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Surgical management of unstable both-bone forearm fractures in children

Çocuklarda instabil önkol çift kırıklarının cerrahi tedavisi

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Amaç: Çocuklarda instabil önkol çift kırıklarının cerrahi tedavisinde uyguladığımız iki farklı tekniğin sonuçları değerlendirildi.

Çalışma planı: İnstabil önkol çift kırıklı 35 çocuk hasta geriye dönük olarak incelendi. Bu hastaların 14'üne (grup 1; 4 kız, 10 erkek; ort. yaş 13; dağılım 10-15) açık redüksiyon ve plak-vida ile osteosentez, 21'ine (grup 2; 5 kız, 16 erkek; ort. yaş 11.5; dağılım 8-13) kapalı redüksiyon ve intramedüller çivileme yapıldı. Grup 1'de kırıkların hepsi kapalı kırıktı. Grup 2'de kırıkların 15'i kapalı, altısı tip 1 açık kırıktı. Yaralanmadan cerrahi müdahaleye kadar geçen süre grup 1'de 4.3 gün, grup 2'de 3.1 gün idi. Hastalar son kontrollerinde Price ve ark.nın ölçütlerine göre değerlendirildi. Ortalama takip süresi grup 1'de 34 ay, grup 2'de 37 ay idi.

Sonuçlar: Kaynamama sadece grup 1'de bir hastada görüldü; ortalama kaynama süresi grup 1'de 7.2 hafta (dağılım 6-11 hafta), grup 2'de 6.5 hafta (6-10 hafta) idi. Price ve ark.nın değerlendirmesine göre, grup 1'de 11 hastada (%78.6) mükemmel, iki hastada (%14.3) iyi, bir hastada (%7.1) orta sonuç alındı. Grup 2'de sonuçlar 18 hastada (%85.7) mükemmel, üç hastada (%14.3) iyi idi. Grup 1'de üç hastada (%21.4) önemli, iki hastada (%14.3) daha hafif komplikasyon görülürken, grup 2'de bir hastada (%4.8) önemli, sekiz hastada (%38.1) daha hafif komplikasyon görüldü. Hiçbir olguda ekstremite uzunluk farkı veya eklemlerde deformite, açısal veya rotasyonel deformite; sinostoz, enfeksiyon gibi komplikasyonlar görülmedi.

Çıkarımlar: Çocuklarda instabil önkol çift kırıklarının tedavisinde intramedüller çivilemenin, emniyetli, etkili ve uygulaması kolay bir yöntem olduğu sonucuna varıldı.

Anahtar sözcükler: Kemik plağı; kemik vidası; çocuk; önkol kırığı/cerrahi; kırık tespiti, intramedüller/yöntem; radius kırığı/cerrahi; ulna kırığı/cerrahi.

Objectives: We evaluated the results of two different surgical methods for the treatment of unstable both-bone forearm fractures in children.

Methods: Thirty-five children with unstable both-bone forearm fractures were retrospectively evaluated. Of these, 14 patients (group 1; 4 girls, 10 boys; mean age 13 years; range 10 to 15 years) underwent open reduction and plate-screw fixation, and 21 patients (group 2; 5 girls, 16 boys; mean age 11.5 years; range 8 to 13 years) underwent closed reduction and intramedullary fixation. All the fractures in group 1 were closed, while, in group 2, there were 15 closed and six type 1 open fractures. The mean time to surgery was 4.3 days in group 1, and 3.1 days in group 2. The results were assessed using the criteria of Price et al. The mean follow-up was 34 months in group 1, and 37 months in group 2.

Results: Nonunion was observed in only one patient in group 1. The mean time to union was 7.2 weeks (range 6 to 11 weeks) in group 1, and 6.5 weeks (range 6 to 10 weeks) in group 2. According to the criteria of Price et al., the results in group 1 were perfect in 11 patients (78.6%), good in two patients (14.3%), and fair in one patient (7.1%). In group 2, 18 patients (85.7%) had excellent, three patients (14.3%) had good results. Complications were major in three patients (21.4%) and minor in two patients (14.3%) in group 1, compared to one major (4.8%) and eight minor (38.1%) complications in group 2. None of the patients had limb-length discrepancy, joint deformity, angular or rotational deformity, or complications such as synostosis and infection.

Conclusion: It was concluded that intramedullary nailing was safe, effective, and easy to perform in the management of unstable both-bone forearm fractures in children.

Key words: Bone plates; bone screws; child; forearm injuries/surgery; fracture fixation, intramedullary/methods; radius fractures/surgery; ulna fractures/surgery.

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Forearm fractures are approximately 3.4% of all pediatric fractures and about 30% of all upper extremity fractures.[1] Eighteen percent of pediatric both-bone forearm fractures are observed in the middle third, 7% in the proximal third, and 75% in the distal third.[2] Unlike the adult both-bone forearm fractures which are usually managed with open reduction and internal fixation, most of the pediatric both-bone forearm fractures can be managed conservatively. Complications observed after conservative treatment of adult both-bone forearm fractures such as nonunion or malunion are also rarely seen in children.[3-8] Treatment alternatives of irreducible unstable pediatric forearm fractures are closed remanipulation under general anesthesia and casting, Kirchner wire and casting [9], closed or mini open reduction and intramedullary fixation [10,11], open reduction and internal fixation with plates.[8]

The results of open reduction-internal fixation with plates method and closed reduction-intramedullary fixation method in pediatric patients with unstable both-bone forearm fractures were compared.

Patients and Methods

The final assessments of 35 pediatric patients who were operated between 2000-2005 for both-bone forearm fractures and with adequate follow up were done and their medical records were retrospectively evaluated. Fourteen patients (group 1; 4 female,10 male; mean age 13;range 10-15) were managed with open reduction and internal fixation with plates, and 21 patients (group 2; 5 female, 16 male; mean age 11.5; range 8-13) were managed with closed reduction and intramedullary fixation using K wires or Rush pins. (Table I) In group 2, only ulna was fixed in 3 and both bones were fixed in 18 patients. Patients with radial head, Galeazzi, Monteggia, pathologic, distal 1/3, incomplete fractures and patients with short term follow up were excluded from the study. The most common mechanism of injury was a fall onto an outstretched hand (n=28 patients). Four patients had a history of being battered and three patients had a history of a road vehicle traffic accident. The interval between the admittance to the hospital and surgery was 4.3 days (range; 2-7) for group 1 and 3.1 days (range;1-5) for group 2. Five patients had their initial treatment done at some other institution.

Gustillo-Anderson classification for open fractures was used. While there was no open fractures in group 1, there were 6 Grade I open fractures in group 2. For patients younger than 10 years old, a fracture angulation of more than 10 degrees on standard AP and lateral x-rays and for older patients, an angulation of more than 20 degrees were accepted as an indication for surgery. Rotational deformity was not accepted at any degrees.

Patients who were admitted to the emergency department with an open fracture were immediately taken to the operation theatre for wound debridment and irrigation. Remanipulation under general anesthesia under fluoroscopic guidance was performed for the patients in whom initial satisfactory reduction could not be obtained in the emergency department or in whom loss of primary reduction was observed during follow up. In group 1, open reduction and internal fixation of first ulna followed by radius using 1/3 semitubular plates was performed. In group 2, ulna was fixed with an anterograde Rush pin or K wire from proximal olecranon to distal forearm. If reduction of the radial fracture was found not to be satisfactory, an entry point is made just proximal to distal radial physis and radius is also stabilized with a Rush pin or a K wire.

In the postoperative period, the patients are placed in a long arm cast brace for two weeks in group 1. In group 2 however, the osteostynthesis is protected with a long arm cast for four weeks followed by a short arm cast for an additional two weeks. Fracture union was defined as bridging callus on both AP and lateral radiographs with clinically no tenderness on fracture sites. All intramedullary implants are removed under local anesthesia at the time of the cast removal. Plates are removed after a minimum period of 6 months under general anesthesia with a secondary procedure. Figure I shows a forearm fracture managed with open reduction - internal fixation (ORIF) and Figure II shows another forearm fracture managed with intramedullary fixation.

Major complications are defined as iatrogenic complications due to unskilled use of the implants or unsatisfactory manipulations which led to secondary procedures and secondary anesthesia causing a negative effect on the long term functional results. Minor complications are defined as complications which had no effect on long term prognosis or functional results. Patients are evaluated at their last assessment using the criteria defined by Price et al.[5] No pain in heavy labor and loss in forearm rotation less than 10 degrees is accepted as perfect; moderate pain in activities and loss of forearm rotation up to 30 degrees is accepted as good; loss of fo-

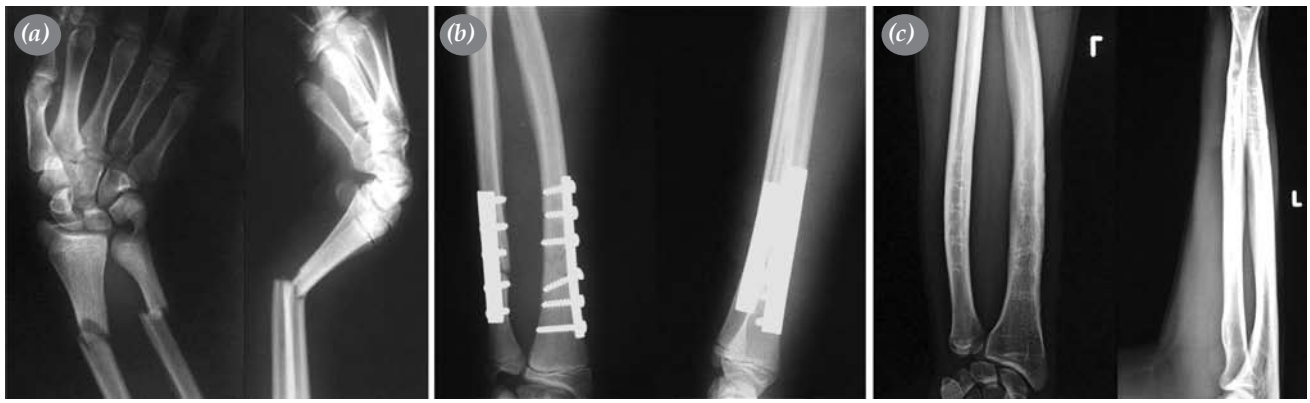

Figure 1. (a) A 14 year old boy was admitted to the hospital after a fall from bicycle which caused both-bones fracture of the right forearm. **(b)** Three days after admittance to the hospital, this patient underwent open reduction and internal fixation with plates; initial postoperative anteroposterior and lateral radiographs. **(c)** Follow up radiographs of this patient 4 years after the initial procedure and 2 years after removal of the implants. Excellent clinical results were observed according to the Price criteria.

rearm rotation up to 90 degrees is accepted as fair and all of the other results are accepted as poor results.

Results

Bony union was observed in all except one patient in group 1 in an average of 7.2 (range;6-11) weeks while all fractures healed in an average of 6.5 (range;6-10) weeks in group 2. The mean follow up periods for group 1 and group 2 were 33.8 (range;10.6-51.6) months and 37 (range;14-52) months, respectively. The mean interval between the injury to the operation were 4.3 (range; 2-7) days for group 1 and 3.1 (range;1-5) days for group 2. Only ulna was fixed in 3 and both bones were fixed in 18 patients in group 1.

In group 1, eleven patients (%79) had perfect, 2 patients (%14) had good and one patient (%7) had a fair result according to the Price criteria (5). In group 2, 18 patients (% 85) had perfect and 3 patients (%15) had good result. Poor results were not observed in any of the groups. Three major (%21.4) and two minor (%14.3) complications were observed in group 1. Loss of extension of the thumb was observed in one patient in the early postoperative period. This complication was thought to be related to the iatrogenic injury to posterior branches of the radial nerve and resolved spontaneously in 8 months. Delayed healing was observed in one patient which healed in 11 weeks. Nonunion developed in one patient; after 20 weeks from the initial procedure,

Figure 2. (a) A 13 year old boy was admitted to the hospital after a fall. **(b)** Two days after admittance to the hospital, both the radius and ulna underwent intramedullary rodding with titanium elastic nail; initial postoperative anteroposterior and lateral radiographs. **(c)** Follow up radiographs of this patient 18 months after the procedure. **(d)** Follow up radiographs of this patient 4 years after the initial procedure and 2.5 years after removal of the implants. Excellent clinical results were observed according to the Price criteria at the latest follow up.

he was managed with open reduction, bone grafting and internal fixation with locked plates. Eight weeks after the second procedure, bony union was observed. As minor complications, superficial wound was observed in two patients which healed with daily dressing. One major (%4.8) and 8 (%38.1) minor complications were observed in group 2. Delayed healing was observed in one patient with an open fracture and bony union was seen at postoperative 10 weeks. As a minor complication, irritation of the hardware caused a painful ulnar bursitis in one patient which resolved totally after implant removal. Irritation of the superficial radial nerve due to the radial K wire was noted in one ather patient which had resolved spontaneously in 3 months. Ulnar neuropathy developed in two other patients. Migration of the hardware causing irritation was observed in 4 patients and removal of the implant was necessary. Synostosis, infection, vascular or anesthesia related complications were not observed in both groups. No limb length inequality, angular or rotational deformities were observed clinically in this study.

Discussion

Although most of the pediatric both-bone forearm fractures can be treated conservatively, alternative fixation methods may be necessary for the unstable and irreducible fractures.[12,13] Displacement of the fracture may be observed in %7 of the patients in whom initial closed reduction and immobilization with a long arm cast was decided to be satisfactory.[7,14]

Various treatment algorithms in the management of pediatric forearm fractures are proposed. Many authors accept a fracture angulation of up to 10 degrees for conservative treatment,[15,16] while some accept up to 20 degrees of fracture angulation.[17,18] However there is a consensus regarding that a rotational deformity can not be accepted in nay case.[15] Obvious limitation of forearm rotation [19] or angular deformities [15,20] may be observed clinically in case of narrowing of the interosseous space. In a cadaveric study, a 20 degrees of fracture angulation in the middle 1/3 of the forearm was reported to cause obvious limitation in forearm pronation-supination.[15] Age of the patient [5,17], degree of the deformity [16] , distance of fracture to the physis [5] , and amount of volar angulation [20] were reported to be correlated with spontaneous remodelation. Accompanying neurovascular injuries and open fractures are the other indications for surgical management. In our study, a fracture angulation of more than twenty degrees for the patients younger than 10 years old and 10 degrees of angulation for the older patients was accepted as the surgery limit.The malunions of the pediatric forearm fractures may have a deterious effect on the functional results. Generally accepted opinion among the orthopaedic surgeons is that malunion of the middle 1/3 forearm fractures may cause more functional disabilities than the distal 1/3 fractures, and that loss of supination is less tolerated than pronation.[5,17] Loss of pronation depends on the initial and perioperative soft tissue damage as well as the degree of correction of the angular and rotational deformities. Good results have been reported with open reduction and internal fixation using plates in the management of both-bone forearm fractures.[4,8,13,18] However, this method requires a wide surgical exposure and is preferred in more skeletally mature pediatric patients (8). The implant to be used may vary upon the surgeon's choice. Comparing the results of open versus closed methods, there was no significant difference in terms of functional results although more serious but less common complications were observed in the open reduction and internal fixation using plates group.

Intramedullary nailing method is preferred in younger pediatric patients. Surgical intramedullary device options include flexible titanium nails,[4,18,21] Rush pins [18] , Steinman or K-wires.[4,21] The advantages of intramedullary fixation are reported as shorter surgical incisions, shorter surgical time, stable and biological fixation, shorter healing time and minimal loss of motion.[4,6,8,10] Secondary surgical procedures may be necessary due to symptomatic hardware.[3,18,21] The use of fluoroscopy may be an disadvantage of the technique. Lascombes et al [3] reported %6 of their patients needed an open reduction because of soft tissue interposition but, on the contrary, Verstreken et al [6] reported they did not need open reduction in any of their patients. None of our patients in this study neded an open reduction.

The complication rates for open reduction-internal fixation with plates have been reported as %0-33, [22] and for intramedullary fixation as %0-16.[3,6,23] Lascombes et al reported 4 major (%5) and 10 minor (%12) complications in 85 patients managed with intramedullary fixation.[3] Some authors who have compared the two methods believe that both methods may give equally same results.[4,18] Three major (%21.4) and two minor (%14.3) complicatioms were observed in the open reduction and internal fixation group while one major (%4.8) and eight minor (%38.1) complications were observed in the intramedullary group in this study. Most

of the complications observed in the intramedullary group were minor and resolved spontaneously after removal af the implants. Deep infection was not observed in any of the groups. The necessity and duration of immobilization in the postoperative period is unclear. Some authors have recommended early active range of motion without immobilization for better soft tissue and fracture healing.[3,6] Lascombes et al reported secondary displacement of the fracture in %5 of the patients when postoperative immobilization was not used. Postoperative immobilization was used as an adjunct to the osteosynthesis in both groups and secondary displacement was not observed. No difficulty was observed in restoration of the elbow and forearm motions.

In preoperative planning of the pediatric both-bone forearm fractures, the age of the patient, the extent of soft tissue damage and general condition of the patient must be considered. Comparison of the techniques in surgically managed patients showed that less but more serious complications had been observed in ORIF group and most of the minor complications had spontaneously resolved after removal of the implants in the intramedullary group. Intramedullary fixation of both-bone forearm fractures is an alternative method to ORIF, external fixation and minimal osteosynthesis with K wires. We believe that intramedullary fixation is a safe, effective and easy method in the management of irreducible unstable both-bone pediatric forearm fractures.

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