

Scaphoid Fractures in Children

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SUMMARY

Introduction Scaphoid fractures are rare in childhood. Diagnosis is very difficult to establish because carpal bones are not fully ossified. In suspected cases comparative or delayed radiography is used, as well as computerized tomography, magnetic resonance imaging, ultrasound and bone scintigraphy. Majority of scaphoid fractures are treated conservatively with good results. In case of delayed fracture healing various types of treatment are available.

Objective To determine the mechanism of injury, clinical healing process, types and outcome of treatment of scaphoid fractures in children.

Methods We retrospectively analyzed patients with traumatic closed fracture of the scaphoid bone over a ten-year period (2002-2011). The outcome of the treatment of "acute" scaphoid fracture was evaluated using the Mayo Wrist Score.

Results There were in total 34 patients, of mean age 13.8 years, with traumatic closed fracture of the scaphoid bone, whose bone growth was not finished yet. Most common injury mechanism was fall on outstretched arm – 76% of patients. During the examined period 31 children with "acute" fracture underwent conservative treatment, with average immobilization period of 51 days. Six patients were lost to follow-up. In the remaining 25 patients, after completed rehabilitation, functional results determined by the Mayo Wrist Score were excellent.

Conclusion Conservative therapy of "acute" scaphoid fractures is an acceptable treatment option for pediatric patients with excellent functional results.

Keywords: scaphoid; fracture; treatment; children

INTRODUCTION

Carpal fractures are rare in children [1-4]. In comparison to fractures of other carpal bones, scaphoid fracture is most common, with peak frequency between 12 and 15 years of age [3, 4, 5]. Characteristics of childhood scaphoid fractures differ from fractures in adults. In children these fractures are almost always incomplete, without dislocation of bony fragments and they heal completely after conservative treatment [1, 2, 5, 6]. Also, there is a difference in the fracture line localization, as well as in the mechanism of injury; fall on an outstretched hand is the most frequent mechanism in children [2, 3].

Clinical presentation of scaphoid fracture in children is not very different from that in adults, even though the risk of failed diagnosis is more frequent [1, 7]. Beside pain in the region of the anatomical snuff box and reduced range of motion of the radiocarpal joint, the most significant is thumb opposition test which is sensitive even for incomplete unicortical fractures [8, 9]. Nevertheless, these fractures are frequently missed in children, partly because of their rarity, and partly because of difficult radiographic diagnostics [10]. In fact, in such cases classical radiography cannot show unossified elements of the immature skeleton [3].

Therefore, in suspected cases comparative and delayed radiography is performed, as well as magnetic resonance imaging (MRI), computerized tomography (CT), ultrasound (US) and bone scintigraphy [7, 8, 11, 12].

Localization of fracture line varies with patient's age. In contrast to adults, where most fractures are situated in the middle third (waist) of the scaphoid, in children it is mostly found in the distal third [5, 6, 13]. Fractures in the proximal third of the scaphoid are extremely rare in children, because ossification direction is from the distal to the proximal pole [6].

In regard to "acute" or "recent" scaphoid fractures in children, conservative treatment is the gold standard (long-arm or short-arm thumb spica cast) [4]. Model and duration of immobilization depends on the localization of fracture [1, 2, 4, 6, 14].

Vast majority of "acute" scaphoid fractures in children diagnosed on time and adequately treated, completely heal [15, 16]. Complications are rarely encountered and can be pseudoarthrosis, nonunion and avascular necrosis. Pseudoarthrosis is most frequent, and is typical for adolescent children [3]. Nonunion and avascular necrosis of the proximal pole in comparison with previous are seen rarely [3, 10]. In cases of nonunion, different treatment modalities are suggested; prolonged immobiliza-

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tion, Matti-Russe procedure, insertion of bony grafts and fixation with K-wire, compressive screws with or without insertion of bone graft, etc. [3, 4, 6, 13, 14, 15].

OBJECTIVE

The aim of the study was to present the mechanism of injury, clinical healing process, types and outcome of treatment for scaphoid fractures in children.

METHODS

This is a retrospective study conducted over a 10-year period (2002–2011), which involved a total of 34 patients with traumatic fracture of scaphoid; of these, 18 from the Clinic of Pediatric Surgery in Novi Sad and 16 from the Clinic of Pediatric Surgery and Orthopedics in Niš. All patients had closed fractures, with open epiphyseal plate. We also noted one pathological fracture of the scaphoid (enchondroma); the patient was a 13.2-year old girl who was not included in our study.

Protocol of research included history (time and mechanism of injury), physical examination and standard radiography. In some cases, delayed radiography was done for diagnostic confirmation. Outcome of treatment was evaluated using the Mayo Wrist Score [17].

RESULTS

In total, our research included 34 patients with traumatic closed fracture of the scaphoid. The youngest patient had 9.6 years, and the oldest one 15.9 years; the mean age at the moment of diagnosis was 13.8 ± 1.2 years. There were 27 boys (79%) and 7 girls (21%). In 25 children (74%) fracture was verified on the right hand, and in 9 on the left hand (26%); 28 children (82%) had injury of the dominant hand.

Mechanism of injury in 26 children (76%) was fall on outstretched hand; in 17 during sport activities and in 9 during play. Direct force injury (during fighting sports or in a fight) was found in 6 patients (18%), and one fracture (3%) in traffic accident. One patient, an active sportsman, could not recall time and mechanism of injury.

Five children (15%) had associated fractures; three patients had fracture of the contralateral radius, and two patients had ipsilateral fracture of the fifth metacarpal bone.

During the studied period, 31 children had "acute" scaphoid fracture and they had visited physician on the same day or the day after injury. The initial radiography was positive for fracture in 27 patients (87%). Despite negative initial radiography, four patients (13%) were initially treated with cast immobilization. Scaphoid fracture was confirmed two weeks later on the control radiography.

In three children scaphoid fracture was diagnosed later. In the first child, the fracture was diagnosed 5 months after the initial injury, because of the delayed visit of the physician. The second patient had a scaphoid fracture that was

missed on the initial radiography examination 4 months before. The third child could not recall the exact time and the mechanism of injury.

In the group of 22 patients (71%) with "acute" fracture of the scaphoid, the fracture line was localized in the distal part and in 9 children (29%) in the middle third of the scaphoid. Three children in whom the diagnosis was delayed, the fracture line was in the waist of the scaphoid.

In 27 patients in whom the diagnosis was established on the initial radiographic examination, there was no dislocation or dislocation was up to 1 mm. Two boys, 10.2 and 11.3 years old, had fragments dislocation of 2 mm. The fractures confirmed after two weeks were without dislocation.

All patients with "acute" fractures were treated with short-arm spica cast which included the basis of thumb, index and middle finger ("plaster glove"). The average immobilization period was 51 ± 18.61 days. In 28 patients (90%), the duration of immobilization was between 4 and 8 weeks. After the removal of immobilization and the radiographic confirmation of the healed fracture, patients were referred to physical therapy. In the remaining three children (10%) after 8 week of immobilization, nonunion was noticed radiographically and confirmed by CT scan. In two children immobilization ("plaster glove") was prolonged for 6 weeks and in one child for 8 weeks. During the prolonged immobilization the patients were treated with magnetotherapy to stimulate healing. After removal of immobilization, the healed fracture was radiographically confirmed.

Three children, in whom the diagnosis was delayed, were also initially treated with conservative treatment for three months and magnetotherapy. In the child who could not recall the mechanism and the time of the injury healing was revealed radiographically. Four months after the initiation of physical therapy, full active range of motion without pain was verified. Another two children, with fractures identified four and five months after the injury, were treated conservatively with "plaster glove" and magnetotherapy for three months. Pseudoarthrosis was noticed radiographically and confirmed by CT scan. Both patients had pain, limited active range of motion of the wrist and weakened grip. One patient rejected operative treatment, and was lost for further follow-up. The second patient was treated operatively; anterior approach, bone graft, fixation with K-wire and plaster immobilization for 8 weeks. On the last follow-up, there was radiographical confirmation of healed fracture, with full active range of motion and occasional pain.

The group of 6 patients with "acute" fracture was lost to follow-up. On the last radiographic examination all 6 patients showed regular healing process, but final clinical evaluation could not be established. Follow-up time for the remaining 25 children was 3.5 months (1–6 months), and the result of treatment according to the Mayo Wrist Score [17] was excellent (Table 1). Score 100 had 23 children. One patient had score 95; in spite of full active range of motion; pain was present. Because of restricted extension of the wrist, one child had score 90.

Table 1. Mayo Wrist Score in patients with "acute" fracture of scaphoid

| Mayo Wrist Score | Number of patients |
|----------------------|--------------------|
| Excellent (90-100) | 25 |
| Good (80-90) | / |
| Satisfactory (60-80) | / |
| Bad (lower than 60) | / |
| Lost to follow-up | 6 |
| Total | 31 |

We did not have any scaphoid refracture. Necrosis of the scaphoid was not identified in any of 9 patients who came for follow-up examination 12 months after treatment.

DISCUSSION

Scaphoid fracture is the most common carpus fracture [3, 4, 5]. The first description of this fracture was done by Destot, a French surgeon, anatomist and radiologist [18]. Peak incidence is in 2nd-4th decade of life; in adults it makes 2-7% of all fractures [9, 18, 19]. Wilson et al. [8] points out that epidemiology, mechanism of the injury and optimal treatment in children are not clear. Also, Bhatti et al. [5] have reported that the exact incidence of this fracture in children is a subject of debate. However, there is a consensus that scaphoid fracture is one of very rare fractures in childhood; it makes about 0.4% of all fractures found in children [1, 6, 7, 13]; 0.5% of all fractures of the upper extremity [3], or 2.9% of fractures of hand and wrist [7]. In a 10-year period there were 34 traumatic closed fractures of the scaphoid. One of reasons for the rarity of these fractures is that ligamentous and cartilaginous structures in children make carpal bones relatively resistant to injury, in contrast to the distal part of the radius which is the weakest point of the radiocarpal joint and is more susceptible to injury [8, 13]. The second reason for rarity is that the scaphoid, before complete ossification, is less sensitive to trauma [3, 8]. In fact, the ossification centre of the scaphoid is surrounded by a thick layer of non-ossified cartilage which has a protective role, i.e. a cushioning effect [5] for traumatic forces [1]. Also, there is a possibility that the difference between the physical activity of children and adults contributes to their low incidence [5]. However, in older children we are witnessing an increase in the frequency of scaphoid fractures, mainly because of growing sports popularity and increased use of punching machines [4].

Scaphoid fracture in children is most frequently found between the age of 12 and 15 [3, 4, 5]. They are extremely rare in the first decade of life [5], particularly in children younger than 8 years; until 1998 only 9 cases were reported in the literature [6]. Authors have reported the average age of 13.4 years [6], 13.9 years [4], while in our study it was 13.8 years.

Predominance of male [1, 4, 11] was also found in our study; 27 males vs. 7 females. Fractures of the right hand were disclosed in 24 (71%) patients and in 10 patients (29%) of the left hand. Wulff and Schmit [6] reported

similar relationship (23:13 cases); they had one child with bilateral scaphoid fracture. Toh et al. [4] reported greater predominance of boys; 61:3. In 52 (81%) children the dominant hand was affected. In our study 28 children (82%) had dominant side injury.

In contrast to fractures of other carpal bones, scaphoid fractures are the result of low energy trauma [6]. The mechanism of trauma is mostly indirect - fall on an outstretched hand with the wrist being in hyperextension and pronation [2, 3]. In fact, the person tends to extend the hand which has a tendency to play the amortizing role in the fall, which forces wrist hyperextension [1, 4, 7, 8]. It is interesting to point out that the same mechanism can result in supracondylar fractures of the humerus in children and fractures of the distal part of radius and carpal bones in adults [19]. Predominant etiology in our patients was a fall on the outstretched hand (76%), which confirms the concept that the fracture is the result of force applied on the palmar aspect of wrist in extreme dorsiflexion. Six fractures resulted from participation in fighting sports or during fights, with a direct fist impact. In a series of 64 scaphoid fractures in children younger than 15 years, Toh et al. [4] reported that 27 cases were the result of sport activities, whereas 22 cases were the result of participation in a fight or use of punching machine. The mechanism of injury during sport activity included: fall on the outstretched hand with ulnar deviation (during football or basketball) in 19 cases, punching (during boxing or karate) in 7 cases, and other mechanism in one case. The mechanism of injury when using a punching machine was forced hyperflexion with radial deviation [4]. Wulff and Schmidt [6] also reported that the most frequent mechanism of scaphoid fracture was fall on the outstretched hand (26 patients), after that punching with a fist (5 patients), crash injury in one patient and traffic accident in another one.

We identified associated fractures in five children (15%). Wulff and Schmidt [6] reported five cases with associated fracture (metacarpal bones, radius styloid, ulnar styloid, compressive fracture of fourth lumbar vertebra and navicular foot bone). These data emphasize the need for careful examination of radiograph.

Scaphoid fractures in children are frequently overlooked because of their rare incidence and difficult radiographic analysis [3, 10, 20]. Diagnosis in cases with not yet fully matured hands is even more problematic due to difficulty in the examination of injured child. A recent study of childhood fracture injury has shown that detection by clinical examination of point tenderness is the best clinical determinant of the presence of fracture. Identification of point tenderness in the small anatomical snuffbox in children is challenging, and separation of pain site is equally difficult [8]. Pain in the region of anatomical snuffbox, pain during radial deviation motion and during testing active range of motion of the wrist are clinical signs that raise the suspicion of scaphoid fracture [6]. However, fracture of radial styloid, trapezium, and the first and the second metacarpal bone, as well as different articular distortions, could result in pain of anatomical snuffbox [8].

Diagnosis of scaphoid fracture also depends on the awareness of possibility that this injury can happen in children. Therefore, a high level of suspicion should be maintained in cases of hand and wrist injury in children [12, 21]. In the child complaining of pain in the region of anatomical snuffbox, Fabre et al. [2] suggest that wrist radiograph should be always taken, even though the large cartilage mass makes evaluation of radiograph difficult [3]. Because of the poor ability of radiography to show unossified elements of skeleton, 37% of children with carpal fractures are missed [12] due to a "normal" initial radiograph [10, 20]. High percentage (30%) of clinically suspected scaphoid fracture in children later becomes apparent on follow-up radiographic examinations [10]. In cases of suspected scaphoid fracture, comparative and delayed radiographs are used. According to Hernandez et al. [22] their application is very useful in the detection of scaphoid fractures. Also, some authors suggest that additional projections should be undertaken (oblique projection and pronation-ulnar deviation) [6, 21]. Our approach to diagnosis and treatment of suspected fractures of scaphoid was constant during the study period. We were guided by the principal that in suspected cases, with negative radiography finding, we immediately started therapy with cast immobilization. Follow-up involving clinical and radiographic examinations, after removing immobilization, was done after two weeks, according to the suggestion by Evanski et al. [10]. The fracture line in "acute" cases of scaphoid fracture was apparent on the initial radiographic examination in 27 children (87%). Four patients (13%) had the so-called "occult" [9] scaphoid fracture; existence of fracture was confirmed on follow-up examination two weeks later. One fracture was missed by EMS, and was diagnosed four months later.

Some authors treat suspected cases of scaphoid fracture in children with immediate immobilization without additional diagnostic procedures [1, 9, 10], but most of authors do perform additional diagnostics: CT, MRI, US and bone scintigraphy [7, 8, 11, 12]. Wilson et al. [8] advise that these additional diagnostic tools should be employed to boost the precision and speed of the diagnosis. They are in favor of early MRI examination in order to minimize the amount of exposure to ionizing radiation in childhood, and to obtain the diagnosis as quickly as possible so that adequate treatment could be started promptly, and also to minimize unnecessary overtreatment [8]. It should be kept in mind that radiographic diagnosis for childhood scaphoid fractures is difficult because they are frequently incomplete and non-dislocated [1, 2], i.e. in children fractures are mainly unicortical and located at the border between the ossified and cartilaginous part. That is why most authors choose MRI as the diagnostic method of choice [7, 8, 9, 11, 12, 21]. MRI is also suitable for ruling out possible anatomical variations of scaphoid [2, 5]. Benefits of MRI examination have been undoubtedly proved and accepted. However, in our country, the economic situation and organizational structure did not give us the opportunity to take advantage of this diagnostic method. In our study, we had not used MRI, US, or bone scintigraphy, whereas

we used CT in 6 children, primarily in the evaluation of further treatment.

Localization of fracture line varies with age of patients. In adults it is mostly located (70%) in the middle third of scaphoid [6, 13, 18], which make 20% of these fractures with dislocation [23]. Historical review of the literature shows that scaphoid fractures in children predominantly involve the distal third and are mostly without dislocation [1, 2, 3, 5, 6, 13, 15, 19]. The frequency of fracture line located in the distal pole is between 59% and 87%, in waist 12%-36% and in the proximal pole up to 2% [1, 2, 6, 13]. Our experience with 34 cases of scaphoid fractures confirms these findings. Among the children with "acute" fracture, in 22 cases (71%) the fracture line was situated in the distal pole, and in 9 cases (29%) in the waist. We had no cases where the fracture line was located in the proximal pole. All three patients, in whom the diagnosis was delayed for several months, had fractures in the waist of scaphoid. The review of recent literature shows change in the epidemiological characteristics of scaphoid fractures in childhood; they are becoming more similar to those of adults [8, 9, 15]. There is evident rise in waist scaphoid fractures, which is attributed to changes in children's activities [5]. The fact is that nowadays children start to participate actively in sport activities at younger age, and some of them prefer contact fighting sports. Gholson et al. [15] reported that among 351 children with scaphoid fracture, in 71% the fracture line was located in the waist, 23% in distal pole and in 6% in proximal pole. Toh et al. [4] emphasizes that fracture that occurred in a fight or after the use of punching machine, were always located in the waist.

It is widely accepted that "acute" scaphoid fractures in children have a very good prognosis after conservative treatment [1-4, 21]. Duration of cast immobilization depends on the localization of fracture, ranging from 4-12 weeks [1, 2, 4, 6, 14]. Fractures in the distal pole usually demand a shorter period of immobilization [2]. D'Arienzo [1] reports that in all 39 children treated conservatively healing of fracture was complete with good functional results. Huckstadt et al. [16] in a series of 17 patients younger than 18 years treated conservatively, a complete fracture healing was verified with one case of delayed healing. Based on the Cooney score, 94% of patients had good to excellent outcome. Wulff and Schmidt [6] point out that most of childhood scaphoid fractures completely heal after conservative treatment. Our results also confirm that conservative treatment of "acute" scaphoid fractures gives good functional result. Our patients were treated by "plaster glove"; average duration of immobilization was 51 days. In 28 patients (90%), the period of applied immobilization was between 4 and 8 weeks, after which radiographically complete healing was verified. After a prolonged duration of immobilization and magnetotherapy, in the remaining three patients complete healing was also verified. Six patients were lost for follow-up. Average follow-up period in the remaining 25 patients was 3.5 months. Functional outcome was excellent; Mayo Wrist Score in 23 children was 100, in one 95 and in another one 90. Also, this group comprised two boys in whom the dislocation of scaphoid

fracture fragments was 2 mm. Conservative treatment for these two patients was also applied, having in mind their age (10.2 and 11.3 years, respectively), future growth and remodelling capacity which enabled adequate correction of poorly fused fractures of lesser degree [13]. Namely, if the child has a potential for growth for two or more years, even in cases of poor healing of fracture, acceptable remodelling of scaphoid can be expected [3].

Although most authors recommend conservative treatment, there is a growing trend of surgical treatment of childhood scaphoid fracture with early fixation, even for fractures without dislocation, using different types of screws. Gholson et al. [15] reported that $\frac{1}{3}$ of pediatric patients with scaphoid fracture would show a chronic nonunion and they recommended surgical reduction and internal fixation in primary treatment. It is likely that due to the rarity of scaphoid fractures in children, Wilson et al. [8] concluded that their treatment in children was based on data related to characteristics and complications of scaphoid fractures in adults. Bond et al. [24], identically as Chloros et al. [25], propose insertion of a bone graft and internal fixation with a screw as the first line treatment, even in nondisplaced fractures in pediatric population. Explaining the reason for this course of treatment they state that children return to school and sport activities earlier. However, benefits and risks of early fixation of scaphoid fracture in children are yet to be determined [4, 26]. Anz et al. [20] proposed that surgical intervention should be reserved for patients with fracture dislocation near skeletal maturity or finished skeletal growth, and for patient in whom conservative treatment did not give satisfactory results. From our standpoint we agree with Anz et al. To our opinion, great care should be taken in the choice of operative treatment because of negative effects of surgery and anesthesia in childhood, as well as high expenses of this treatment. In the 10-year study period, we indicated operative treatment in two children. One patient rejected operative treatment. The second patient had complete healing of fracture that was radiologically confirmed and full range of motion in the wrist. However, the patient complained of occasional pain.

Complications of scaphoid fracture in children are rarely encountered and they can be pseudoarthrosis, nonunion and avascular necrosis. Pseudoarthrosis is encountered more often than other complications. Some fractures are identified in pseudoarthrosis phase, partly due to minimal signs and symptoms at the time of injury and delay in seeking treatment [3]. Nonunion and avascular necrosis of proximal pole are rarely seen [2, 3, 10]. Even though in

5-10% adult patients scaphoid fracture nonunion is seen [27], in children it is extremely rare; until 1998 only 19 cases were described in the literature [6]. Children that develop nonunion could be divided into two groups [1, 2, 13, 20]. In the first group of patients scaphoid fracture was diagnosed and no course of treatment was undertaken (injury was discarded or missed). In the second group of patients fracture was diagnosed and was initially treated conservatively, but the fracture did not heal. After reviewing the literature, Fabre et al. [2] in 2001 reported 29 cases of nonunion of scaphoid fracture in children, stating that "acute" fractures if diagnosed in time and treated conservatively, had a very low risk of developing nonunion (0.8%). Most authors advise for nonunion scaphoid fractures in children, insertion of bone graft as the treatment of choice [3, 13, 19, 26, 27]. However, some authors have reported very good results after conservative treatment and propose that operative treatment should be considered after prolonged immobilization (three months) [2, 14, 28]. We also applied the same therapeutic approach. In our group of patients with "acute" fracture, in three children after the 8-week conservative treatment, nonunion was identified, but as it was later seen, a delayed healing process occurred. After prolonged immobilization ("plaster glove") and magnetotherapy in these three children the consolidation of fracture was identified. In one patient a complete healing was verified. In the remaining two patients, because of the development of pseudoarthrosis, operative treatment was indicated.

Avascular necrosis of scaphoid fracture in children is a very rare event, and there is no treatment protocol established [29]. Anz et al. [20] when reviewing the literature have found only one report of three cases of avascular necrosis after scaphoid fracture in children.

CONCLUSION

Results of this preliminary study indicate that conservative treatment of "acute" scaphoid fractures have excellent functional outcome and represent acceptable treatment option in the pediatric population, which is in accordance with the results of other authors. Our experience with three children with delayed fracture healing of scaphoid suggests that prolonged immobilization along with magnetotherapy yields good results. There is still a need for further research of greater number of patients so that guidelines could be established regarding the optimal treatment of scaphoid fractures in children.

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Преломи чунасте кости код деце

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КРАТАК САДРЖАЈ

Увод Преломи чунасте кости су ретки у детињству. Њихова дијагностика је отежана чињеницом да карпалне кости још нису потпуно осификоване. У сумњивим случајевима користе се компаративна и одложена радиографија, компјутеризована томографија, магнетна резонанција, ултразвук и коштану сцинтиграфија. Већина тзв. акутних прелома чунасте кости нормално зараста након конзервативног лечења. Уколико до зарастања не дође, на располагању су различити модалитети лечења.

Циља рада Циљ рада био је да се утврде механизам повређивања, клинички ток, начин и исход лечења прелома чунасте кости код деце.

Методе рада Ретроспективно су анализирани болесници са трауматским затвореним преломом чунасте кости током десетогодишњег периода (2002–2011. године). Исход лечења

„акутних“ прелома чунасте кости процењен је помоћу скорa за ручни зглоб Клинике „Мејо“ (*Mayo Wrist Score*).

Резултати Истраживање је обухватило 34 деце са трауматским затвореним преломом чунасте кости код којих коштану раст није завршен, просечног узраста од 13,8 година. Најчешћи механизам повређивања био је пад на испружену руку (76%). Током посматраног периода 31 дете с „акутним“ преломом лечено је конзервативно; средњи период имобилизације био је 51 дан. Шест болесника није даље надгледавано. Код преостало 25 деце, након потпуне рехабилитације, функционални резултат према примењеном скору био је одличан.

Закључак Конзервативно лечење „акутних“ прелома чунасте кости је прихватљива опција у педијатријској популацији и даје одличне функционалне резултате.

Кључне речи: чунаста кост; прелом; лечење; дете