	14.72	15.17	1.58	1.43	2.70	2.60	1.60
Enamel	2.34 (0.27)	1.59 (0.26)	5.90 (0.38)	5.89 (0.30)	1.34 (0.26)	0.72 (0.17)	1.14 (0.20)	1.37 (0.20)	0.92 (0.16)
Dentin	0.93 (0.11)	0.39 (0.09)	2.27 (0.20)	2.52 (0.25)	0.48 (0.10)	0.40 (0.09)	0.62 (0.12)	0.48 (0.10)	0.31 (0.07)
Pulpal damage	0.25 (0.03)	0.12 (0.05)	0.70 (0.13)	0.72 (0.13)	0.17 (0.08)	0.03 (0.02)	0.11 (0.03)	0.01 (0.04)	0.08 (0.04)
Repair – tooth	1.26 (0.11)	0.67 (0.12)	3.92 (0.25)	3.79 (0.22)	0.89 (0.14)	0.07 (0.03)	0.52 (0.11)	0.36 (0.10)	0.04 (0.02)
Repair – pulpal	0.23 (0.04)	0.20 (0.08)	0.61 (0.15)	0.83 (0.16)	0.12 (0.04)	0.03 (0.02)	0.03 (0.02)	0.04 (0.02)	0.01 (0.01)
Missing	0.60 (0.09)	0.71 (0.10)	1.32 (0.16)	1.41 (0.16)	0.58 (0.11)	0.18 (0.05)	0.28 (0.07)	0.26 (0.06)	0.16 (0.04)

markedly as overjet increased. Neither overbite nor open bite was significantly associated with incisal trauma.

Table 5 shows bivariate logistic regression models for mandibular incisor trauma. Males had greater odds of trauma than females (OR = 2.10). The association between race-ethnicity and trauma was not significant. The odds of trauma generally increased with age (compared to the referent), peaking at age 36–40 (OR = 6.34), and then declining. While the Wald F-test for the main effect of overjet was significant ($P = 0.03$), odds ratios for 1–3, 4–6, and 7–8 mm were elevated but not significantly different from the referent. Individuals with open bites >2 mm had lower odds of trauma than the referent.

Tables 6 and 7 show multivariate models for maxillary and mandibular incisor trauma, respectively. The odds ratios given are adjusted for the presence

Table 4. Bivariate logistic model for risk factors associated with maxillary incisor trauma

	Estimate	SE	OR	95% CI for OR	t	P
Gender						
Male	0.5376	0.0808	1.71	1.46, 2.01	6.65	<0.0001
Female	[Referent]					
Race-ethnicity						
White	0.3260	0.0853	1.39	1.17, 1.64	3.82	<0.0001
Black	0.3003	0.0774	1.35	1.16, 1.58	3.88	<0.0001
Mexican–American	[Referent]					
Age (years)						
<10	[Referent]					
11–15	0.5969	0.1650	1.82	1.30, 2.50	3.62	0.0007
16–20	1.0652	0.1857	2.90	2.00, 4.21	5.74	<0.0001
21–25	1.2133	0.1759	3.36	2.36, 4.79	6.90	<0.0001
26–30	1.2864	0.1745	3.62	2.55, 5.14	7.37	<0.0001
31–35	1.3214	0.1503	3.75	2.77, 5.07	8.79	<0.0001
36–40	1.2536	0.1580	3.50	2.55, 4.81	7.93	<0.0001
41–45	1.2881	0.1991	3.63	2.43, 5.41	6.47	<0.0001
46–50	1.0779	0.2034	2.94	1.95, 4.42	5.30	<0.0001
Overjet (mm)						
−8 to −1	−0.0075	0.2965	0.99	0.55, 1.80	−0.02	0.9798
0–3	[Referent]					
4–6	0.4180	0.0695	1.52	1.32, 1.75	6.01	<0.0001
6–8	0.7415	0.2022	2.10	1.40, 3.15	3.67	0.0006
>8	1.4215	0.2894	4.14	2.32, 7.41	4.91	<0.0001
Overbite (mm)	0.0283	0.0225	1.03	0.98, 1.08	1.58	0.21
0	[Referent]					
1–2	0.0776	0.1204	1.08	0.85, 1.38	0.64	0.53
3–4	0.1687	0.1264	1.18	0.92, 1.53	1.33	0.19
5–6	0.2325	0.1618	1.26	0.91, 1.75	1.44	0.16
> 6	0.1164	0.2256	1.12	0.71, 1.77	0.52	0.61
Open bite (mm)	−0.0650	0.0844	0.94	0.79, 1.11	0.59	0.45
0	[Referent]					
1–2	0.0889	0.3717	1.09	0.52, 2.31	0.24	0.82
3–4	−0.6470	0.5466	0.52	0.17, 1.57	−1.18	0.24
>4	−0.1873	0.6004	0.83	0.25, 2.77	−0.31	0.76

Table 5. Bivariate logistic model for risk factors associated with mandibular incisor trauma

	Estimate	SE	OR	95% CI for OR	*t*	*P*
Gender						
Male	0.7440	0.1251	2.10	1.63, 2.71	5.91	<0.0001
Female	[Referent]					
Race-ethnicity						
White	−0.0014	0.1529	1.00	0.73, 1.36	−0.009	0.99
Black	−0.1746	0.1449	0.84	0.63, 0.12	−1.20	0.23
Mexican–American	[Referent]					
Age (years)						
<10	[Referent]					
11–15	1.0279	0.3323	2.80	1.43, 5.45	3.09	0.0032
16–20	1.5962	0.2982	4.93	2.71, 8.98	5.35	<0.0001
21–25	1.7809	0.3961	5.94	2.70, 13.16	4.50	<0.0001
26–30	1.5909	0.3185	4.91	2.59, 9.31	5.00	<0.0001
31–35	1.7819	0.3353	5.94	3.03, 11.65	5.31	<0.0001
36–40	1.8469	0.3255	6.34	3.30, 12.19	5.67	<0.0001
41–45	1.5940	0.3251	4.92	2.56, 9.46	4.90	<0.0001
46–50	1.3698	0.4162	3.93	1.70, 9.08	3.29	<0.0001
Overjet (mm)						
−8 to −1	0.1673	0.4829	1.18	0.45, 3.12	0.35	0.7304
0–3	[Referent]					
4–6	− 0.0534	0.1606	0.95	0.69, 1.31	−0.33	0.7407
6–8	−0.0256	0.3564	0.97	0.48, 2.00	−0.07	0.9431
>8	0.2656	0.6554	1.30	0.35, 4.87	0.41	0.6871
Overbite (mm)						
0	[Referent]					
1–2	0.1464	0.2377	1.16	0.72, 1.87	0.62	0.54
3–4	0.5887	0.2486	1.80	1.09, 2.97	2.37	0.021
5–6	0.6412	0.2767	1.90	1.09, 3.31	2.32	0.025
>6	0.5492	0.3027	1.73	0.94, 3.18	1.81	0.075
Open bite (mm)						
0	[Referent]					
1–2	−1.0951	0.8048	0.33	0.07, 1.69	−1.36	0.179
>2	−1.6338	0.6793	0.20	0.05, 0.76	−2.41	0.019

Table 6. Multivariate logistic model for risk factors associated with maxillary incisor trauma

	Estimate	SE	OR	95% CI for OR	*t*	*P*
Gender						
Male	0.5042	0.0837	1.66	1.40, 1.96	6.02	<0.0001
Female	[Referent]					
Race-ethnicity						
White	0.3447	0.0949	1.41	1.17, 1.71	3.6	0.0007
Black	0.2918	0.0808	1.34	1.14, 1.57	3.61	0.0007
Mexican–American	[Referent]					
Age (years)						
<10	[Referent]					
11–15	0.3970	0.1627	1.49	1.07, 2.06	2.44	0.0181
16–20	0.9980	0.1944	2.71	1.84, 4.01	5.13	<0.0001
21–25	1.0747	0.1829	2.93	2.03, 4.23	5.88	<0.0001
26–30	1.0823	0.1703	2.95	2.10, 4.16	6.36	<0.0001
31–35	1.0562	0.1702	2.88	2.04, 4.048	6.21	<0.0001
36–40	1.0110	0.1772	2.75	1.92, 3.92	5.70	<0.0001
41–45	0.8699	0.2407	2.39	1.47, 3.87	3.61	0.0007
46–50	0.4541	0.2496	1.57	0.95, 2.60	1.82	0.0745
Overjet (mm)						
−8 to −1	−0.1504	0.2716	0.86	0.50, 1.48	−0.55	0.5822
0–3	[Referent]					
4–6	0.5394	0.0744	1.71	1.48, 1.99	7.25	<0.0001
6–8	0.8208	0.2189	2.27	1.46, 3.53	3.75	0.0005
>8	1.4609	0.3107	4.31	2.31, 8.05	4.70	<0.0001

Table 7. Multivariate logistic model for risk factors associated with mandibular incisor trauma

	Estimate	SE	Odds ratio	95% CI for OR	*t*	*P*
Gender						
Male	0.7529	0.1282	2.12	1.64, 2.75	5.87	<0.0001
Female	[Referent]					
Age (years)						
<10	[Referent]					
11–15	0.5949	0.3520	1.81	0.89, 3.68	1.69	0.091
16–20	1.1370	0.3274	3.13	1.61, 6.02	3.47	0.001
21–25	1.3964	0.4023	4.04	1.80, 9.07	3.47	0.001
26–30	1.1482	0.3390	3.15	1.60, 6.30	3.39	0.001
31–35	1.3265	0.3386	3.77	1.91, 7.44	3.92	0.0003
36–40	1.4782	0.3386	4.36	2.22, 8.66	4.37	<0.0001
41–45	1.1712	0.3469	3.23	1.61, 6.48	3.38	0.001
46–50	0.9482	0.4528	2.58	1.04, 6.41	2.09	0.041
Overbite (mm)						
0	[Referent]					
1–2	0.2324	0.2424	1.26	0.76, 2.05	0.96	0.341
3–4	0.7079	0.2478	2.03	1.23, 3.34	2.86	0.006
5–7	0.7299	0.2631	2.07	1.22, 3.52	2.77	0.008
>7	0.0340	0.3632	1.03	0.50, 2.15	0.09	0.925

of all other variables in the regression. Males (OR = 1.67) had greater odds of trauma than females; Whites (OR = 1.41) and non-Hispanic Blacks (OR = 1.34) had greater odds of trauma than Mexican–Americans. The odds of trauma increased with age, peaking from age 21 to 25 years (OR = 2.93), and declining to 1.57 for age 46–50 years. As overjet increased, so did the odds of trauma. Compared to individuals with 0–3-mm overjet, the odds of trauma increased from 1.71 (4–6 mm) to 2.27 (6–8 mm), to 4.31 (>8 mm).

Males (OR = 2.12) had greater odds of mandibular trauma than females (Table 7). The odds of trauma were higher in older individuals compared to the referent. Compared to individuals with 0-mm overbite, the odds of trauma were significantly greater in subjects with overbites of 3–4 mm (OR = 2.03) and 5–7 mm (OR = 2.07) but approached unity for >7 mm.

Discussion

We found that non-Hispanic Blacks (OR = 1.34) and Whites (OR = 1.41) had higher odds of maxillary incisor trauma than Mexican–Americans. This is consistent with the findings of Alonge et al. (1) and with the univariate analysis of Kania et al. (19), although not with their multivariate analysis. After adjusting for age, gender and race-ethnicity, overjet was the only occlusal covariate significantly associated with maxillary incisor trauma, with the odds of trauma increasing markedly as overjet increased. Only levels of overjet >3 mm were statistically different from the null (Table 6). This is consistent with previous studies (6, 11, 18, 19, 21, 29). We found that the prevalence of mandibular incisor trauma was substantially lower than that of maxillary incisor trauma but similarly associated with gender. However, maxillary incisor trauma is significantly associated with overjet while mandibular incisor trauma is associated with overbite.

Nguyen et al. (30) compared the results of several studies of the association between overjet and incisal trauma. They point out that age and gender confound the incisal trauma–overjet relationship. Consequently, studies that do not adjust for confounders by either stratification of multivariate analysis may be biased. Moreover, we found that in the US population, race-ethnicity is a confounder and must be adjusted for. To compare our results (Table 6) to previous studies that classified overjet into ≤3 mm and >3 mm, we dichotomized overjet and reran our model accordingly. Compared to individuals with overjet ≤3 mm, those with overjet >3 mm had 1.89 times greater odds (95% CI: 1.64, 2.18) of trauma. In comparing our results to those of previous studies, it is important to remember that the results presented in Tables 6 and 7 are from multivariate models that adjust for the covariates age, gender, and race-ethnicity where they are statistically significant.

While NHANES III is an extremely robust data source, several areas or caution in interpretation bear mentioning. NHANES III is a cross-sectional study and may be used to explore associations, not causation. Problems or biases associated with recall memory, particularly in adults, make this a very conservative estimate of tooth trauma. To the extent to which individuals suffering incisor trauma before orthodontic treatment had less overbite/overjet at the time of examination, the importance of overbite and overjet will be underestimated in the logistic models. As NHANES III was not designed specifically to explore the association between incisor trauma and occlusal characteristics, some potential

covariates were not measured. Several studies (4, 6, 9, 10, 21, 24) have shown inadequate lip coverage to be a risk factor for incisor trauma. Radiographs were not taken, making assessment of the periapical area impossible. While some studies classify subjects as prognathic or retronathic (8, 19, 24), NHANES III did not assess skeletal relationship visually or radiographically.

Our study comprised 15 364 individuals between the age of 6 and 50 years, of which 5879 were between the age of 6 and 18 years. This makes it the largest such study to date. Moreover, we modeled mandibular incisors separately, a frequent omission in incisor trauma studies. While traumatic injuries to the incisors were relatively frequent, for the most part they were not serious. Overjet is the principal modifiable risk factor for maxillary incisor trauma.

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