Risk factors associated with incisor injury in elementary school children

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Incisor teeth play a critical role in esthetics, phonetics, and functional activities involving the mandible.[1-3] However, the morphology and location of these teeth make them susceptible to a range of traumatic injuries, including fractures of enamel and/or dentin, pulp exposure, luxation, and avulsion.

The prevalence of incisor injury has been reported to range from 4% to 49%,[4,5] with injuries involving enamel only or enamel and dentin occurring more often than those involving pulpal exposures, luxations, or avulsions.[6-13] The maxillary central incisor has been found to be the most frequently injured incisor.[6-9,12,14-18] Numerous studies have reported that incisor injuries occur more frequently in males,[5-9,14,16,17,19,20] although other studies have reported no sexual dimorphism.[10,15] The prevalence of incisor trauma tends to increase until 10 to 12 years.[7,8,13,16,17,20-23] Several authors have described seasonal fluctuations in the rates of injuries.[13,15,16,20]

The frequency and severity of incisor trauma has been associated with increased protrusion,[11,19,20,24] Class II malocclusion,[19,24] increased overjet,[10,14,20,21,24] lip incompetence,[14,16,19,24] and inadequate soft tissue (lip) coverage.[9,11,14] Prevention of injury to protruding incisors has been cited as a benefit of orthodontic care.[25]

The results of previous studies are difficult to compare and must be interpreted with caution due to differences in experimental design. Sample populations have seldom been randomly

Abstract

This study examined risk factors associated with incisor injury in 3396 third and fourth grade school children in Alachua County, Florida. One of six orthodontists completed a standardized examination form for each child to assess severity of incisor injury, gender, age, race, skeletal relationships, morphologic malocclusion, incisor exposure, interlabial gap, TMJ sounds, chin trauma, and history of lower facial trauma. One in five (19.2%) exhibited some degree of incisor injury. This was limited to a single tooth in 73.1% of those with injury, while enamel injury predominated (89.4%). The majority of the injuries (75.4%) were localized in the maxillary arch, with central incisors the most frequently traumatized. Chi-square tests of association indicated that gender, race, school, orthodontist, history of lower facial trauma, chin trauma, profile, and maxillary and mandibular horizontal positions were associated with incisor injury ($P<0.05$). Wilcoxon rank sum tests identified differences in age, overjet, time of screening, and interlabial gap between those with and without injury ($P<0.05$). Results of logistic regression analyses indicated risk of incisor injury was greater for children who had a prognathic maxilla, a history of trauma, were older, were male, and had greater overjet and mandibular anterior spacing.

Key Words

Incisor injury • Children • Epidemiology • Statistical models • Malocclusion

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Table 1
Interexaminer agreement for scoring a child as having incisor injury (yes/no). Pairwise Kappa statistics are shown, N=39.

Examiner	2	3	4	5	6
1	0.268	0.606	0.321	1.000	0.480
2		0.156	0.074	0.268	0.057
3			0.321	0.606	0.653
4				0.321	0.323
5					0.480

Median Kappa value = 0.321

selected; rather, they have frequently represented individuals with a history of trauma or those reporting to an emergency clinic. In addition, previous studies have used differing classification systems to describe incisor injury, have not always differentiated between injuries involving the primary and permanent dentitions, and have not always presented statistical analyses of the data. None have explored the difficulties in assessing incisor injury.

Previous studies have typically assessed the relationship between single features of the individual (for example, sex, age, or overjet) and incisor injury using univariate statistical methods; none have used multivariate methods. This study examined the relationship between incisor injury and multiple characteristics of the individual to determine the most discrete set of characteristics modeling the probability of incisor injury using multivariate statistical methods.

Materials and methods

The 4393 third and fourth grade students attending the 21 public elementary schools in Alachua County, Florida during the academic years 1990 and 1991 were targeted for inclusion. Those students who had health permission screening forms on file with the school system and were at school on the day of the screening were examined. This screening was a component of a larger study; the motivation for and primary goal of the screening was to identify students with Class II malocclusion for a study of early orthodontic treatment in preadolescent children.

Examinations were performed in a room separated from the classroom (typically a media center or vacant classroom) with the student standing erect in front of a seated examiner. Each examiner used a hand- or head-held light, a millimeter ruler, gloves, and tongue depressor for cheek retraction. Only one of the six examining orthodontists examined each child; not all examiners went to each school. The mean number of children seen by an examiner was 569.8, with a range of 369 to 1008. Information from seven specific areas was recorded on a standardized examination form:

Demographics. Demographic information included name, address, phone number, age, sex, race (Caucasian, non-Caucasian), and history of orthodontic therapy.

Incisor injury. Injury involving the maxillary and mandibular permanent incisors was classified according to Sweet,[26] during a clinical exam, as: (1) enamel injury only, (2) enamel and dentin injury, (3) pulpal exposure, (4) fracture at or below the gingival margin, or (5) restoration present, trauma status not determinable. Deciduous incisors and missing permanent incisors were not scored. Injuries involving only the root or alveolar bone were not assessed as radiographic surveys were not obtained. Only pulp exposures that were visible were scored.

Skeletal relationships. The facial profile was assessed visually as Class I (orthognathic), II (convex), or III (concave). In addition, the anterior/posterior positions of the maxilla and mandible were assessed as either (1) retrognathic, (2) orthognathic, or (3) prognathic.

Morphologic malocclusion. The following parameters were assessed with the child in centric (habitual) occlusion:

Overbite was scored in units of 1/3 as the amount of mandibular incisor crown covered by the maxillary incisor, using incisors with the deepest overbite or least open bite, from (0) open bite to (4) greater than 100% overbite.

Overjet was measured with a millimeter ruler from the buccal surface of the most protrusive mandibular incisor to the buccal surface of the most protrusive maxillary central incisor.

Molar relationship was scored for both right and left sides based upon the Angle classification system in 1/4 cusp increments from (0) greater than full cusp Class II to (10) greater than full cusp Class III.

Presence/absence of teeth, both primary and permanent, in the oral cavity was recorded.

Anterior crowding/spacing from canine to canine, in each arch, was scored as none, slight (>0 to ≤3 mm), moderate (≥3 to ≤6 mm), or excessive (>6 mm) on a scale from (0) excessive space to (6) excessive crowding.

Mandibular function. Joint sounds were scored as (0) none, (1) clicking, or (2) crepitus through the use of light finger pressure laterally over the temporomandibular joint area while the subjects were instructed to open as wide as possible and then close slowly.

Maximum vertical opening of mandible was measured with a millimeter ruler as the distance between the incisal edges of the maxillary and mandibular central incisors while the subjects opened as wide as possible.

Soft tissue relations. Interlabial gap was measured from the most inferior portion of the upper lip, at the midline, to the most superior portion of the lower lip using a millimeter ruler. The subject was instructed to lick his or her lips, swallow, and relax prior to this measurement in an attempt to assess an unstrained position.

Incisor exposure was determined at the maxillary central incisors using a millimeter ruler with the lips at rest.

Lower facial trauma. History of trauma to the incisor teeth, lips, or chin was recorded as (0) no or (1) yes. This question was asked of the student by the orthodontist during early screenings (Spring of 1990) and later by the staff assistant, prior to the examination of the mouth and teeth.

Chin trauma was scored as (0) none, (1) cut/bruise, or (2) scar.

Training and reliability of examiners

All six examining orthodontists participated in training sessions to review the screening forms and examination procedures and, in two calibration sessions, to gather data describing reliability of the measures collected. During the calibration sessions, which took place during the student screenings, all orthodontists examined the same 39 elementary school students; the results were tabulated and discussed. In the present analysis, for students examined by more than one orthodontist, one exam was randomly selected for inclusion. Interexaminer reliability for scoring a child as having incisor injury (Sweet scores 1-5) was examined using pairwise Kappa statistics;[27] these data are reported in Table 1. These Kappa statistics were all greater than 0, ranging from 0.06 to 1.00 with a median value of 0.32, indicating fair agreement, better than expected by chance alone.

Statistical analysis

Univariate analysis compared students with incisor injury with those without injury for measured demographic, malocclusion, and screening-related variables. Chi-square tests, *t*-tests, and Wilcoxon rank sum tests were used where appropriate to test for differences between the injury and no injury groups.[28] A P-value of less than 0.05 was considered statistically significant.

Logistic regression[29] was used to evaluate the joint or multivariate effect of the explanatory variables with regard to the presence of incisor injury. The goal of this analysis was to develop a model for the probability of incisor injury, by selecting an important subset of the explanatory variables. A priori it was decided to include variables to account for differences among orthodontists without requiring these variables to be statistically significant. This was done in recognition of the fact that differences existed between the orthodontists and it would have been inappropriate to adjust for some but not for others based on P-values alone. This yielded information regarding the relative risk associated with each variable, controlling for other variables related to incisor injury. A forward selection procedure was used to determine the factors in the final model. The Hosmer-Lemeshow test[30] was used to assess goodness-of-fit of the model. The final model was refit, comparing those who had severe injury (omitting those who had only an enamel injury) with those students who had no incisor injury, as a check on consistency. These procedures were performed on a Unix workstation using SAS[31] and SPlus[32] statistical software.

Table 2
Univariate results examining the relationship between discrete variables and incisor injury.

Variable	Group	N	Percent injury	Chi-square P-value
Sex				
	Female	1618	16.87	0.001
	Male	1773	21.21	
Race				
	Caucasian	2020	17.48	0.002
	Non-Caucasian	1363	21.72	
History of lower face trauma				
	No	2037	13.30	0.001
	Yes	1353	28.01	
Chin trauma				
	None	2903	18.39	0.013
	Cut/bruise	45	24.44	
	Scar	431	24.13	
Profile				
	Class I	2018	17.64	0.025
	Class II	1317	21.41	
	Class III	50	20.00	
Maxilla				
	Retrognathic	20	15.00	0.002
	Orthognathic	3056	18.39	
	Prognathic	311	26.69	
Mandible				
	Retrognathic	1191	21.49	0.004
	Orthognathic	2061	17.42	
	Prognathic	134	24.63	
TMJ sounds				
	No	3043	19.65	0.065
	Yes	342	15.50	

Table 3
Univariate results for the continuous variables comparing the injury and no injury groups.

Variable	Injury status	N	Median	Mean	S.D.	Min.	Max.	Test*
Age								
	No injury	2700	9.38	9.41	0.75	6.95	12.36	<.001
	Injury	640	9.73	9.77	0.77	7.81	12.61	
Incisor exposure (mm)								
	No injury	2034	1	1.64	1.80	0	10	0.702
	Injury	537	1	1.62	1.82	0	10	
Interlabial gap (mm)								
	No injury	2033	0	1.27	1.96	0	12	0.019
	Injury	537	0	1.21	2.23	0	15	
Maximum opening (mm)								
	No injury	2741	46	47.29	5.79	25	70	0.194
	Injury	650	47	47.63	6.09	32	67	
Overjet (mm)								
	No injury	2743	3	3.47	1.94	-4	12	<.001
	Injury	651	4	3.78	1.91	-2	12	
Screening date**								
	No injury	2742	59	24.55	78.48	-242	172	<.001
	Injury	651	31	-13.39	90.77	-142	104	

*Wilcoxian rank sum test, P-value
**Number of days from screening exam date to 9/1/90

Results

A total of 3742 third and fourth grade public elementary school children in Alachua County, Florida were examined between January 2, 1990 and February 20, 1991; these students represented 85.2% of the targeted population. Following the exclusion of students with only incisors scored as restored or indeterminable injury status (n=44) or those with a history of previous orthodontic treatment (n=302), a sample of 3396 students remained, with 27,155 incisors evaluated. This final sample for analysis had a mean age of 9.5 (S.D. = 0.8, Range = 7.0 - 12.6) years, was 52% male, and 60% Caucasian. In this group, incisor injury was noted in 651 students (19.2%) and 868 teeth (3.2%).

Incisor injury occurred primarily in the maxillary arch; maxillary central incisors accounted for 66.8% of the injured teeth, while each of the six remaining maxillary and mandibular incisors accounted for 4.3% to 6.1% of the observed injuries. Enamel fractures were by far the most common injury, accounting for 89.4% of the incisor injuries. Combination enamel/dentin fractures were observed in 90 incisors, accounting for 10.4% of the injuries. Only two (0.2%) of the traumatized incisors had evidence of pulpal exposure. There were no teeth judged as having fractures at or below the gingival margin. Incisor injuries were located in the maxilla for 75.4% of the students, in the mandible for 15.7%, and in both jaws for 7.8%. The number of injured teeth per student ranged from one to six, with only one tooth affected in 73.1% of the students with injury. Twenty-seven students had injury to three or more incisors.

Univariate results for discrete variables are presented in Table 2. A significantly higher percentage of incisor injury was found in males, non-Caucasians, students reporting a history of trauma, and in those with chin trauma, Class II profile, prognathic maxilla, and prognathic mandible. There were no differences between the injury and no injury groups in frequency of TMJ sounds.

Statistically significant associations existed between presence of incisor injury and both examining orthodontist and school. The frequency with which incisor injury was noted ranged from 9.3% to 34.9% among the six orthodontists (P<0.001), while the percent of students with incisor injury ranged from 8.5% to 39.4% over the 21 schools (P<0.001).

Descriptive statistics and statistical test results for continuous variables are displayed in Table 3. Wilcoxon rank sum tests indicated that children with incisor injury differed from those without incisor injury by being older, having smaller interlabial gaps and larger overjets, and attending a school that was visited earlier in the screening schedule. Wilcoxon rank sum tests were also performed on the ordinary coded variables overbite, anterior crowding (maxillary and mandibular), and molar class (left and right). No significant differences were found between injury and no injury groups in these variables.

Logistic regression analysis was used to identify a set of variables that, taken together, produced the most discrete model of the probability of a child having incisor injury. All variables examined for a univariate relationship with incisor injury were used in this analysis, with the exception of incisor exposure and interlabial gap. These two variables were evaluated in a separate analysis, using a reduced sample size due to missing values; neither contributed significantly to the model for incisor injury. Students with complete information for all variables were used in this analysis. This resulted in a group of 3151 students, 601 (19.1%) with incisor injury. Variables distinguishing the six orthodontists were included in all models. A stepwise selection procedure was used to select variables for inclusion in the model, with a 0.05 level for entry.

The explanatory variables selected in the final model are presented in Table 4, along with their coefficients and relative risk estimates. For discussion and comparison, these explanatory variables have been separated in the table into four groups: demographic variables, malocclusion variables, screening variables, and interactions. As reported in the table, mandibular anterior crowding/spacing scores were negatively associated with incisor injury (i.e., less injury occurring with greater crowding), while increased overjet and prognathic maxilla were positively associated with incisor injury.

Table 4
Logistic regression model for incisor injury (yes,no)

Variable		Coefficient	Relative risk estimate	95% Confidence interval
Demographic				
History of facial trauma		1.107	3.025	(2.469, 3.707)
Age		0.436	1.547	(1.345, 1.778)
Male sex		0.230	1.259	(1.035, 1.531)
Malocclusion				
Overjet		0.070	1.072	(1.019, 1.128)
Anterior crowding, lower		-0.139	0.870	(0.783, 0.967)
Prognathic maxilla		4.472	87.557	(2.210, 3468.97)
Screening				
Orthodontist	1	-0.021	0.979	(0.602, 1.594)
	2	0.514	1.672	(1.142, 2.447)
	3	1.267	3.551	(2.362, 5.339)
	4	1.508	4.517	(3.064, 6.659)
	5	1.551	4.715	(3.124, 7.116)
Screening date		-0.006	0.994	(0.992, 0.995)
Interaction				
History of facial trauma x screening date		0.007	1.007	(1.004, 1.009)
Age x prognathic maxilla		-0.4121	0.662	(0.456, 0.961)

The relationship between age, sex, and incisor injury is illustrated in Figure 1. Notice that both boys and girls had low amounts of injury in the youngest age group, while the amount of injury as well as the discrepancy between boys and girls were greatest in the oldest age group. Care must be taken in interpreting these results from regression analysis, particularly when interaction variables are considered. Note from Table 4 that the effect of a prognathic maxilla is always tempered by the effect of an age-maxilla interaction. This interaction, displayed graphically in Figure 2, demonstrates that students with a prognathic maxilla had a higher incidence of incisor injury for all age groups under consideration; however, the rate of increase in incisor injury was less for those with a prognathic maxilla.

Table 5 presents the percent of injury in various groups cross-classified by overjet, maxilla, and anterior crowding status. Overjet and anterior crowding were used as continuous and ordinal variables, respectively, in the model, but have been displayed in categories in Table 5 for illustrative purposes. The percent of students with incisor injury ranged from 13.3% for the group with trauma variables associated with the lowest level of injury to 32.7% for those students with orthodontic variables associated with the highest levels of injury.

The logistic regression model contained variables to adjust for each orthodontist and screening data. A model was fit without the five variables to control for the six orthodontists, and parameter estimates for the remaining variables did not change dramatically. The negative coefficient of -0.006 for screening date indicated a decrease in the amount of scored injury as the screenings progressed. Based on this model, for two students with all variables identical except for having been screened 30 days apart, the first student would have 1.2 times the risk of incisor injury as the second student (computed as $e^{\{0.006 \times 30\}}$). Interaction was also detected with regard to screening date and history of facial trauma. While less injury was noted as the screenings progressed, this decrease did not occur as rapidly for those with a history of facial trauma compared with those who had a negative history.

A significant lack of fit was not indicated by the Hosmer-Lemeshow test. As part of this test, the model was used to calculate the estimated probability of incisor injury for each student, based on the student's values of the explanatory variables. These estimated probabilities were then ordered. Considering the decile of students with the smallest estimated probabilities of injury (ranging form 0.011 to 0.035), only 1.6% (5/316) actually had incisor injury. For those in the high-

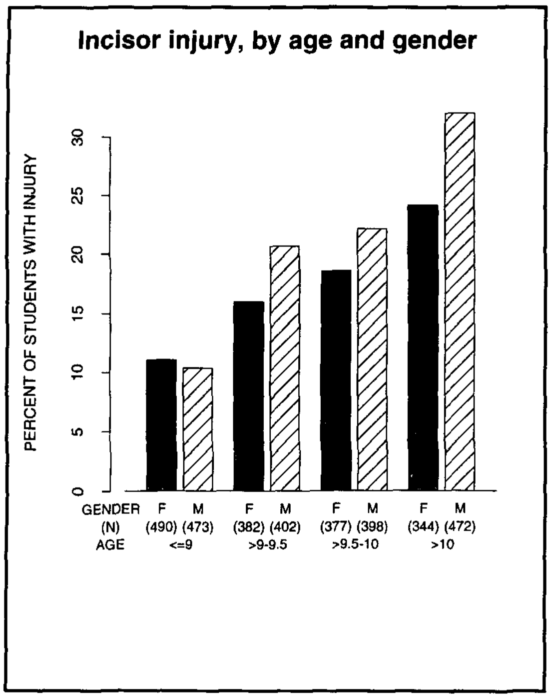

Figure 1

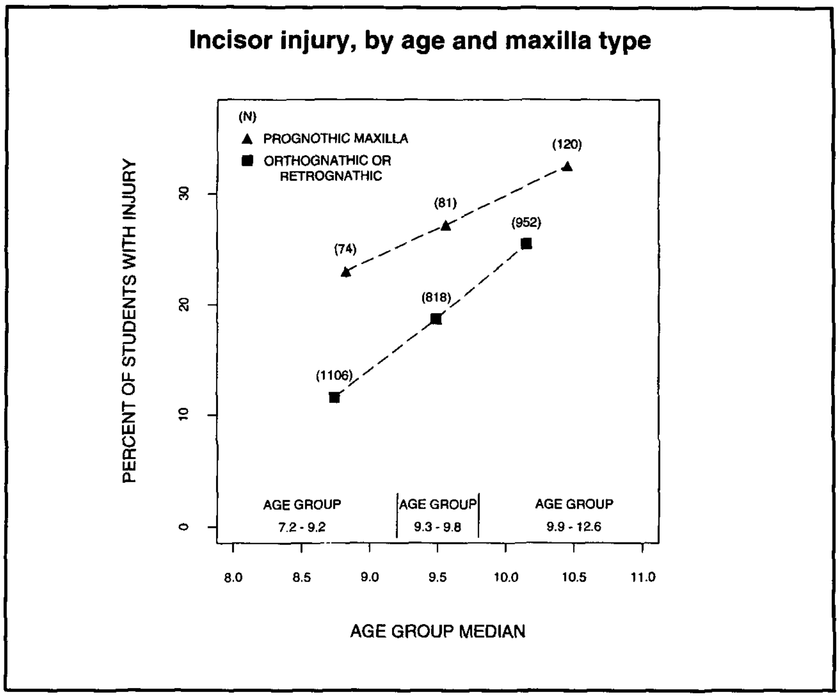

Figure 2

Figure 1
The percentage of students identified as having at least one incisor scored as injured by age group and sex.

Figure 2
The percentage of students identified as having at least one incisor scored as injured by age group and maxillary horizontal position.

est decile, with estimated probabilities of incisor injury ranging from 0.418 to 0.802, 52.7% (166/315) were recorded as having incisor injury. Note that we are evaluating the model using the same data we used to develop the model.

In order to further evaluate the model, it was refit, comparing those who had severe injury (excluding those who had only enamel injuries) with those who had no incisor injury. This was done, in part, because of the wide discrepancy in prevalence rates among orthodontists assessing enamel injury (from 7.39% to 30.59%). Differences also existed among orthodontists in prevalence of reported severe (> enamel only) injury, although the discrepancies appeared to be less (from 0.79% to 3.97%). The second goal of refitting the model was to evaluate which risk factors were associated with incisor injury in general and which were involved with more severe injury.

A description of the model refit to examine severe injury follows; the reader is referred to Table 4 for a comparison with the original model established on all levels of incisor injury. Relative risk estimates from this new model varied for orthodontist (from 2.10 to 5.91, comparing the orthodontist who coded dentin or worse injury least frequently), remained the same for screening date and history of trauma by screening date interaction, and increased slightly for age (relative risk estimate per year = 1.70), male sex (1.34) and overjet (1.13). Estimates from this model were also more extreme for prognathic maxilla and maxilla by age interaction, indicating more severe injury at an earlier age for those with a prognathic maxilla, but a leveling off at later ages. In addition, the relative risk associated with a history of trauma increased to 9.12. In contrast to the prediction of all types of incisor injury, for distinguishing severe incisor injury greater than only enamel fracture, mandibular anterior crowding/spacing was not an important explanatory variable (Wald test P-value = 0.64, relative risk estimate = 1.07).

Due to concerns regarding the agreement among orthodontists with respect to incisor injury, data of the orthodontist with poorest agreement were excluded and an additional logistic regression was developed. The variables that entered this model and the parameter estimates were quite close to the original model based on all the data. (Data available on request.)

Discussion

Large discrepancies exist in reports on the prevalence of incisor trauma. Reported prevalences range from less than 6%[4,19,33] to nearly 50%,[5] although a majority of previous studies have found prevalence rates in the range of 10% to 20%.[6-8,10,12,14,15,17,21,24] The 19.2% prevalence rate of the present study falls within this range. Discrepancies in reported prevalence are due in part to differences in methodology and sample populations. For example, McEwen and McHugh[19] reported a prevalence of incisor injury of 5.5% in 2607 13-year-old children; however, the examination was limited to the maxillary central incisors. Previous studies have selected subjects who had a positive history of trauma[11,20] or who had reported to an emergency clinic[9,16,34] or orthodontic office;[14] have not described the sample populations in terms of age, gender, or stage of dental development (i.e., primary vs. permanent dentition);[5,8,11,19] and have characterized culturally different populations.[6-8,11,12,22,23,34]

The results show variations among examiner subgroups in prevalence of incisor injury, especially the milder forms. These differences could result from differences in each examiner's population subset, differences in applying Sweet's scale, or perhaps random misclassifications. Data indicated that each orthodontist evaluated a different group of students with regard to various other risk factors of incisor injury (gender, age, overjet). (Data available on request.) In addition, the difficulties in judging incisor injury (see Table 1) have not been described previously. Given the difficulties in judging incisor injury in the clinical setting, the determination of the prevalence of incisor injury in the general population remains problematic; however, the prevalences reported do reflect those reported previously in the literature.

The central goal of the data analysis was to explore the associations between incisor injury and multiple predictor variables. The statistical approach (logistic regression) taken in this study is similar to that used to model DMFS increments by Disney et al.[35] These authors reported that the examiners were significant components of the model explaining DMFS increments. Our data also revealed that the examiners needed to be accounted for when modeling the likelihood of incisor injury.

Our finding of a greater frequency of incisor injury in males is supported by the majority of previous studies.[5-10,14-16,19,20] This might be explained by observations that males participate in more strenuous activities with higher trauma risks, such as contact sports and more aggressive types of play,[13] and by the observation of delayed maturation rates in males.[36] These types of data were not obtained in this study.

Baghdady, Ghose, and Enke[33] reported a higher prevalence rate among females below the age of 9 years, with injury more frequent in older males. The present data also indicated a gender and age interaction (see Figure 1) with greater gender discrepancies (male > female) in frequency of incisor injury occurring in the older age groups.

The findings of this study showing that maxillary teeth are more frequently traumatized than mandibular teeth and that maxillary central incisors are the most commonly traumatized incisors are generally supported in the existing literature.[4,6-10,15,17,33,34] These are not unexpected findings as maxillary central incisors tend to erupt earlier than the maxillary lateral incisors and, thus, are at risk longer. It has been suggested that maxillary incisor injury is more frequent than mandibular because blows to the mandibular teeth are dissipated, thanks to the mandible's nonrigid connection to the cranial base.[33]

Table 5
Malocclusion variables and incisor injury:
Number of students in group and percent with incisor injury

Retrognathic or orthognathic maxilla					
overjet (mm)		<2	3 - 4	>5	total
Mandibilar anterior crowding					
Yes	n	376	472	324	1172
	%	13.3	19.3	21.3	17.9
No	n	543	691	470	1704
	%	14.5	21.4	18.3	18.4
Total	n	919	1163	794	2876
	%	14.00	20.6	19.5	18.2
Prognathic maxilla					
overjet (mm)		<3	>4	total	
Mandibular anterior crowding					
Yes	n	49	61	110	
	%	26.5	26.2	26.4	
No	n	61	104	165	
	%	24.6	32.7	29.7	
Total	n	110	165	275	
	%	25.55	30.3	28.4	

Injuries involving the enamel and enamel/dentin were the most common types found in this study. In addition, the majority of the injuries were limited to a single tooth. These findings are in agreement with the findings of earlier studies.[6,7,10-12,17,24] Hospital-based studies have indicated that traumatic injuries involving two teeth were more prevalent than those limited to a single tooth and that the injuries were more severe.[9,34] It is likely that less severe injuries, such as enamel injury, are under-represented in samples derived from hospital settings.

A possible limitation of our study is related to our applying Sweet's classification scale clinically without radiographic examination. Thus, we could not detect injury, such as fractured roots or periapical pathology, if it existed. In addition, as the examiners were not the treating dentists, teeth treated for pulp exposures by pulp capping and restoration could not be differentiated from teeth with only restorations restoring enamel or enamel/dentin fractures without pulpal injury.

We could not account for 13 incisor teeth in 3396 students. These could have been unerupted, congenitally missing, or avulsed due to an earlier injury. Only a small number of subjects (n=44) were identified as having only teeth scored as restoration/indeterminable status. Although it was not possible to distinguish caries from a traumatic experience, even if these were due to severe trauma, these data (44 subjects out of 3742), plus the low prevalence of injury greater than enamel/dentin fracture (2 of 27,155 examined incisors) and the low number of unaccounted for incisors, suggested that serious traumatic injuries to the incisors were extremely rare in this population.

Andreasen reported that as a child begins to walk and run, the incidence of dental injuries increases until an initial peak around the age of 4, followed by a second peak at the age of 8 to 10.[13] Others have identified the 9 to 10 year-old age range as having the highest prevalence of incisor injury,[8,17,21,22] while still others have suggested that incisor injury tends to increase until around 12 years of age.[7,23] The present data showed increased prevalence with age over the ages examined (7 to 12 years), without demonstrating a peak.

Previous studies have reported a relationship between incisor trauma and Class II malocclusion,[9,24] increased incisor protrusion,[11,19,20,24] increased overjet,[10,14,19-21,24] inadequate soft tissue incisor coverage,[9,11,14] and lip incompetence.[14,16,19,24] The findings of the present study indicated that no relationship exists between incisor injury and the Angle molar classification. Interestingly, subjects in this study with incisor injury had significantly smaller interlabial gaps; the mean difference between injury and no injury groups was not meaningful.

The data indicated that events capable of producing a soft tissue chin injury (cuts, bruises, or scarring) might indirectly cause incisor injury. Such indirect trauma, in which a blow forcefully closes the mandibular dentition against the maxillary teeth, has previously been associated with coronal and/or root fractures involving only the posterior teeth,[13] which were not examined in this study. No association existed between joint sounds and incisor injury in our data.

The present study found greater prevalence of incisor injury in non-Caucasian children (Blacks, Hispanics, Orientals, and individuals of Mediterranean descent). This finding has not been previously reported and may be related to cultural, social, or economic differences.

In addition, a relationship between incisor injury and the anterior/posterior position of the maxilla and the mandible existed, with more frequent injury in children with a prognathic maxilla and/or mandible. These skeletal relationships would tend to place the incisors in a more prominent position related to the rest of the face, thereby increasing the likelihood of a traumatic incisor injury.

Although O'Mullane reported that patient's recall of traumatic dental injuries does not correlate to clinical findings,[7] the present data indicated scored dental injury was related to the children's reports of previous trauma. The history of facial trauma question was asked of the child by the orthodontist during early screenings and later by the staff assistant, prior to the examination of the mouth/teeth. In retrospect, the clinical examiner should have been blinded to student self-reported trauma during all screenings; however, the identification of incisor injury was not the primary aim of the screening. The history question and the evaluation of incisor injury were separated by a number of items on the screening form. Nonetheless, due to the timing of these components, the interpretation of the history of facial trauma variable is tainted. Most likely there is a correspondence between a positive history and incisor injury, but more careful evaluation of students reporting facial trauma cannot be ruled out. The multivariate analysis permitted an adjustment for this variable and an evaluation of other relationships.

Significant differences existed in prevalence of injury among the schools. Differences in the school populations in terms of race and age, as well as the fact that not all six examiners were present at every school, may account for these differences.

Date of screening exam was also related to the occurrence of incisor injury, as less injury was noted as the screening progressed. This may be due to a tendency of the screening orthodontists to focus more on the primary variables of the screening as more and more screening took place, or to increased experience and a more stringent criteria for what constituted incisor injury, or to fatigue from repeated screenings. Seasonality could also play a role. The early screenings took place in the spring and early fall, with the later screenings occurring in the late fall and winter. If, as has been suggested,[13,15,16,20] more trauma occurs in the spring and summer, we would expect the occurrence to be higher for a given age in the spring and early fall. In our data, this would appear as a decrease in observed injury with increasing screening date. Again, the model for predicting incisor injury accounts for these variables.

Results of the logistic regression analysis (Table 4) describe a set of characteristics that best explain incisor injury in Alachua County elementary school children. After accounting for examining orthodontist and screening date, the risk of incisor injury was greater for children who had a prognathic maxilla, a history of trauma, were older, were male, and had a greater amount of overjet and mandibular anterior spacing. Other characteristics, such as race, chin scar/cut/bruise, and profile, which were individually associated with incisor injury in the univariate analyses, did not add appreciably to the model in explaining the presence of incisor injury. On the other hand, one variable (mandibular crowding/spacing), in which the injury and no injury groups did not differ when examined in isolation, did add significantly to the model explaining incisor injury, after the other variables had entered.

Interestingly, more severe injury (greater than enamel fracture) was more strongly associated with a history of trauma, a prognathic maxilla, increased age, sex (male), and increased overjet. Other than a previously reported relationship existing between severity of injury and increased overjet,[21] the relationship between severity of injury and the other factors has not been reported.

It is not possible from these data to determine whether early orthodontic treatment (to decrease overjet, for example) is an efficacious approach to reduce the risk of incisor injury, because injury could occur before or during such treatment. These data are currently being collected as outcome measures in a prospective clinical trial evaluating the efficacy, cost, and benefits of early orthodontic therapy.

Conclusions

The results of this study support the following conclusions:

1. One in five (19.2%) third and fourth grade school children in Alachua County, Florida had clinically detectable incisor injury. Incisor injury in these children primarily involved the enamel only (89%), was localized in the maxilla (75%), involved the maxillary centrals (67%), and affected a single tooth (73%).

2. Age, gender, race, school, time of screening, orthodontist, history of facial trauma, chin trauma, profile, overjet, interlabial gap, and maxillary and mandibular horizontal positions were associated with incisor injury.

3. The risk of any incisor injury was greater for children who had a prognathic maxilla, a history of trauma, were older, were male, and had greater overjet and mandibular anterior spacing. These associations were stronger in those having incisor injury more severe than an isolated enamel fracture.

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