Root Fractures in Children and Adolescents: Diagnostic Considerations

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ABSTRACT

JULIE MOLINA: Root Fractures in Children and Adolescents: Diagnostic Considerations
(Under the direction of William F. Vann, Jr.)

Purpose: To (1) characterize epidemiological trends in anterior permanent tooth trauma (2) examine the relationship of crown fractures and root fractures to determine if crown fractures are protective against root fractures (3) determine the diagnostic value of obtaining three periapical radiographic projections to assess potential root fractures.

Methods: Two dentists served as expert examiners for the radiographic assessments. Kappa statistics, Pearson's Chi-Square tests and logistic regression analyses were employed.

Results: The final sample included 185 teeth. Expert examiners detected: 22 root fractures, 10% of the teeth exhibited root fractures when no crown fractures was documented, and 14% of the teeth had both crown fractures and root fractures as separate entities.

Conclusions: Crown fractures were not protective against root fractures. As radiographic projections increased, root fractures were identified more often. Our data support obtaining multiple radiographic projections at different vertical angulations to rule out root fractures in children and adolescents.

ACKNOWLEDGEMENTS

To the casual observer, a master's thesis may appear to be solitary work. However, to complete a project of this magnitude requires a network of support, and I am indebted to many people. I am most grateful to my principal advisor, Dr. William F. Vann, Jr. for all his support and guidance through this journey.

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CHAPTER 1

INTRODUCTION

Root fractures are relatively uncommon, comprising only 0.5-7% of all dental injuries in the permanent dentition.[1] The most common age range for root fractures involving the permanent dentition in children is between 11-20 years[1] with 75% affecting maxillary central incisors.[2] Typically the mechanism of root fractures is a frontal impact that creates compression zones labially and lingually.[1]

Root fractures often present clinically as a slightly extruded tooth, often lingually displaced. Such a tooth is often mobile but the degree of mobility is determined by the fracture site. Root fractures are more commonly found in the middle third of the root.[1] Without radiographic examination, usually it is impossible to distinguish between displacement due to a luxation injury or root fracture.[3] The authors clinical experience suggest that in children and adolescents, coronal fractures may be a protective and mitigating factor against root fractures but to date this clinical perception is untested.

Diagnosis of Root Fractures in Children and Adolescents

Correct diagnosis of root fractures is essential to ensure proper treatment to achieve the best possible prognosis.[2] A correct diagnosis will aid the clinician in decisions about immediate treatment and splinting strategies as well as the timing of follow-up examinations, radiographs, and sensitivity testing.

A root fracture can be seen only if the radiographic beam is directed through the plane of fracture. Many authorities argue that one radiograph often will not lead to optimal disclosure of root fractures. One protocol to diagnose or rule-out root fractures in children and adolescents is advocated by the guidelines[4] established by the International Association of Dental Traumatology (IADT). This protocol includes four periapical radiographs: an occlusal, a periapical central angle, periapical mesial and distal excentric projections.[4] Currently, there are no published data to support this recommendation.

A multi-directional approach using a conventional periapical exposure and two additional vertical periapical projections that vary +/- 15-20° from the central beam has been advocated by Andreasen and Andreasen[1], Wilson[3], Degering[5], Bender[6], Berman[7], and Herweijer[8]. Both Andreasen and Andreasen[1] and Degering[5] have published eloquent illustrations involving artificial root fractures in human incisors, adding a weight of documentation to this radiographic protocol. At The University of North Carolina at Chapel Hill (UNC-CH) School of Dentistry, the protocol for examining permanent incisor root fractures in children and adolescents entering the Pediatric Dentistry or Endodontic Clinics is to obtain three periapical radiographic projections at different vertical angulations[1,3,5-8] for dental-related tooth trauma wherein root fracture is possible. This protocol has been the standard of care since the mid-1990s. While many authorities recommend a multi-projection clinical protocol for diagnosis of root fractures, it should be noted that there are no clinical trials to support these recommendations.

Treatment and Prognosis of Root Fractures

Treatment and prognosis of root fractures in permanent teeth is dependent on a variety of factors including stage of root development, type of healing and optimal

repositioning of coronal fragments and/or splinting of teeth. Both the IADT[4] and Andreasen and Andreasen[1] recommend repositioning the coronal fragment if displaced and immobilizing the tooth with a splint with follow-up in 3-4 weeks. Recent research suggests that optimal repositioning may be more critical than splinting. With dislocation of coronal fragments, optimal repositioning enhances the likelihood of both pulp healing and hard tissue repair in mature and immature teeth.[9] Cvek and colleagues[9] found no difference in the frequency of healing between splinted and non-splinted teeth.

One exception to the concept of repositioning root fractures involves teeth with incomplete fractures with immature roots wherein fractures have been found to heal spontaneously.[10] Similar findings have been reported by Freely and colleagues[11] as well as Cvek and colleagues[9], both of whom found good root healing to occur most often in teeth with incomplete root development.

Based on the current literature, root fractures in children and adolescents have a good prognosis if a proper diagnosis is made at the time of the traumatic injury and if the proper treatment is undertaken. Radiographic information is a key component for making such diagnosis, and rendering the proper treatment. Accordingly, our findings should offer important insights for clinicians to consider in making a radiographic diagnosis of root fractures. These insights may lead to the development of new clinical standards of care that may save time, money and unneeded radiation exposure.

ENDNOTES

[1]Andreasen JO, Andreasen FM. Textbook and color atlas of traumatic injuries to the teeth. 3rd edn. Copenhagen: Munksgaard; 1994: p. 151-8, 171-5, 279-81.

[2]Majorana A, Pasini S, Bardellini E, Keller E. Clinical and epidemiological study of traumatic root fractures. Dent Traumatol 2002;18:77-80.

[3]Wilson C. Management of trauma to primary and developing teeth. Dental Clinics of North America 1995;39:133-67.

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[7]Berman L. A Clinical Guide to Dental Traumatology. Chapter 4 Intraalveolar root fractures. 2006: p. 51-71.

[8]Herweijer JA, Torabinejad M, Bakland L: Healing of horizontal root fractures, J Endod 1992;18(3):118-122.

[9]Cvek M, Andreasen JO, Borum MK. Healing of 208 intraalveolar root fractures in patients aged 7-17years. Dent Traumatol 2001;17:53-62.

[10]Andreasen FM, Andreasen JO, Bayer T. Prognosis of root-fractured incisors: prediction of healing modalities. Endod Dent Traumatol 1989;5:11-22.

[11]Feely L, Mackie IC, Macfarlane T. An investigation of root-fractured permanent incisor teeth in children. Dent Traumatol 2003;19:52-4.

CHAPTER 2

MATERIALS AND METHODS

Specific Aims

1. To characterize epidemiological trends in anterior permanent tooth trauma in a sample of children and adolescents aged 6-18.
2. To examine the relationship of root fractures with and without concomitant crown fractures to answer the question: are crown fractures protective against root fractures in children and adolescents?
3. To carefully examine our patient population for radiographic evidence of root fractures and determine the diagnostic and clinical value of obtaining three vertical periapical radiographic projections to assess maxillary anterior root fractures in children and adolescents aged 6 -18.

We tested two null hypotheses for children and adolescents aged 6-18: 1) crown fractures are **not** protective against root fractures and 2) three vertical periapical radiographs at different angles are **not** necessary for the diagnosis of root fractures.

Sample Size Estimations

For sample size estimates, we used reported prevalence scores from a recent study of dental trauma in children[12] in which children (7-18 years of age) had a reported crown and root fracture prevalence of 32.1% and 2.1%, respectively. Assuming the same prevalence levels with an alpha error of 0.05 and beta of 0.80, we estimated a sample size of 134 cases

would be needed to detect a difference using simple parametric tests such as chi-square tests. Because our inclusion criteria required three *clearly diagnostic* radiographs, we expected that some patient records would be hard to access, some radiographs would be missing from some records, and others would not meet our strict standard of being *clearly diagnostic*.

Sample Characterization

We reviewed our eight-year emergency registry and carefully selected only the cases involving permanent maxillary incisor trauma for which three diagnostic vertical periapical radiographs were available in each patient's record. All cases were then categorized by diagnostic category with tooth/bone-related trauma: uncomplicated, complicated, root fracture, crown-root fracture, alveolar fracture and luxation-related trauma: concussion, subluxation, luxation, intrusion, extrusion and avulsion. In classifying the type of trauma, we relied upon the diagnosis given by the treating dentists at the time of trauma.

We classified each trauma case according to ethnicity, gender, age, and etiology. The etiology was classified into seven groups: falls during free-play, sports-related accidents, bicycle accidents, automobile accidents, ATV/motorbike accidents, child abuse, and "other." For athletic injuries, we recorded whether an athletic mouthguard was in use by the child at the time of the injury.

Root Fracture Assessment by Expert Examiners

Two experienced dentists with expertise in dental trauma served as expert examiners for root fracture assessment. The examiners were trained in two consensus-building calibration sessions using a sub-sample of trauma cases that included three periapical radiographs obtained at different vertical angulations. All radiographic interpretations were accomplished using view boxes in a dark room. The purpose of each session was to 1)

review the definition of root fractures 2) complete independent reviews of selected radiographs from sample cases including some with root fractures and 3) to debrief all reviews to achieve calibration and build examiner consensus.

The current literature included no data on the degree of examiner agreement achievable. Our goal was to achieve a Kappa score of at least 0.80 for both intra- and inter-examiner reliability. After training and calibration, the examiners independently assessed the case-study radiographs for root fractures in a final, structured session under the supervision of the Principal Investigators. A random sample group of twenty cases were re-examined unknowingly by the examiners to provide data for the determination of intra-examiner reliability. Following a review of all cases, the examiners discussed those cases for which there were diagnostic disagreements and reached a diagnostic consensus. Kappa statistics were performed to determine the level of agreement for intra- and inter-examiner reliability.

Why Expert Examiners?

Considering that the patients in this study had undergone a comprehensive dental trauma examination and many had subsequent follow-up care during which root fractures could have been detected and diagnosed, the purpose of deploying expert examiners was to cross-examine the study sample to determine whether there were cases diagnosed with root fractures with actual clinical/radiographic assessments and follow-up care that went ***undetected*** by the expert examiners. Further, we also wanted to examine if the expert examiners would detect any ***occult*** fractures not detected by clinical/radiographic assessment and follow-up care. Finally, we wanted to generate data for intra- and inter-examiner reliability to illuminate the ease or difficulty in the radiographic diagnosis of root fractures in children and adolescents.

Statistical Analysis

All analyses were conducted using STATA 9.0 (STATA Corp. College Station, Texas). We examined the relationship between crown fractures and root fractures using a Likelihood Ratio Chi-square test with the level of significance set at an alpha of 0.05. We determined the diagnostic value of obtaining three vertical periapical radiographs using inspection of our examiner-derived positive root fractures.

Human Subject Assurances

This study was approved by the Institution Review Boards of the Schools of Dentistry and Medicine at The University of North Carolina at Chapel Hill.

ENDNOTES

[12]Skaare AB, Jacobsen I. Dental Injuries in Norwegians aged 7-18 years. Dent Traumatol 2003;19:67-71.

CHAPTER 3

RESULTS

Demographic Findings

During the study time-frame (1997-2004) the total emergency visits ranged from 400-700 annually with an estimated 125 permanent anterior tooth trauma cases each year. A total of 114 patients experienced dental trauma to the permanent maxillary incisors for which three radiographs were obtained at the initial emergency visit. Relevant demographic data for the patients are found in Table 1.

Epidemiologic Findings

Our 114 patients experienced a total of 201 traumatized maxillary incisor teeth. The epidemiological data are illustrated in Figure 1. From our sample size of 201 traumatized teeth, using our strict inclusion criteria of three *clearly diagnostic* radiographs, 185 teeth met our inclusion criteria. The expert examiners assessed these images to generate data for root fractures.

Intra- and Inter-Examiner Reliability

The radiographic assessment session for the study data generation yielded Kappa scores of 81% for inter-examiner reliability and 100% consensus for those cases wherein examiners at first disagreed. The intra-examiner reliability Kappa scores were 0.80 and 0.75 respectively for examiners 1 and 2.

Radiographic Assessment Findings

The expert examiners focused on the 185 teeth that met our strict inclusion criteria for the availability of three *clearly diagnostic* radiographs having been obtained at the initial trauma visit. The expert examiners assessed these images to generate data for root fractures as illustrated in Table 2. Crown fractures were not protective against root fractures; indeed, teeth with crown fractures were two times as likely to have a root fracture as those without crown fractures.

Findings Related to the Number of Radiographic Images

Our expert examiners reached a consensus on a total of 22 root fractures in the sample. Three root fractures (13%) were seen on only one of three images, 14 (64%) were seen on two of the three images and five (23%) were seen on all three images.

Characteristics of the Root Fractures

Table 3 illustrates specific details of the root fractures in our study. The prevalence of the root fractures diagnosed by the clinicians at the time of injury was 1.6% (3 out of 185). The prevalence of root fractures identified by the expert examiners was 11.9 % (22 out of 185). The patients in our study for whom root fractures were identified were in the age range of 7y1m to 13y6m with a median of 8y10m. The prevalence slightly favored males.

Table 3 illustrates concomitant tooth/bone and luxation injury relationships. Of special interest are location and fracture type categories. Note that half of the occult fractures were found in the mid-root location and half in the apical location. A more dramatic finding is that 95% of the occult fractures were incomplete while only 5% (one fracture) was complete.

CHAPTER 4

DISCUSSION

Epidemiology

It should be recognized that ours is a select sample of trauma to only permanent maxillary incisors; however, relative to gender and etiology our epidemiological findings are very similar to those reported by Rajab[13] and Andreasen and Andreasen.[1] One difference in our patient population was the age of those patients. In our sample of 185 teeth, patients' ages ranged from 7y1m to 13y6m. Our patients are clearly younger and this is in contrast to root fractures reported by Rajab[13] that occurred in older children (10-15) and those reported by Andreasen and Andreasen[1] with ages ranging from 11-20.

None of our trauma cases involved mouthguard use, including the 14 children with sports-related injuries. Also, we were surprised that sports injuries were not higher among our study sample. Mouthguard use among school-aged athletes is relatively high in our community and we speculate that this phenomenon might have reduced the prevalence of sports-related trauma during the time-frame of the study.

Intra- and Inter-Examiner Reliability

Our examiners were experienced clinicians with expertise in dental taumatology and both were active in the field. While the Kappa scores for intra-examiner reliability were acceptable, in general the findings suggest that radiographic diagnosis of root fractures in children and adolescents is difficult, even under the most ideal conditions.

The Challenge of Root Fracture Diagnosis

It should be noted that our sample included only three root fractures that were diagnosed on the basis of the clinical/radiographic data at the time of injury and no additional diagnoses were made during trauma follow-up. Our examiners correctly identified only one of those three fractures. The examiners found an additional 21 *occult* fractures that were not detected by the treating dentists at the time of injury. These 21 fractures were either undiagnosed or not recorded by the attending dentist following the traumatic injury. The difficulty of root fracture diagnosis is highlighted by the results that even calibrated "experts" in dental trauma had difficulty detecting root fractures. This further emphasizes the importance of the additional clinical exam, as well as the radiographic exam, to accurately detect or suspect root fractures; again, our experts did not have any information related to the clinical exams that had taken place. It is evident how even after "sensitizing" examiners to detect root fractures, two remained undiagnosed.

It is interesting that the large prevalence of *occult* root fractures detected were incomplete and Andreasen and Andresean [10] point out that such fractures heal with subsequent hard tissue formation and have an excellent prognosis. The one complete fracture was located in the apical third, which authorities[1] suggest have an excellent prognosis with no treatment required.

One could also justify that it is not important to diagnose root fractures as long as repositioning is performed. Studies show optimal repositioning leads to better healing and a more favorable prognosis.[9] These findings underscore the challenge of detecting root fractures in children and adolescents and also suggest that the clinical examination is an important adjunct to supplementing radiographic assessment for diagnosis at the time of

injury. These results also emphasize the need to examine radiographs very carefully, using a dark room and close inspection. It is important to diagnose a root fracture because if it is missed, the diagnosis may be a severe luxation injury which would typically necessitate root canal treatment. However, if a root fracture is correctly diagnosed, root canal treatment should NOT be performed and will eventually only be needed about 25% of the time. [1]

Are Coronal Fractures Protective Against Root Fractures?

Clinical experience had suggested to us that coronal fractures seemed to be protective against root fractures in children and adolescents. The rationale is that injury to the tooth occurs at the site of impact and if a tooth has a coronal fracture, this is the focus of impact and the remaining tooth should remain sound. Yet, the results from the present investigation indicated that crown fractures were **not** protective against root fractures. In fact, teeth with crown fractures were almost twice as likely to have a root fracture.

These findings suggest clinicians should be more suspicious of a root fracture in those teeth with uncomplicated crown fractures or no trauma to the coronal aspect of the tooth because these teeth were more likely to have an accompanying root fracture. Table 3 illustrates this point. This finding should heighten clinicians' awareness when evaluating and diagnosing dental trauma.

How Many Radiographic Projections are Needed?

The literature supports that multiple radiographic projections are needed to increase the likelihood of diagnosing a root fracture.[1,3,5-8] Degering[5] looked at radiographs of experimental root fractures of the anterior teeth to find which angulations provided the most diagnostic information. His study revealed fractures were diagnostic in a latitude of +/- 15 to 20 degrees of vertical angulation relative to the fracture plane. Two additional radiographs

should be obtained of the questionable area with a +15 degree and -15 degree vertical angulation in relation to the original tube position.[5]

Our findings indicate that multiple radiographic projections are needed to increase the likelihood of diagnosing a root fracture. Under the conditions of our study, we were not able to say definitively that three radiographs is the best protocol. However we hypothesize that a root fracture that can be detected in more than one image increases the clinician's confidence in the diagnosis and is more likely to be recorded and treated by the clinician as a true root fracture. Without obtaining more than one film, the root fracture may be overlooked or disregarded as a defect in root development, an artifact, or bone trabeculae/bony trabeculation.

ENDNOTES

[1]Andreasen JO, Andreasen FM. Textbook and color atlas of traumatic injuries to the teeth. 3rd edn. Copenhagen: Munksgaard; 1994: p. 151-8, 171-5, 279-81.

[3]Wilson C. Management of trauma to primary and developing teeth. Dental Clinics of North America 1995;39:133-67.

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[10]Andreasen FM, Andreasen JO, Bayer T. Prognosis of root-fractured incisors: prediction of healing modalities. Endod Dent Traumatol 1989;5:11-22.

[13]Rajab LD. Traumatic dental injuries in children presenting for treatment at the Department of Pediatric Dentistry, Faculty of Dentistry, University of Jordan, 1997-2000. Dent Traumatol 2003;19:6-11.

CHAPTER 5

STRENGTHS AND POTENTIAL LIMITATIONS

This study included all children and adolescents who presented with a traumatic dental injury over an eight-year period of time. Because we relied on patient records, we were not able to monitor root fracture outcomes over time because some patients did not return for follow-up. An ideal study design would be a prospective, randomized controlled trial; however, such a study for a population of this size for eight consecutive years would be strategically challenging and enormously costly. Our sample offered us an opportunity to study a relatively large cohort with relative ease, and at a fraction of the cost. At the same time, it would not be ethical to conduct a prospective, randomized controlled trial assessing one *versus* multiple projections under a scenario where the latter is the standard of care.

By using a research design that included two calibrated and "sensitized" examiners, our findings yielded new information about the diagnostic challenge of radiographic interpretation of root fractures in children and adolescents.

CHAPTER 6

CONCLUSIONS

Moving toward Evidence-Based Practice Guidelines

One area for which more evidence-based study is needed is in the realm of diagnosis and clinical management of dental trauma in children and adolescents. A 20-year (1985-2005) Medline search revealed 102 published studies on this subject but only 20 were focused on children and adolescents and only three of these were scientific investigations and none established clinical guidelines or recommendations. These results were confirmed by a search in the Cochrane Collaboration systematic review database that revealed no studies on this topic.[14] Our study sought seeks to fill a gap through the generation of evidenced-based clinically relevant guidelines for the diagnosis of root fractures in children and adolescents.

Conclusions and Implications for Clinical Practice

Under the conditions of this study examining children and adolescents 6-18 years of age with anterior permanent tooth trauma:

1) Crown fractures were not protective against root fractures. Teeth with crown fractures were almost twice as likely to sustain root fractures.

2) Radiographic root fractures were very difficult to detect. Radiographic images aimed at detection of root fractures should be reviewed carefully under ideal conditions of illumination to make a proper diagnosis.

3) Root fractures in children in the pre-teen years are likely to be incomplete and located in the apical or middle third of the root.

4) Our data would suggest there is no reason to suspect a complete root fracture in pre-teen children **unless** the tooth exhibits clinical signs such as luxation or excessive mobility; in short, obtaining three radiographic images to examine for root fractures for all tooth trauma in this age group seems unnecessary.

5) When root fractures are suspected, multiple radiographic projections at different vertical angulations will increase the diagnostic precision for making a root fracture diagnosis.

ENDNOTES

[14]Cochrane Collaboration. Available at: http://www.cochrane.org/index0.htm. Accessed February 10, 2006.

Table 1. Epidemiology and Demographics N=114

Variables	n	Percent
Gender		
Male	72	63%
Female	42	37%
Age		
Six	5	4%
Seven	20	18%
Eight	27	24%
Nine	22	19%
Ten	14	12%
Eleven	7	6%
Twelve	14	12%
Thirteen	0	0%
Fourteen	0	0%
Fifteen	3	3%
Sixteen	2	2%
Seventeen	0	0%
Eighteen	0	0%
Etiology		
Falls	38	34%
Bicycle Accident	22	20%
Playing Sports	14	12%
ATV/motorbike Accident	2	2%
Automobile Accident	1	1%
Child Abuse	0	0%
Other (i.e., free play, random accidents, etc)	37	31%
Mouthguard Use	0	0%

Table 2. Relationship between Crown Fractures and Expert Examiners' Radiographic Diagnosis of Root Fractures

Crown Fracture Presence	Radiographic Root Fractures' Presence No	Yes	Total
No	75 (41%)	8 (4%)	83 (45%)
Yes	88 (48%)	14 (7%)	102 (55%)
N=185	163 (89%)	22 (11%)	185 (100%)

Likelihood Ratio Chi-square, P = 0.052
Odds Ratio = 1.97

Table 3. Root Fracture Assessment by Expert Examiners

Case Number	Patient Age	Sex	Tooth Number	Tooth Injury	Luxation Injury	Fracture Type	Fracture Location	Radiographic Images *
1	7y1m	M	8	None	SUB	INC	API	3
2	7y3m	F	9	None	CON	INC	API	3
3	7y6m	M	8	UCF	None	INC	MID	2
4	7y8m	M	8	UCF	None	INC	API	2
5	8y0m	M	8	UCF	None	INC	MID	2
6	8y0m	M	9	UCF	SUB	INC	API	2
7	8y1m	M	7	None	SUB	INC	API	2
8	8y3m	M	9	None	SUB	INC	MID	2
9	8y5m	F	9	UCF	None	INC	API	3
10	8y6m	M	8	UCF	None	INC	MID	3
11	8y10m	M	8	UCF	SUB	INC	MID	1
12	8y10m	M	9	UCF	SUB	INC	MID	1
13	9y2m	F	8	CRF	SUB	INC	MID	2
14	9y4m	M	9	UCF	CON	INC	API	2
15	9y6m	F	8	CCF	None	INC	API	2
16	9y8m	F	9	UCF	None	INC	API	2
17	9y8m	F	9	UCF	None	INC	MID	2
18	10y4m	M	8	UCF	None	INC	API	2
19	10y11m	M	9	None	SUB	INC	MID	3
20	11y6m	M	8	None	SUB	INC	MID	2
21	11y6m	M	9	None	SUB	INC	MID	2
#22	**13y6m**	**M**	**8**	**RF**	**LUX**	**COM**	**API**	**1**

N=22

Two Root Fractures Not Detected by Expert Examiners

1	9y0m	F	9	RF	LUX	COM	API	2
**2	10y3m	M	8	RF	SUB	INC	MID/M	1

Tooth Injury: None, UCF=uncomplicated crown fracture, CCF=complicated crown fracture, CRF=crown-root fracture, RF=root fracture.

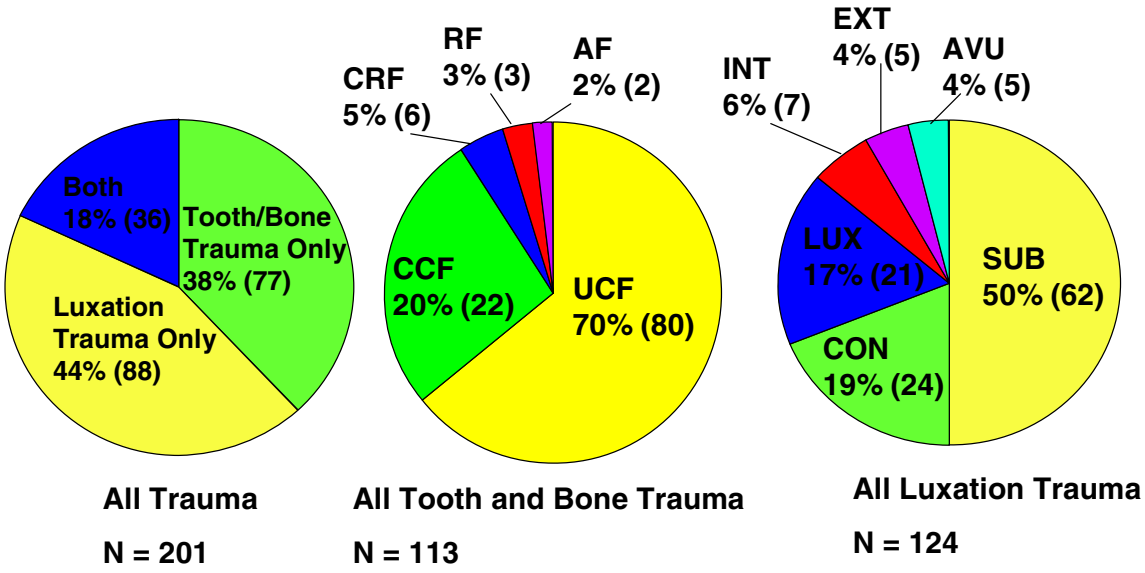
Luxation Injury: None, CON=concussion, SUB=subluxation, LUX=luxation.

Fracture Type: INC=incomplete fracture, COM=complete fracture.

Fracture Location: CER=cervical third, MID=middle third, API=apical third.

* The total number of radiographic images on which the fracture was noted by the expert examiners.
** Conventional radiographs were obtained for all cases except Case 2 in those root fractures **not** detected by expert examiners. Digital radiographs were obtained for this case.
# Case identified at the time of injury and by expert examiners as positive for root fracture.

Figure 1. Epidemiology of Maxillary Anterior Trauma in Children and Adolescents.



Tooth and Bone Trauma: UCF=uncomplicated crown fracture, CCF=complicated crown fracture, CRF=crown-root fracture, RF=root fracture, AF=alveolar fracture.

Luxation Trauma: SUB=subluxation, CON=concussion, LUX=luxation, INT=intrusion, EXT=extrusion, AVU=avulsion.

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[5]Degering C. Radiography of dental fractures: an experimental evaluation. Oral Surg 1970;30:213-9.

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