

Temporomandibular Joint Dysfunction After Mandibular Fracture in Children

A 10-Year Review

Shelby C. Leuin, MD; Emily Frydendall, BA; Dexiang Gao, PhD; Kenny H. Chan, MD

Objectives: To collect demographic and clinical data on pediatric mandibular fractures and to assess temporomandibular joint (TMJ) dysfunction in patients with condylar and subcondylar (C/SC) fractures.

Design: Retrospective case series of pediatric mandibular fractures (1999-2009) with follow-up telephone questionnaire of patients with C/SC fractures. Collected data included age, gender, unilateral vs bilateral C/SC fracture, presence of concomitant fracture, velocity of injury, and treatment modality.

Setting: Tertiary care children's hospital.

Patients: Of 164 patients with mandibular fractures, 83 (50.6%) had C/SC fractures, of which 45 (54.2%) completed the questionnaire.

Main Outcome Measures: Helkimo Anamnestic Dysfunction Index (A_i) quantification of TMJ dysfunction after C/SC fracture and treatment modality of C/SC fractures.

Results: Of the 164 patients, 122 (74.4%) were male (median age, 10.4 years; age range, 0.6-19.0 years). Of the 83 patients with C/SC fractures, 61 (73.5%) were male (median age, 9.1 years; age range, 1.1-18.7 years); 66 (79.5%) had unilateral fractures and 17 (20.5%) had bilateral fractures. The A_i distribution of the 45 patients who completed the questionnaire was as follows: 15 (33.3%) none, 6 (13.3%) mild, and 24 (53.3%) severe. Females have more severe dysfunction than do males (95% confidence interval, 1.6-140.0; $P = .02$). No other significant predictors of treatment modality or TMJ dysfunction were identified. Patients with bilateral fracture are 8.1 times (95% confidence interval, 1.0-66.1 times; $P = .05$) more likely to have closed reduction than are those with unilateral fracture.

Conclusions: This is one of the largest series of pediatric C/SC fractures reported in the recent literature. Findings are significant for increased severity of TMJ dysfunction in females and higher incidence of closed reduction in patients with bilateral C/SC fracture.

Arch Otolaryngol Head Neck Surg. 2011;137(1):10-14

FACIAL FRACTURES ARE AN UNCOMMON occurrence in children owing to differences in the ratio between cranial and facial volume in children vs adults. At birth, the ratio of cranial to facial volume is approximately 8:1. By the completion of growth, this ratio decreases to 2.5:1.^{1,2} As a result, young children are more likely to sustain a skull fracture from frontal impact, whereas adults are more likely to develop facial fractures.^{1,2} Despite the lower incidence of facial fractures in children, they do occur, and they account for 5% of all pediatric trauma.³

Excluding nasal fractures, mandible fractures account for approximately one-third of all pediatric facial trauma.⁴ However, the management of pediatric mandibular fractures should be considered different from that of adults. In children, one must consider the potential disruption of growth centers, especially when managing condylar fractures. Also impor-

tant to consider is that the deciduous teeth have short, bulbous crowns and are often poor abutments for wires or arch bars, making interdental immobilization significantly more challenging in children than in adults.⁵ The placement of wire through alveolar bone may damage developing permanent tooth follicles.⁶

 CME available online at www.jamaarchivescme.com and questions on page 8

Although condylar and subcondylar (C/SC) fracture of the mandible is the most common fracture site in children, its treatment remains controversial, and it poses long-term functional sequelae. The optimal management of C/SC fractures in children has been the subject of debate throughout the literature for many years. It has been historically argued that condylar fractures in children may be the only

Author Affiliations: Department of Otolaryngology, University of Colorado Denver, School of Medicine (Drs Leuin and Chan and Ms Frydendall) and Research Institute, The Children's Hospital, Aurora (Dr Gao), Colorado.

skeletal fracture in which no attempt to regain anatomic reduction is necessary.⁶ Options for treatment include open reduction with intraosseous fixation and intermaxillary fixation, closed reduction with immobilization using intermaxillary fixation, and nonimmobilization with emphasis on early motion.⁶

There have been few long-term surveys of functional outcome after condylar fractures in children, making a comparative assessment of optimal treatment all the more challenging. The goal of this study was to collect information on all pediatric mandible fractures occurring at The Children's Hospital, Aurora, Colorado, during the past 10 years. After identifying all patients who experienced C/SC fractures, we administered a follow-up telephone questionnaire to assess the degree of temporomandibular joint (TMJ) dysfunction and long-term functional outcome based on demographic and clinical data.

METHODS

After Colorado Multiple Institutional Review Board approval was obtained, we performed a 10-year (1999-2009) retrospective medical record review of all pediatric patients treated for a mandible fracture by members of the Department of Otolaryngology at The Children's Hospital. Demographic and clinical data collected about all the patients included age, gender, date of fracture, presence of unilateral vs bilateral C/SC fracture (termed *laterality of fracture*), presence of concomitant fracture with C/SC fracture, mechanism and velocity of injury, fracture location, type of management (medical or surgical), and date and type of surgical management, if applicable.

All the families in the C/SC fracture group were offered a questionnaire to assess functional disabilities related to the TMJ. The questionnaire was modeled after the 1993 questionnaire of Nørholt et al⁷ (Figure 1). Based on the response to the questionnaire, an Anamnestic Dysfunction Index (A_i) score of 0 to 2 was assigned as described by Helkimo.⁸⁻¹¹ An A_i value of 0 (A_i0) denotes no symptoms of dysfunction; A_i1, mild symptoms of dysfunction (including joint sounds, stiffness, or fatigue of the jaw); and A_i2, severe symptoms (including locking, luxation, and joint pain).

To organize the disparate types of mandibular injuries seen in this cohort, we modified the mechanism of injury categories described by Ferreira et al¹ into 3 types: low, medium, and high velocity. Low-velocity injury includes a fall from ground level. Medium-velocity injury includes bicycle accident, sport, animal accident, assault, violence, and fall from a height above ground level. High-velocity injury includes motor vehicle crash (car, motorcycle, and all-terrain vehicle).

Fracture location was identified by reviewing hospital medical records, operative reports, and radiographic findings (a panoramic tomogram [Panorex; SS White Co, Holmdel, New Jersey] or computed tomography). The C/SC fractures were further categorized into distinct types: unilateral, bilateral, and concomitant (defined as unilateral or bilateral C/SC fracture in conjunction with an additional mandibular fracture site).

When age was used for comparison purposes, the classification based on eruption of primary and secondary dentition as described by Thorén et al¹² was used. The classification breaks down the age range into 5 groups: group 1 (0-5 years), group 2 (6-9 years), group 3 (10-12 years), group 4 (13-15 years), and group 5 (16-18 years).

Summary statistics were used to describe patient demographic and clinical characteristics. Logistic regressions were used to examine the potential association between the 2 outcome mea-

Telephone Questionnaire			
Patient Name: _____			
Parent Verbal Consent:	Y	N	
Child Verbal Assent:	Y	N	N/A
Please state the number that most closely represents your/your child's opinion:			
How would you describe your child's ability to chew?			
Poor	1	2	3 4 5 Good
How would you describe your child's ability to open the mouth wide?			
Poor	1	2	3 4 5 Good
Does your child experience sounds from the temporomandibular joints?			
Right: Often	1	2	3 4 5 Never
Left: Often	1	2	3 4 5 Never
Does your child feel pain from the joints?			
Right: Often	1	2	3 4 5 Never
Left: Often	1	2	3 4 5 Never
Does your child feel tired in the jaws?			
Often	1	2	3 4 5 Never
Does locking of the joints occur?			
Often	1	2	3 4 5 Never
Are you aware of any asymmetry of your child's face?			
Very Much	1	2	3 4 5 Not at All
Has your child sustained any other facial fractures?			
If yes, please describe what kind.			
Has your child had orthodontic treatment after the fracture?			
If yes, please describe what kind.			

Figure 1. Telephone questionnaire administered to the study patients.

asures of A_i value and treatment modality compared with the following potential predictors: age, gender, treatment, velocity of injury, laterality of fracture, concomitant mandible fracture, and time from surgery to questionnaire completion. Univariate analysis was performed first, and variables with $P \leq .1$ were entered into multivariate models to examine the association with the outcome while adjusting for the other covariates.

RESULTS

A total of 164 children were identified in the 10-year retrospective review. The mean patient age was 10.3 years (median age, 10.4 years; age range, 0.6-19.0 years). There were 122 males and 42 females (2.90:1 ratio). The distribution of patients by injury type was 42, 93, and 27 for high-, medium-, and low-velocity injuries, respectively. Two patients had an unknown mechanism of injury. Distribution of patient characteristics is seen in the Table. A total of 258 fractures were identified, and the distribution of the fractures is depicted in Figure 2.

Eighty-three of 164 patients (50.6%) were identified as having C/SC fractures. Their mean age was 8.9 years (median age, 9.1 years; age range, 1.1-18.7 years). There were 61 males and 22 females (2.77:1 ratio). The distribution of patients by injury type was 15, 50, 17, and 1 for high-, medium-, low-, and unknown velocity injuries, respectively. Sixty-six patients had unilateral C/SC fractures and 17 had bilateral fractures. Concomitant fractures occurred in 38 of the 83 patients with C/SC fractures. Twenty-six of the patients were managed medically, which consisted of a soft diet, analgesics, and warm

Table. Distribution of Patient Demographics

Variable	Patients With Mandibular Fractures		
	All (N=164)	C/SC (n=83)	C/SC and Completed Questionnaire (n=45)
Age, mean (median) [range], y	10.3 (10.4) [0.6-19.0]	8.9 (9.1) [1.1-18.7]	9.9 (10.0) [1.1-18.7]
Gender			
Male, No.	122	61	33
Female, No.	42	22	12
Ratio M/F	2.90:1	2.77:1	2.75:1
Laterality, No.			
Unilateral	NA	66	35
Bilateral	NA	17	10
Concomitant	NA	38	26
Velocity of injury, No.			
High	42	15	9
Medium	93	50	28
Low	27	17	8
Unknown	2	1	0
Treatment, No.			
Medical	NA	26	13
Surgical	NA	57	32
Time from surgery to questionnaire completion, mean (range), y	NA	NA	3.72 (0.42-10.34)

Abbreviations: C/SC, condylar and subcondylar; NA, not applicable.

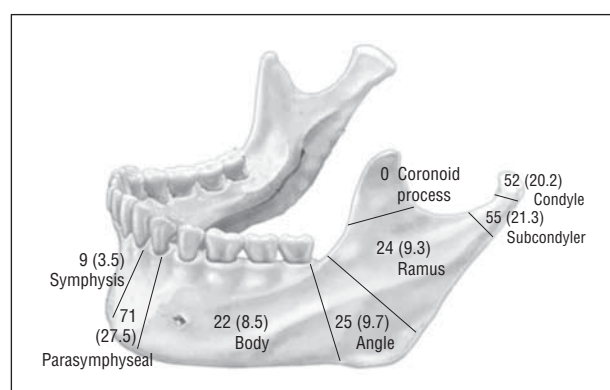


Figure 2. Distribution of the 258 mandibular fractures by region. Data are given as number (percentage). Adapted with permission from *Encyclopedia Britannica*, 2007 Encyclopedia Britannica Inc.

compresses. Fifty-six patients underwent closed reduction with maxillomandibular fixation using ivy loops or arch bars for an average of 25.7 days (range, 15-43 days). One patient underwent an open surgical reduction (Table).

The questionnaire was completed by 45 of the 83 patients (54.2%) with C/SC fractures. The demographic and clinical characteristics of this subgroup were similar to those of the total C/SC group (Table). The patient who underwent open reduction did not complete the questionnaire and, therefore, was not included in this portion of the data analysis. Therefore, this resulted in 2 treatment groups: medical treatment vs closed reduction. An A_1 0 was found in 15 patients (33.3%), A_1 1 in 6 (13.3%), and A_2 in 24 (53.3%).

Univariate logistic regressions were used to examine the association of A_1 value with the following independent variables: age, gender, laterality of fracture, presence of concomitant mandibular fracture, velocity of in-

jury, treatment, and time from surgery to questionnaire completion. All the models met the proportional odds assumption, that is, the regression functions are parallel on the logistic scale for mild symptoms vs no symptoms and for severe symptoms vs mild symptoms of dysfunction. The variables of age ($P=.50$), presence of concomitant mandibular fracture ($P=.88$), velocity of injury ($P=.39$), treatment ($P=.36$), and time from surgery to questionnaire completion ($P=.99$) were not significant. The variables of gender ($P=.009$) and laterality of fracture ($P=.05$) had $P < .1$ and were, therefore, entered into the multivariate logistic regression model. This showed that gender is still significantly associated with the outcome adjusting for the laterality of fracture (odds ratio [OR], 15.0; 95% confidence interval [CI], 1.6-140.0; $P=.02$), whereas laterality of fracture is no longer associated with the outcome in the presence of the gender effect (OR, 0.5; 95% CI, 0.10-1.97; $P=.30$). Compared with males, females are 15 times more likely to show a worse A_1 value for mild symptoms vs no symptoms and for severe symptoms vs mild symptoms of dysfunction (95% CI, 1.6-140.0; $P=.02$). In analyzing the A_1 distribution by gender, findings included 15 males with A_1 0, 5 males with A_1 1, and 13 males with A_2 . This is compared with 0 females with A_1 0, 1 female with A_1 1, and 11 females with A_2 . Therefore, 92% of females reported severe TMJ dysfunction while 60% of males had either mild or no TMJ dysfunction following C/SC fracture.

The association between treatment modality and potential predictors, including age, gender, laterality of fracture, presence of concomitant mandibular fracture, and velocity of injury, was examined using logistic regression, where outcome was closed reduction vs medical management. The single patient with open surgical reduction was deleted from the analyses, which were, thus, performed using data from the 82 patients with C/SC frac-

ture. The results are significant for laterality of fracture ($P=.04$) and presence of concomitant fracture ($P=.08$) but not for age ($P=.15$), gender ($P=.37$), or velocity of injury ($P=.28$).

Laterality of fracture and presence of concomitant mandibular fracture were then entered into the multivariate regression model. This showed that laterality of fracture is still significantly associated with treatment modality (OR, 8.1; 95% CI, 1.0-66.1; $P=.05$), whereas the presence of concomitant mandibular fracture is no longer associated with the outcome (OR, 2.1; 95% CI, 0.8-5.8; $P=.16$). Patients with bilateral fracture are found to be 8.1 times (95% CI, 1.0-66.1; $P=.05$) more likely to have closed reduction than are patients with a unilateral fracture.

COMMENT

The management of pediatric C/SC fractures of the mandible has been a subject of debate for many decades. This has been due, in part, to the lack of implementation of a standardized, systematic method for assessing their functional outcomes. Multiple studies published in the past decade have sought to address these issues.

Nørholt et al⁷ examined 55 pediatric patients who were medically treated for a fracture of the mandibular condyle and created a questionnaire to measure their functional outcome. He found that in younger children, a conservative treatment strategy is preferable, whereas older children had an often unsatisfactory outcome. A report of 26 condylar fractures by Thorén et al¹² concluded that no benefit was gained by maxillomandibular fixation and that a soft diet and immediate mobilization is the treatment of choice. Choi et al¹³ reviewed a series of 11 consecutive children and adolescents with condylar fractures who had been treated with conservative therapy. They concluded that nonsurgical management of condylar fractures in children results in a satisfactory long-term outcome despite abnormal radiographic findings. Deleyiannis et al¹⁴ reviewed 6 children 14 years or younger with a C/SC fracture who underwent open reduction with internal fixation. These patients were found to have outcomes similar to those of patients managed nonsurgically, and they concluded that until there is a distinct advantage to open surgery, these patients should be managed medically as a first-line treatment.

The present study provides the first large-scale review of pediatric mandible fractures in the past 10 years that collected demographic data on the entire population and provided data regarding TMJ dysfunction based on a follow-up questionnaire. The reported incidence of condylar fracture varies widely in the literature (19%-62%).¹² Most studies^{1,2,7,12,15,16} have found an incidence of 19% to 50%. The preponderance of C/SC fractures in this series (50.6% of all patients and 41.4% of all fractures) is, therefore, at the high end or slightly higher than the incidence quoted in most other studies.

Regarding the outcome measure A_1 , we noted a new finding of increased reported TMJ dysfunction in females compared with males. Multivariate analysis showed that this gender difference is not confounded by age, lat-

erality, presence of concomitant fracture, velocity of injury, or treatment modality. These findings are in disagreement with studies in the literature that TMJ dysfunction correlates with increasing age. We did not see evidence of increased dysfunction with age in this patient population. The increased incidence of closed reduction treatment in the presence of bilateral fractures is an expected finding. The presence of a bilateral fracture would increase the likelihood of malocclusion or unstable fracture, requiring rigid fixation. In accordance with most previous studies, we did not demonstrate an improved outcome with surgical management of C/SC fracture compared with medical management.

The dreaded complication of a condylar fracture is the development of TMJ ankylosis with or without growth retardation, which is reported to occur in 1% to 7% of condylar fractures.^{2,5} Ankylosis of the TMJ is more likely to occur in children with bilateral condylar fractures, in children aged 2 to 5 years, if treatment is delayed, or if maxillomandibular fixation is prolonged.² To our knowledge, none of the 45 questionnaire respondents had this complication. Yet, 53% of the respondents reported significant TMJ complaints (A_2). This underscores that C/SC fractures in children have long-term consequences regardless of treatment strategies.

This study identified gender as a statistically significant factor in the outcome of TMJ function after C/SC fracture, a finding that has not been reported in previous literature, to our knowledge. A previous population-based epidemiologic study of adults by LeResche¹⁷ found that TMJ dysfunction is a disorder of adults and is less seen in children. He also found that TMJ pain and crepitus in the joint was universally found to appear about twice as frequently in women as in men. He did not find these gender differences to be present in children, however. When investigating possible etiologic factors, it was noted that life stress, depression, and the presence of multiple somatic symptoms are often found to be risk factors for TMJ pain, and these tend also to be reported more frequently in women. Female reproductive hormones have also been implicated in joint pain and pain syndromes, whereas testosterone in males may help attenuate pain symptoms.¹⁸ However, this would be less relevant in the pediatric population. Further investigation is warranted to determine whether other factors contribute to the increased level of dysfunction reported in female pediatric patients vs males in the present study.

The major limitations of this study rest in the intrinsic weakness of a retrospective review and in the reliance on an unvalidated instrument for the follow-up questionnaire. Yet, one has to recognize that a randomized clinical trial for the treatment of C/SC fractures is ethically and logistically difficult to accomplish. Furthermore, the internal and external validity of any TMJ dysfunction instrument is difficult to establish owing to the relative infrequency of this entity, as shown in the slow accrual of patients in this and other studies. Despite the retrospective nature of this study, closed reduction was found to be more likely to occur in children with bilateral C/SC fractures at The Children's Hospital. Other factors, such as age, gender, presence of concomitant fracture, and velocity of injury, do not play a significant role

in the surgical decision. In conclusion, this study represents one of the largest series of pediatric C/SC fractures to be reported in the recent literature. It combines a 10-year retrospective review of pediatric mandibular fractures with the collection of follow-up data regarding TMJ dysfunction. Increased reporting of TMJ dysfunction in females, although not thoroughly understood, stands out as the most significant finding of the study. Further study is warranted to determine whether there are other potential predictors of TMJ dysfunction that could then help guide management.

Submitted for Publication: March 31, 2010; final revision received June 15, 2010; accepted October 11, 2010.

Correspondence: Shelby C. Leuin, MD, 13123 E 16th Ave, Box 455, Aurora, CO 80045 (sleuin@gmail.com).

Author Contributions: All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Leuin and Chan. *Acquisition of data:* Frydendall. *Analysis and interpretation of data:* Gao and Chan. *Drafting of the manuscript:* Leuin, Frydendall, Gao, and Chan. *Critical revision of the manuscript for important intellectual content:* Gao and Chan. *Statistical analysis:* Gao. *Administrative, technical, and material support:* Frydendall and Chan. *Study supervision:* Leuin and Chan. **Financial Disclosure:** None reported.

Previous Presentation: This study was presented at the American Society of Pediatric Otolaryngology Annual Meeting; May 2, 2010; Las Vegas, Nevada.

REFERENCES

1. Ferreira PC, Amarante JM, Silva PN, et al. Retrospective study of 1251 maxillofacial fractures in children and adolescents. *Plast Reconstr Surg.* 2005;115(6):1500-1508.
2. Zimmermann CE, Troulis MJ, Kaban LB. Pediatric facial fractures: recent advances in prevention, diagnosis and management. *Int J Oral Maxillofac Surg.* 2006; 35(1):2-13.
3. Rowe NL. Fractures of the facial skeleton in children. *J Oral Surg.* 1968;26(8):505-515.
4. Posnick JC, Wells M, Pron GE. Pediatric facial fractures: evolving patterns of treatment. *J Oral Maxillofac Surg.* 1993;51(8):836-845.
5. Kaban LB, Mulliken JB, Murray JE. Facial fractures in children: an analysis of 122 fractures in 109 patients. *Plast Reconstr Surg.* 1977;59(1):15-20.
6. Leake D, Doykos J III, Habal MB, Murray JE. Long-term follow-up of fractures of the mandibular condyle in children. *Plast Reconstr Surg.* 1971;47(2):127-131.
7. Nørholt SE, Krishnan V, Sindet-Pedersen S, Jensen I. Pediatric condylar fractures: a long-term follow-up study of 55 patients. *J Oral Maxillofac Surg.* 1993; 51(12):1302-1310.
8. Helkimo M. Studies on function and dysfunction of the masticatory system, IV: age and sex distribution of symptoms of dysfunction of the masticatory system in Lapps in the north of Finland. *Acta Odontol Scand.* 1974;32(4):255-267.
9. Helkimo M. Studies on function and dysfunction of the masticatory system. 3: analyses of anamnestic and clinical recordings of dysfunction with the aid of indices. *Sven Tandlak Tidskr.* 1974;67(3):165-181.
10. Helkimo M. Studies on function and dysfunction of the masticatory system, I: an epidemiological investigation of symptoms of dysfunction in Lapps in the north of Finland. *Proc Finn Dent Soc.* 1974;70(2):37-49.
11. Helkimo M. Studies on function and dysfunction of the masticatory system, II: index for anamnestic and clinical dysfunction and occlusal state. *Sven Tandlak Tidskr.* 1974;67(2):101-121.
12. Thorén H, Hallikainen D, Iizuka T, Lindqvist C. Condylar process fractures in children: a follow-up study of fractures with total dislocation of the condyle from the glenoid fossa. *J Oral Maxillofac Surg.* 2001;59(7):768-774.
13. Choi J, Oh N, Kim IK. A follow-up study of condyle fracture in children. *Int J Oral Maxillofac Surg.* 2005;34(8):851-858.
14. Deleyiannis FW, Vecchione L, Martin B, Jiang S, Sotereanos G. Open reduction and internal fixation of dislocated condylar fractures in children: long-term clinical and radiologic outcomes. *Ann Plast Surg.* 2006;57(5):495-501.
15. Eskitascioglu T, Ozyazgan I, Coruh A, Gunay GK, Yuksel E. Retrospective analysis of two hundred thirty-five pediatric mandibular fracture cases. *Ann Plast Surg.* 2009;63(5):522-530.
16. Hattef DA, Cole PD, Hollier LH Jr. Contemporary management of pediatric facial trauma. *Curr Opin Otolaryngol Head Neck Surg.* 2009;17(4):308-314.
17. LeResche L. Epidemiology of temporomandibular disorders: implications for the investigation of etiologic factors. *Crit Rev Oral Biol Med.* 1997;8(3):291-305.
18. Fischer L, Clemente JT, Tambeli CH. The protective role of testosterone in the development of temporomandibular joint pain. *J Pain.* 2007;8(5):437-442.