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Traumatic dental injuries in twins: Is there a genetic risk for dental injuries?

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Correspondence to: Prof. Dr Andreas Filippi, Department of Oral Surgery, Oral Radiology and Oral Medicine, University of Basle, Hebelstr. 3, CH-4056 Basle, Switzerland Tel.: +41 61 267 2609 Fax: +41 61 267 2607 e-mail: andreas.filippi@unibas.ch Accepted 17 December, 2007 Abstract – Traumatic dental injuries are a major cause of morbidity among children. Investigation of risk factors of dental trauma is important to take preventive measures in patients at high risk for tooth accidents. The aim of this work was to conduct a pilot study in twins, assessing concordance of suffered traumatic dental and facial injuries. Comparison of concordances between monozygotic and dizygotic twin pairs was performed in order to investigate possible genetically determined accident-proneness. Standardized interviews were conducted focusing on the frequency of orofacial accidents and their circumstances. In addition, the front teeth of all participating twins were clinically examined. A total of 104 twins (52 twin pairs) were surveyed: 31 of the 52 twin pairs were DZ and 21 pairs were MZ. 36 (34.6%) of the 104 interviewees had already suffered from a tooth injury, whereas 53 (51%) of the participants had experienced a facial injury. Investigation of concordances of suffered traumatic dental injuries revealed that 66.7% of the MZ twin pairs and 58.1% of the DZ pairs were concordant. With respect to facial traumata, 52.4% of the MZ pairs compared to 58.1% of the DZ pairs were concordant. Differences between zygosity were not statistically significant (P \ge 0.05). With the present pilot study, no statistical evidence of genetic risk for dental and facial injuries could be displayed. On the contrary, environmental factors seem to dominate in determining an individual's risk for orofacial traumata.

Dental trauma is a serious and frequent oral health problem. Up to 30% of all children and adolescents suffer dental accidents to their permanent teeth (1–7). Almost every second patient with traumatic dental injury is at risk of suffering further trauma episodes (8). In order to prevent some injuries it is important to know the risk factors predisposing to dental injuries. With this knowledge, preventive measures, such as mouthguards or orthodontic treatment at an early stage, can be applied where they are most likely effective (9).

Predisposing factors to traumatic dental injuries are occlusal variations such as increased protrusion (1, 10), class II malocclusion (10), increased overjet (11-14), and inadequate lip coverage (12, 13, 15). Male individuals are at higher risk of suffering dental trauma compared to female (5, 16–20). Dental injuries related to sports often occur in contact-sports of high intensity and velocity, such as football, hockey and rugby (21). Other risk factors for traumatic injuries to teeth are childhood obesity (22) and attention deficit/hyperactivity disorder (23, 24). All those risk factors are determined by environmental and genetic influences. Depending on the risk factor the genetic components vary considerably: sex is fully determined by genes, whereas occlusal traits result from a combination of genetic and environmental influences during development in which environmental factors seem to dominate (25-27).

The use of twins in genetic research is well recognized. Based on the *Equal Environment Assumption* (EEA) comparison of behavior or physical features within *monozygotic* (MZ, genetically identical) and *dizygotic* (DZ, genetically non-identical) twin pairs can provide insights into the relative contribution of genetic and environmental influences (28). The EEA assumes that environmental influences within a pair of twins are shared to the same extent by monozygotic and dizygotic twins (28). In case of predominating genetic influences on a trait, MZ twins are expected to show major intrapair correspondence concerning that particular trait compared to DZ twins.

To date no data regarding potential genetic risk for dental injuries are available. The aim of this work was to conduct a twin study assessing concordance of suffered traumatic dental and facial injuries in monozygotic and dizygotic twins.

Comparison of concordances was performed in order to investigate possible inheritance for orofacial injuries which would refer to a genetically determined accidentproneness.

Materials and methods

Ethical approval for this pilot study was obtained from the Ethical Commission Basle (Switzerland). Written consent was obtained from the twins and from the parents of underage twins, respectively. The study group consisted of 52 pairs of twins attending local twins clubs or answering an advertisement in a twins club magazine ('Swiss twins club'). All participating twins were residents in Switzerland.

After obtaining consent, details were recorded of name, date of birth, sex, and zygosity. In 48 pairs zygosity was known: independent of the study, zygosity determination had been carried out at an earlier point in time. All opposite sex pairs were assigned as dizygotic. In case of unknown zygosity in same-sex twins, a similarity questionnaire of demonstrated validity, proposed by Peeters et al., was conducted in order to determine zygosity (29). The mother of the twins had to answer a questionnaire, based on general knowledge on her twins, without checking them. The applied questionnaire (weighted questionnaire index) has an accuracy of 98% in giving the correct zygosity (29). Several studies have shown that the establishment of zygosity based on questionnaires is of considerable accuracy and often used in epidemiological research; results from such questionnaires have been shown to have good agreement with results from tests using blood or genetic markers (29 - 31).

Standardized interviews were conducted with all participating twins. The interview contained five questions about experienced facial injuries and dental traumata to permanent teeth (Table 1). Facial injuries were subdivided into 'nose fracture', 'laceration', 'jaw fracture', 'eye injury', and 'other injuries'. The latter comprised minor injuries, such as abrasion and haematoma of facial skin. Dental traumata were classified into 'avulsion', 'crown fracture', 'dislocation', and 'other injuries'. In case of tooth fractures, no distinction was made between fractures of enamel only and fractures confined to enamel and dentine, since it was considered to be impossible that the interviewees knew or recalled their type of experienced tooth fracture correctly. 'Other injuries' comprised minor injuries such as concussion of teeth, laceration, contusion, and abrasion of gingiva and oral mucosa. The investigator went through the questions with each twin separately. Subsequent to the interview the twin was clinically examined. The examination was conducted in a standardized, systematic manner and comprised the examination of the permanent incisors and canines of the upper and lower jaw. The dental examination aimed at finding indications of sustained traumatic dental injuries. As traumatic dental injuries more frequently affect incisors and canines than premolars and molars (32), the examination considered only front teeth. The following observations were charted: enamel infractions, untreated enamel fractures, tooth discolorations, restorations, percussion sound, mobility, clinically visible caries and missing teeth.

Descriptive statistics including crosstables for categorical data and mean and standard deviation (SD) for metric data was calculated. To compare the concordance

Table 1. Questionnaire

1.	Have you ever suffered from a facial injury?
2.	If yes, what kind of facial injury ('nose fracture', 'laceration',
	'jaw fracture', 'lip injury', 'eye injury', or 'other injury')?
3.	Have you ever suffered from a dental injury?
4.	If yes, what kind of dental injury ('avulsion', 'crown fracture',
	'dislocation', 'other injury')?
5.	If yes, which tooth was affected?

of injury events within twin pairs, each pair was assigned to one of two possible classes: the first class consists of pairs in which both members of the twin pair either had experienced an injury or had not experienced an injury (*concordance*). Twin pairs in which only one member suffered from an injury were attributed to the second class (*non-concordance*). To compare differences between zygosity (MZ/DZ) and sex (male/female) related to the two concordance classes a generalized mixed-effect model (33) was performed. Subsequently, odds ratios with corresponding 95% confidence intervals were calculated. The level of significance was determined to be P < 0.05. All analyses were done using R version 2.5 (a language and environment for statistical computing).

Results

In the present pilot study 52 twin pairs were interviewed and examined. Thirty-one pairs among them were DZ (11 female, 6 male and 14 opposite sexed) and 21 pairs were MZ twins (10 female and 12 male). The average age of participating persons was 23.42 years (SD 12.28) (Table 2).

In response to the question 'Have you ever suffered from a facial injury?', 53 (51%) of the interviewees answered with yes, 51 (49%) with no. Men had suffered more facial injuries (56.2%) compared to women (46.4%). Likewise, DZ twins had experienced more facial injuries (53.2%) with respect to MZ twins (47.6%) (Fig. 1). However the differences between sex (P = 0.52) and zygosity (P = 0.60) were not statistically significant at the determined level of significance. Females with a

Table 2. Demographic data of the interviewed twin pairs

	MZ		DZ			
	m/m	f/f	m/m	f/f	m/f	All
Count Average age SD	11 28.2 11.3	10 22.3 12.2	6 17.8 12.2	11 28.1 11.4	14 19.2 11.1	52 23.4 12.2



Fig. 1. Participants having sustained an injury (with respect to zygosity and sex).

twin brother suffered from more facial injuries (50%) compared to females with a twin sister (45.2%). The finding was not statistically significant (P = 0.76), though. Most frequent injuries were lacerations (n = 38) and lip injuries (n = 10). Eye injuries (n = 1) and 'other injuries' (n = 4) were less common. None of the participating twins had experienced a jaw or nose fracture. Concerning the occasion, most facial injuries occurred in spare-time (n = 32) followed by accidents at home (n = 15). Accidents during sports (n = 5) and at school/work (n = 1) were less frequent.

Regarding the question 'Have you ever experienced a dental injury?, 36 (34.6%) of the participants replied with yes, 68 (65.4%) with no. Concerning the number of traumatized teeth in case of an accident, 26 (72.2%) individuals had one traumatized tooth, eight (22.2%) had two injured teeth, one (2.8%) participant had three and one (2.8%) had four traumatized teeth. Men and MZ twins had experienced more dental injuries (39.6% and 35.7%, respectively) compared to women and DZ twins (30.4% and 33.9%, respectively) (Fig. 1). Statistical differences between sex (P = 0.53) and zygosity (P = 0.87) could not be determined. Females with a twin brother sustained more dental injuries (42.9%)compared to females with a twin sister (26.2%). The finding was not statistically significant (P = 0.26), though. Twenty-five individuals suffered from crown fractures (23 in the permanent dentition, two in the primary dentition), six individuals experienced dislocations (four in the permanent dentition, two in the primary dentition), five individuals sustained avulsions (four in the permanent dentition, one in the primary dentition), and only three participants suffered from 'other injuries' (two in the permanent dentition, one in the primary dentition). Accidents in spare-time (n = 18)were the most frequently reported occasions, whereas accidents at home (n = 8), during sports (n = 7) and at school/work (n = 2) were less frequent. During the interview, injuries to 49 teeth had been reported. Of the 49 injured teeth, 43 were permanent teeth (42 front teeth, one premolar) and six were deciduous teeth. In case of a tooth injury, the maxillary central incisors were the most frequently injured teeth: 17 teeth were right upper central incisors and 13 left upper central incisors (Fig. 2).

Comparison of concordances between MZ and DZ twins showed the following: concerning facial injuries recorded during the interviews, 11 (52.4%) MZ twin

40.4%

11

31

4.8%

30.9%

21

41

4.8%

7.1%

22

42

0.0%

0.0%

23

43

0.0%

Fig. 2. Type of injured permanent front teeth.

4.8%

12

32

4.8%

50%

40% 30% 20%

10%

0%

0%

10%

00 20%

90 30% 40%

50%

13

33

0.0%

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Fig. 3. Concordances of facial injuries among twins.



Fig. 4. Concordances of dental injuries among twins.

pairs were concordant, compared to 18 (58.1%) DZ pairs (Fig. 3). The odds ratio for concordance of facial injuries (DZ/MZ) was 1.25, meaning that DZ twins had a 1.25fold higher relative risk of being concordant regarding facial injuries. This finding was not statistically significant (P = 0.78). Regarding dental injuries recorded during the interviews, 14 (66.7%) MZ twin pairs were concordant, compared to 18 (58.1%) DZ pairs (Fig. 4). The odds ratio for concordance of dental injuries (MZ/ DZ) was 1.43, that is, MZ twins had a 1.43-fold higher relative risk of being concordant regarding dental injuries. Again, no statistical difference between MZ and DZ twins could be determined (P = 0.57). Investigation of concordance regardless of zygosity showed that 32 (61.5%) of the 52 pairs were concordant concerning dental injuries, whereas 29 twin pairs (55.8%) were concordant concerning facial injuries (Figs. 3 and 4).

The clinical examination of the totally 1248 front teeth established the following observations: of all examined teeth, 98 were deciduous teeth. In the permanent dentition 57 teeth showed enamel infractions, 34 exhibited untreated fractures in enamel, 10 teeth showed discolorations, 29 teeth had been restored (18 composite reconstructions, four bridges, four implants, one crown, two laminate veneers), eight teeth were missing, 18 teeth displayed an ankylotic percussion sound, three teeth showed an increased mobility, and clinically visible caries was detected in two teeth.

Discussion

The present pilot study revealed a total prevalence of 34.6% of traumatic dental injuries. This finding is slightly higher than results of other studies examining

samples of the same age as in the present pilot study (2, 6). In most (72.2%) accidents, only one tooth was injured; this is in agreement with earlier investigations (34, 35). In reference to dental injuries, facial injuries were more frequent: 51% of all individuals had already suffered from a facial injury. This shows that accidents pertaining the face more often result in facial soft tissue injuries, especially lacerations, than in tooth injuries with subsequent tooth damage. This is in agreement with previous work (36).

Concerning sex, there was a trend for male being at higher risk suffering from an orofacial injury compared to female. Differences in prevalence of orofacial injuries between men and women were statistically not significant, though. These relatively small differences between sex may be explained by several theories concerning females with a twin brother (which is referred to as opposite-sex twin girls in the literature). In opposite-sex twin pairs, female fetuses are exposed to testosterone from adjacent male fetuses in utero. This condition has been shown to have substantial consequences for the female co-twin, such as masculinized anatomy and behaviour (37). The effect of testosterone in utero on females with twin brothers was demonstrated on toothsize: tooth-size is a sexually dimorphic trait, with males having significantly larger dental crown diameters than females on average (38, 39). Further studies showed that opposite-sex females had increased tooth crown size compared to same-sex female twin pairs (40). In behavioural aspects, investigations revealed that females with a twin brother showed a more masculine pattern of aggression proneness (41). In the present study, oppositesex twin girls had sustained more injuries compared to females with a twin sister: 50% of the females with twin brothers had suffered from facial injuries, compared to only 45.2% of the females with twin sisters. Concerning dental injuries, differences were more obvious: 42.9% of the opposite-sex twin girls had experienced an injury compared to 26.2% of the females with twin sisters. Among all participants, 14 of totally 56 women were opposite-sex twin females. A more aggressive behaviour in sports and everyday life of the girls with twin brothers may explain the fact that in the present work females suffered from orofacial injuries almost in the same extent as males.

In accordance with previous findings (42), accidents in spare-time were the most frequent occasion with respect to both dental and facial injuries. The most affected teeth were the maxillary central incisors; this corresponds with previous studies (43–45). Concerning the type of injury, crown fractures occurred most (55.1% of all tooth injuries). This had also been demonstrated in a number of preceding investigations (1, 18, 43, 46–49). The clinical examination revealed a high number of teeth with infractions (n = 57) and untreated enamel fractures (n = 34), even though in the interview only 23 twins reported fractures to their permanent teeth. This finding suggests that slight dental injuries often occur and it is likely that the patients are not worried about the sustained injuries and do not seek dental care, especially in absence of symptoms. This consists with previous investigations (1). Further it is possible that patients do

not recall slight injuries to their teeth, especially if the injuries had no consequences and took place a long time ago. Nevertheless, one must consider that not all fractures and infractions in enamel are due to traumatic dental injuries: slight fractures and especially infractions often are caused by occlusal trauma or bruxism (50). The most common restorations were composite restorations (n = 18), being in agreement with other surveys showing that acid etch restorations were the most common treatment provided in case of traumatized teeth (51).

The present pilot study focused on twins and their prevalence of orofacial injuries in order to establish concordance rates. For over a century, twin studies have served as a basic tool in evaluating the relative contribution of genetic and environmental factors (52). However, the twin method has limitations in several aspects. First, it is difficult to obtain a sufficient number of participating twin pairs, especially in absence of national twin registers. Second, it can be difficult to confirm that environmental factors are in fact the same for both members of twin pair and for DZ and MZ twins, i.e. that the EEA is valid. Third, unknown gene-gene and environment-gene interactions may alter the phenotype and distort the outcome of twin studies (53). These aspects need to be considered when interpreting twin studies, in general.

Statistically significant higher concordances of injuries within MZ twins compared to DZ twins would refer to a strong genetic influence on accident proneness. The study at issue showed high concordances of facial and dental injuries: concerning facial injuries, 52.4% of the MZ twins and 58.1% of the DZ twins were concordant. Regarding dental injuries, a higher fraction of twins were concordant: 66.7% MZ twins and 58.1% DZ twins, respectively. With an odds ratio of 1.43 (MZ/DZ) there is a trend for a higher concordance in MZ twins. However, differences in concordance were not statistically significant, neither for dental nor facial injuries. Nevertheless, caution is warranted because the current sample of twins in the present pilot study is small. A greater sample size could possibly display statistically significant differences.

Based on the present findings, environmental factors seem to dominate in determining the individual's risk for traumatic orofacial injuries. This partly consists with previous knowledge concerning the determination of possibly genetically influenced risk factors for traumatic dental injuries: large maxillary overjet is mainly characterized by environmental influences during development (25–27), whereas studies concerning childhood obesity had found a heritability of fat mass between 40% and 70% (54). Numerous twin studies investigating the aetiology of attention deficit/hyperactivity disorder are consistent in suggesting substantial genetic influences (i.e. heritability ranging from 60% to 90%) (55). Nevertheless even high heritability of common risk factors does not seem to control the final risk of experiencing orofacial trauma. No statistical evidence of genetic risk for orofacial injuries could be displayed.

The high concordance of suffered dental (61.5%) and facial (55.8%) injuries in twin pairs, regardless of their respective zygosity, is interesting. It indicates shared

environmental influences to a great degree. This finding is consistent with previous work estimating shared environment of twins and non-twin siblings for psychological traits: shared environmental influences are greater in twins (MZ and same-sex DZ twins) than in non-twin siblings (56). This might be due to influences by parents and teachers, treating twins more similarly, or due to environmental effects twins have on each other that do not affect non-twin siblings (56). Another hypothesis suggests that twins experience more shared influences because they are exactly at the same age (56). However, in the present pilot study we only focused on twins and were surprised by the high concordances in twins, regardless of zygosity; therefore further work should include non-twin siblings in order to investigate whether concordances of orofacial injuries actually are lower in non-twin siblings compared to twins.

In summary, our results provide no genetic risk for orofacial injuries, but emphasize the important part of environmental influences on accident proneness.

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