



Contents lists available at ScienceDirect

Journal of Clinical Orthopaedics and Trauma

journal homepage: www.elsevier.com/locate/jcot

Incidence and mechanism of injury of clavicle fractures in the NEISS database: Athletic and non athletic injuries

Steven F. DeFroda^{*}, Nicholas Lemme, Justin Kleiner, Joseph Gil, Brett D. Owens

Department of Orthopaedic Surgery, Brown University, Warren Alpert School of Medicine, Providence, RI, USA

ARTICLE INFO

Article history:

Received 19 December 2018

Received in revised form

22 January 2019

Accepted 24 January 2019

Available online 26 January 2019

Keywords:

Clavicle fracture

Emergency department

Sports

Collision sports

Epidemiology

ABSTRACT

Background: Clavicle fractures are a very common injury due to accidental trauma, specifically during athletics. The purpose of this study was (1) to determine the incidence of clavicle fractures presenting to United States emergency departments; (2) to compare the rate of clavicle injuries from 2012 to 2015 to 2002–2005 (3) to determine the most common mechanisms of injury for clavicle fractures.

Methods: The National Electronic Injury Surveillance System (NEISS) was queried for the years **2002–2005 and 2012–2015**. Examined variables included patient age, sex, and year of admission. Total annual case numbers were estimated using NEISS hospital weights. Annual injury incidence rates by age group and patient sex were calculated based on yearly U.S. Census estimates. Chi square test and logistic regression were used to compare injury rates by sex and age groups. Statistical significance was set at $P < 0.05$.

Results: During the 8 years studied, the participating emergency departments (EDs) coded 14,795 fracture exposures. Using weighted estimates, this represent 545,663 injuries nationally (95% CL 425,986–665,339). This resulted in an incidence of 22.4 injuries per 100,000 person years (95% CL 17.5–27.3). The most common causes of injury were bicycles (15.1%), football (10.7%), beds/bedframes (6.8%), stairs (5.4%), and floors (4.0%). Fifty percent of clavicle fractures were due to an athletic activity. There was no significant change in injuries from 2002 to 2005 compared to 2012–2015 (23.1 per 100,000, 95% CL 18.5–27.7, and 22.4 per 100,000 person years (95% CL 17.5–27.3), respectively).

Conclusion: Clavicle fractures continue to occur at similar rates, with athletics accounting for 50% of injuries. Patients most at risk for clavicle fracture was bimodal in nature, with males aged 0–19 being the most common. Females were most at risk between 0 and 9 years old. **We found that clavicle fracture continued to occur at similar rates as compared to 10 years prior, especially in active populations participating in collision sports (bicycle, football, and soccer).**

© 2019 Delhi Orthopedic Association. All rights reserved.

1. Introduction

Clavicle fractures are common injuries that are particularly likely to occur during athletic and recreational activity.²² There is a paucity of literature regarding the epidemiology of this injury, and the most common mechanisms of injury on a large scale. Postacchini et al. reported on the epidemiology of 535 isolated clavicle fractures at a major metropolitan hospital over an 11 year period.¹⁷ Overall clavicle fractures composed 2.6% of all fractures seen in this time period, and 44% of shoulder girdle fractures. A majority (68%)

occurred in men, and the mid-clavicle was the most common location (81%).¹⁷ This study also reported that traffic accidents were the most common mechanism of injury.¹⁷ A larger study utilizing the Swedish Fracture Registry (SFR) identified 2422 clavicle fractures over one year.⁹ This study also found 68% prevalence in males, with 21% of all injuries occurring in the 15–24 age group. Ground level falls and bicycle accidents were the most common mechanisms of injury.⁹ Overall the SFR showed an increasing incidence of clavicle fractures, with a rate of 35.6 per 100,000 person years in 2001 to 59.9 per 100,000 person years in 2012.^{9,24}

Similarly, rates of clavicle injury during various athletic activities have been reported. In 2014 Van Tassel et al. performed a review of clavicle fractures presenting to United States Emergency Departments.²² The authors reported on 9428 fractures, over a 5 year time period and found males 10–19 years of age the be the group most

^{*} Corresponding author. Department of Orthopaedics, Alpert Medical School of Brown University, 593 Eddy Street, Providence, RI, 02903.

E-mail address: sdefroda@gmail.com (S.F. DeFroda).

likely to sustain an injury.²² Overall sports injuries were responsible for 45% of fractures, with 16% due to biking, 12% from football, and 6% soccer.²² While a majority of literature regarding clavicle fractures is focused on smaller patient cohorts at single hospitals or communities, we sought to perform an updated analysis of the incidence and epidemiology of clavicle fractures, as well as the mechanisms of injuries responsible for them. Our goal was to determine epidemiologic trends in clavicle fractures from 2012 to 2015, with a specific focus on injuries incurred during athletic and recreational activity in patients presenting to United States Emergency departments. Additionally, we compared rates and trends in injury from the 2012–2015 time period to injuries reported in the 2002–2005 time period to see if recent trends in youth sports participation as well as increased usage and knowledge of safety equipment has led to any change in the rate of injury in the past 10 years.

2. Methods

The United States Consumer Product Safety Commission (CPSC) National Electronic Injury Surveillance System (NEISS) was used to obtain national estimates of clavicle fractures for the years 2002–2005, and 2012 to 2015. The NEISS is a nationally representative sample of 100 participating hospital emergency departments nationwide. The large sample size and probability weighted sampling allows for estimates generalizable to the national population. Emergency department visits for clavicle fractures were identified using NEISS injury diagnosis codes (57: Fracture) and body part codes (30: Shoulder). Further, the case narratives for all qualifying patients were reviewed. Patients were only included if the NEISS case narrative specifically described **clavicle fracture**. Patient demographics examined included patient age, sex, and year of admission. Primary cause of injury was also identified, and stratified by sex. Total annual case numbers were estimated using NEISS hospital weights, calculated from the probability of inclusion for each visit in the database. Population estimates by age and sex were obtained from annual United States Census estimates and used to calculate clavicle fracture rates for each segment of the population.

2.1. Statistical analysis

Standard error and 95% confidence intervals were calculated for all national estimates. Chi square tests were used to compare injury rate between age groups. Chi square tests were also used to compare the most common causes by sex. National estimates of incidence calculated using NEISS sample weights were used for all analyses. All statistical analyses were performed utilizing SAS statistical software v.9.4 (SAS Institute, Inc. Cary, NC). Statistical significance was set at $P < 0.05$ *a priori*.

3. Results

During the 8 years studied, the participating emergency departments (EDs) coded 14,795 fracture exposures. Using weighted estimates, these patient exposures represent 545,663 injuries nationally (95% CL 425,986–665,339). This resulted in a calculated incidence of 22.4 injuries per 100,000 person years (95% confidence interval 17.5–27.3) using United States Census data available for those years. The most common overall causes of clavicle fracture were bicycles (15.1%), football (10.7%), beds/bedframes (6.8%), stairs (5.4%), and floors (4.0%) (Table 1).

From 2012 to 2015, the participating emergency departments (EDs) coded 7530 fractures. Using weighted estimates, these patient exposures represent 276,492 injuries nationally (95% CL

207,223–345,761). The total incidence of clavicle fractures was relatively unchanged, ranging from 21.5 to 22.0 per 100,000 in this time frame ($p = 0.9473$), with an overall rate of 21.8 injuries per 100,000 person years (95% confidence interval 16.3–27.2).

During this 2012–2015 period, clavicle fractures were more common in males, with 30.5 injuries per 100,000 (range 29.7–31.7, 95% CL 22.8–38.2) than females, who experienced 13.3 injuries per 100,000 (range 12.7–13.6 per 100,000, 95% CL 9.9–16.7) ($p < 0.001$). The age group at highest risk for clavicle fracture was 10–19, with 50.4 injuries per 100,000. The age distribution of clavicle fracture differed by sex ($p < 0.001$). Males were at highest risk for clavicle fracture between ages 10–19 (84.6 injuries per 100,000 person years, 95% CL 64.6–104.7). Females were at highest risk between ages 0 and 9 (41.0 injuries per 100,000 person years, 95% CL 27.0–55.0). The patient group who presented most commonly with clavicle fractures from 2012 to 2015 was males aged 10–19, of which clavicle fracture occurred at a rate of 84.6 per 100,000, 95% CL 64.6–104.7) (Fig. 1). The rate of clavicle fractures declined with increasing age, with the exception of an increased rate in the 80 + age group, representing the highest risk non-pediatric (age < 19) age group in both sexes. The rate of clavicle fracture in the 80 + age group was 26.4 per 100,000 in males (95% CL 19.4–33.4), compared with 36.3 in females (95% CL 26.0–46.6), representing the only age group with higher incidence in females.

Additionally, the more recent 4-year period, 2012–2015, was compared to the 4-year time frame from 2002 to 2005, which had an overall rate of 23.1 per 100,000, (95% CL 18.5–27.7, range 20.9–24.0). During this prior time, injury rate varied similarly by sex, with an overall rate of 34.4 injuries per 100,000 person years in males (95% CL 27.3–41.4), compared with a rate of 12.2 in females (95% CL 9.8–14.6) ($p < 0.0001$). The rate of clavicle fracture in 2002–2005 was compared to that of 2012–2015, and was not found to be significantly different.

Fractures were examined to assess the proportion as a result of sports. Overall sports accounted for 50.0% of fractures (weighted incidence). Other popular etiologies included falls from beds, stairs, floors, and sofas, as well as recreational activities including swings and trampoline. When further examining sports related injuries over this time the activities which were most likely to cause a clavicle fracture included: bicycle riding (15.1%), American football (10.7%), and soccer (3.8%), (Table 2). Injury mechanism varied significantly by sex ($p < 0.001$). In males, the most common mechanisms were mostly athletic in nature: bicycles (17.9%), football (14.6%), dirt bike (4.7%), off-road vehicles (4.2), and soccer (3.9%). In females, the most common mechanisms were a combination of fall related, and sports related injuries: beds (13.9%), stairs (9.5%), bicycles (8.3%), chairs (4.3%), and sofas (3.5%).

4. Discussion

In this study we sought to determine the incidence and characteristics of clavicle fractures in the United States population. We have shown an incidence of 21.8 injuries per 100,000 in 2012–2015 that ranged from 21.5 to 22.0 per 100,000. Fractures of the clavicle most commonly occurred in males 10–19 years old with a large percentage of clavicle fractures occurring during participation in sports. The incidence of clavicle fractures in the United States appears to have remained stable. Van Tassel et al.²³ assessed the incidence of clavicle fractures in the US population from 2002 to 2006 and reported an incidence of 24.4 fractures per 100 000 person-years. We demonstrated that incidence of has not significantly changed since that time period. In the present study we have shown that clavicle fractures occurring during sports accounted for 50.0% of all fractures, similar to the findings by Van Tassel et al.,²³ who demonstrated that 45% of clavicle fractures occurred during

Table 1
Most common causes of clavicle fracture.

| Rank | Overall | | Male | | Female | |
|------|----------------------|---------|----------------------|---------|------------------|---------|
| | Product | Percent | Product | Percent | Product | Percent |
| 1 | Bicycles | 15.1% | Bicycles | 17.9% | Beds/Bedframes | 13.9% |
| 2 | Football | 10.7% | Football | 14.6% | Stairs | 9.5% |
| 3 | Beds/Bedframes | 6.8% | Dirt Bike | 4.7% | Bicycles | 8.3% |
| 4 | Stairs | 5.4% | All Terrain Vehicles | 4.2% | Floors | 8.1% |
| 5 | Floors | 4.0% | Soccer | 3.9% | Chairs | 4.3% |
| 6 | Soccer | 3.8% | Beds/Bedframes | 3.9% | Sofas | 3.5% |
| 7 | All Terrain Vehicles | 3.6% | Stairs | 3.7% | Soccer | 3.5% |
| 8 | Dirt Bike | 3.5% | Snowboarding | 3.4% | Horseback Riding | 3.0% |
| 9 | Snowboarding | 2.5% | Skateboards | 3.3% | Swing Sets | 2.1% |
| 10 | Skateboards | 2.5% | Floors | 2.3% | Bathtubs/Showers | 1.9% |

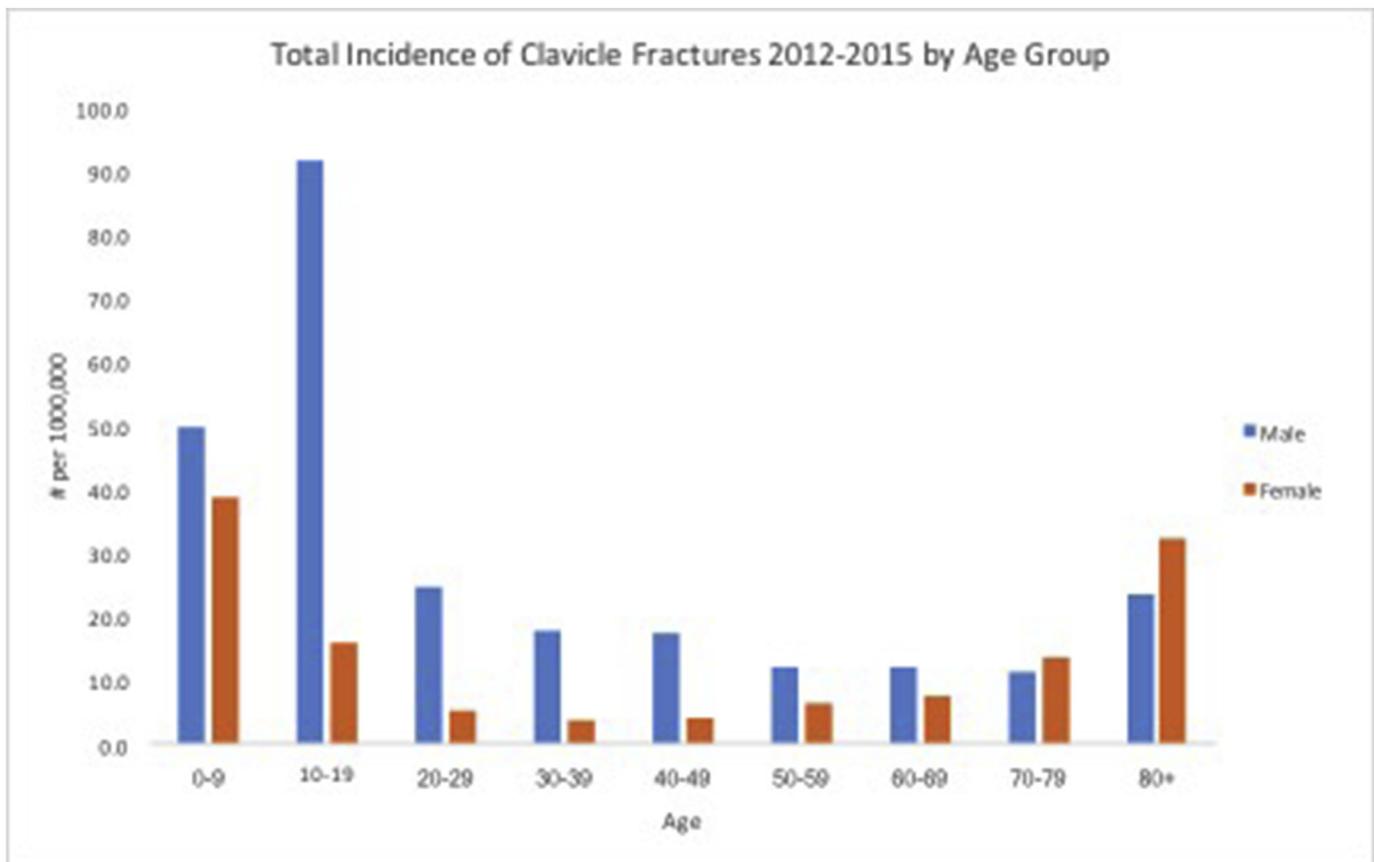


Fig. 1. Total Incidence of Clavicle Fracture 2012–2015 by age Group Per 100,000.

sports participation.

An increased risk of clavicle fracture from participation in sports is not a new finding. Clavicle fractures account for 10% of all sport-related fractures and approximately 85% of all clavicle fractures in adolescents occur during sports.^{10,20} Fractures in athletes generally occur from a fall onto the ipsilateral shoulder. This results in large forces onto the clavicle, as it is the only loadbearing bone that stabilizes the glenohumeral joint.^{16,21}

In the current study we found bicycle riding, American football and soccer to account for the largest percentage of sport-related clavicle fractures. Other studies have noted similar mechanisms of injury.^{6,7,10,12,15,19,23} Nelson et al.¹² performed a retrospective analysis of bicycle-related injuries in the United States and noted clavicle/shoulder fractures to be the second most common injury. Numerous studies have reported high rates of clavicle fractures in

contact/collision sports.^{3,6,16,18,19,23} Recently investigators have been interested in determining the optimal management of clavicle fractures in athletes and the effect that such injuries have on return to sport (RTS) and player performance. The risk of recurrent direct shoulder contact in collision sports complicates when an athlete with a clavicle fracture can safely RTS. Historically, clavicle fractures were managed non-operatively but more recent studies have demonstrated superior functional outcomes and faster RTS in those managed surgically.^{1,5,11,14} When managed non-operatively, athletes are typically allowed to return to play around 6 weeks after radiographic healing has occurred. Jack et al.⁶ examined RTS and performance following clavicle ORIF in 17 National Football League (NFL) players. The authors demonstrated a mean RTS of 211 days with 44% being able to RTS in the same season. No difference in postoperative performance scores or games per season compared

Table 2
Clavicle injuries from 2012 to 2015 by athletic/recreational activity.

| | Injuries (n) | Estimated Weight | % of Total Injuries | Male Injuries | Female Injuries |
|------------------|--------------|------------------|---------------------|---------------|-----------------|
| Bicycle | 2051 | 82536 | 15.13 | 1744 | 307 |
| Mountain biking | 92 | 4089 | 0.75 | 89 | 3 |
| Baseball | 134 | 5037 | 0.92 | 130 | 4 |
| Basketball | 244 | 8263 | 1.51 | 204 | 40 |
| Football | 1816 | 58270 | 10.68 | 1771 | 45 |
| Gymnastics | 56 | 1801 | 0.33 | 20 | 36 |
| Hockey | 116 | 4995 | 0.92 | 108 | 8 |
| Horseback riding | 216 | 8576 | 1.57 | 93 | 123 |
| Lacrosse | 65 | 2042 | 0.37 | 63 | 2 |
| Skateboarding | 305 | 13495 | 2.47 | 286 | 19 |
| Snowboarding | 289 | 13814 | 2.53 | 275 | 14 |
| Skiing | 210 | 10793 | 1.98 | 175 | 35 |
| Rugby | 63 | 2447 | 0.45 | 51 | 12 |
| Soccer | 588 | 20786 | 3.81 | 449 | 139 |
| Softball | 74 | 2904 | 0.53 | 46 | 28 |
| Wrestling | 135 | 5122 | 0.94 | 127 | 8 |

with preoperative scores or games per season for any position were seen. The same authors completed a similar study investigating nonoperative management of clavicle fractures in NFL athletes.⁷ Despite their findings being similar to those in their study of operative management in this population, the mean time to RTS was slightly longer in nonoperatively managed athletes (244.6 days vs 211 days).

The single patient group who presented most commonly with clavicle fractures in the present study were males aged 10–19, of which clavicle fracture occurred at a rate of 91.7 per 100,000 participants. There is a strong correlation between clavicle fractures and younger age.¹³ A possible explanation for this may be that participation in sports is most common during childhood and adolescence. In children nonoperative management is appropriate for almost all clavicle fractures given their superior healing and remodeling abilities.¹⁵ In a survey of the Pediatric Orthopedic Society of North America (POSNA) members, >90% of participants favored nonoperative treatment of nondisplaced clavicle fractures. However, nearly half of all respondents favored surgical treatment of teenagers (age 16–19 years) with segmental fracture patterns and 50% of members indicated that they were more likely to choose surgical treatment for an elite overhead-throwing adolescent athlete.² Vander Have et al.⁴ compared the outcomes of operative vs nonoperative management in 42 adolescent athletes 12–17 years old and reported a faster time to union in operatively managed patients (7.5 vs 9.9 weeks) compared to patients managed conservatively. While no significant complications were seen in those managed with surgery, 5 of the patients managed nonoperatively developed symptomatic malunion adolescents.⁴

This study has several limitations. The NEISS database does not account for the patients that received care outside of emergency departments, including outpatient clinics, urgent care centers, and high school/collegiate athletic training rooms. Therefore, selection bias may exist. Furthermore, the narratives included in the NEISS database are sometimes inconsistent and do not provide uniform information on injury data (mechanism of injury, body site, presence/absence of protective gear, competition vs. practice, etc). Therefore, we were unable to determine the characteristics of each clavicle fracture and where along the shaft they occurred. Furthermore, the database does not provide any information on the clinical management or outcomes for each patient. **Lastly, while a longer time discrepancy would have added strength to the study, we were limited by the database to a 10-year difference. This may not be a long enough time period to appreciate a trend in the epidemiology of clavicle fractures.** Despite these limited weaknesses, the NEISS is a nationwide population-based database

containing a heterogeneous patient population and has significant external validity.

5. Conclusion

In conclusion we have shown that clavicle fractures account for thousands of injuries in the United States annually, and most commonly in adolescent males (age 10–19) whom participate in sports. A decreasing rate of injury was then seen until age 80, identifying a bimodal age distribution for this injury. While newer data has emerged in favor of operative management for displaced clavicle fractures, as it is deemed a safe procedure that may allow for more rapid RTS and improved performance, larger prospective multicenter trials must be done to confirm these findings in athletes. Additionally, it does not appear that emergency visits due to clavicle fractures have decreased in the past 10 years. Furthermore, there is little data investigating clavicle fractures in adolescent athletes and how the management of such injuries influences RTS and performance, which should serve as the basis for future studies.

Conflicts of interest

The authors have no relevant financial disclosures or conflicts to report. Dr. Owens is a consultant for Mitek, and MTF/CONMED.

Funding

No funding was received for this project.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jcot.2019.01.019>.

References

- Canadian Orthopaedic Trauma Society. Nonoperative treatment compared with plate fixation of displaced midshaft clavicular fractures. A multicenter, randomized clinical trial. *J Bone Joint Surg Am*. 2007;89(1):1–10. <https://doi.org/10.2106/JBJS.F.00020>.
- Carry PM, Koonce R, Pan Z, Polousky JD. A survey of physician opinion: adolescent midshaft clavicle fracture treatment preferences among POSNA members. *J Pediatr Orthop*. 2011;31(1):44–49. <https://doi.org/10.1097/BPO.0b013e3181ff67ce>.
- Fanter NJ, Kenny RM, Baker CL, Baker CL. Surgical treatment of clavicle fractures in the adolescent athlete. *Sport Health*. 2015;7(2):137–141. <https://doi.org/10.1177/1941738114566381>.
- Vander Have KL, Perdue AM, Caird MS, Farley F a. Operative versus

- nonoperative treatment of midshaft clavicle fractures in adolescents. *J Pediatr Orthop.* 2010;30(4):307–312. <https://doi.org/10.1097/BPO.0b013e3181db3227>.
5. Hill JM, McGuire MH, Crosby LA. Closed treatment of displaced middle-third fractures of the clavicle gives poor results. *J Bone Jt Surg.* 1997;79(4):537–539. <https://doi.org/10.1302/0301-620X.79B4.7529>.
 6. Jack RA, Sochacki KR, Navarro SM, McCulloch PC, Lintner DM, Harris JD. Performance and return to sport after clavicle open reduction and internal fixation in national football league players. *Orthop J Sport Med.* 2017;5(8):1–7. <https://doi.org/10.1177/2325967117720677>.
 7. Jack RA, Sochacki KR, Navarro SM, McCulloch PC, Lintner DM, Harris JD. Performance and return to sport after nonoperative treatment of clavicle fractures in national football league players. *Orthopedics.* 2017;40(5). <https://doi.org/10.3928/01477447-20170719-03>.
 9. Kihlström C, Möller M, Lönn K, Wolf O. Clavicle fractures: epidemiology, classification and treatment of 2 422 fractures in the Swedish Fracture Register; an observational study. *BMC Musculoskelet Disord.* 2017;18(1):82. <https://doi.org/10.1186/s12891-017-1444-1>.
 10. Meisterling SW, Cain EL, Fleisig GS, Hartzell JL, Dugas JR. Return to athletic activity after plate fixation of displaced midshaft clavicle fractures. *Am J Sports Med.* 2013;41(11):2632–2636. <https://doi.org/10.1177/0363546513501494>.
 11. Morgan RJ, Bankston LS, Hoenig MP, Connor PM. Evolving management of middle-third clavicle fractures in the national football league. *Am J Sports Med.* 2010;38(10):2092–2096. <https://doi.org/10.1177/0363546510372795>.
 12. Nelson NG, Mckenzie LB. *Mountain Biking – Related Injuries Treated in Emergency Departments in the United.* 2008:8–10. <https://doi.org/10.1177/0363546510383478>.
 13. Nordqvist A, Petersson C. The incidence of fractures of the clavicle. *Clin Orthop Relat Res.* 1994;300:127–132.
 14. Nowak J, Holgersson M, Larsson S. Sequelae from clavicular fractures are common: a prospective study of 222 patients. *Acta Orthop.* 2005;76(4):496–502. <https://doi.org/10.1080/17453670510041475>.
 15. Pandya NK, Namdari S, Hosalkar HS. Displaced clavicle fractures in adolescents: facts, controversies, and current trends. *J Am Acad Orthop Surg.* 2012;20(8):498–505. <https://doi.org/10.5435/JAAOS-20-08-498>.
 16. Postacchini F, Gumina S, De Santis P, Albo F. Epidemiology of clavicle fractures. *J Shoulder Elbow Surg.* 2002;11(5):452–456. <https://doi.org/10.1067/mse.2002.126613>.
 17. Postacchini F, Gumina S, De Santis P, Albo F. Epidemiology of clavicle fractures. *J shoulder Elb Surg.* 11(5):452–456.
 18. Robinson CM. *EPIDEMIOLOGY AND CLASSIFICATION.* 1998:476–484.
 19. Robinson L, Gargoum R, Auer R, Nyland J, Chan G. Sports participation and radiographic findings of adolescents treated nonoperatively for displaced clavicle fractures. *Injury.* 2015;46(7):1372–1376. <https://doi.org/10.1016/j.injury.2015.04.019>.
 20. Shah RR, Kinder J, Peelman J, Moen TC, Sarwark J. Pediatric clavicle and acromioclavicular injuries. *J Pediatr Orthop.* 2010;30(suppl 2). <https://doi.org/10.1097/BPO.0b013e3181ba9e94>.
 21. Stanley D, Trowbridge EA, Norris SH. The mechanism of clavicular fracture: a clinical and biomechanical analysis. *J Bone Jt Surg.* 1988;70(3):461–464.
 22. Van Tassel D, Owens B, Pointer L, Moriatis Wolf J. Incidence of clavicle fractures in sports: analysis of the NEISS database. *Int J Sports Med.* 2013;35(1):83–86. <https://doi.org/10.1055/s-0033-1345127>.
 23. Van Tassel D, Owens BD, Pointer L, Moriatis Wolf J. Incidence of clavicle fractures in sports: analysis of the NEISS database. *Int J Sports Med.* 2014;35(1):83–86. <https://doi.org/10.1055/s-0033-1345127>.
 24. Wennergren D, Ekholm C, Sandelin A, Möller M. The Swedish fracture register: 103,000 fractures registered. *BMC Musculoskelet Disord.* 2015;16(1):338. <https://doi.org/10.1186/s12891-015-0795-8>.