Differences of treatment of forearm fractures in children and adult population

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Differences of Treatment of Forearm Fractures in Children and Adult Population

GRADUATE THESIS

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Abbreviations:

DRUJ: Distal radio-ulnar joint

FCR: Flexor carpi radialis

ECRB: Extensor carpi radialis brevis

EDC: Extensor digitorum communis

TFCC: Triangular fibrocartilage complex

ESIN: Elastic stable intramedullary nailing

ORIF: Open reduction internal fixation

CT: Computed tomography

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1 Summary

Title: Differences of Treatment of Forearm Fractures in Children and Adult Population

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Forearm shaft fractures are common fractures seen in all age groups. Choosing the right treatment is important in order to restore patients forearm movements, especially pronation and supination. Restriction of those movements can significantly decrease quality of life of a patient. Treatment depends on type of the fracture and age of the patient. Preschool children are treated mainly conservatively. School children with stable fractures may also be treated conservatively but unstable fractures are treated with reduction and minimally invasive surgical technique elastic stable intramedullary nailing (ESIN). ESIN can only be used in children till adolescence. Children near skeletal maturity and adults need open surgery with rigid plate and screws fixation of the fracture. Nondiplaced ulnar fracture can be treated conservatively. Anatomical reduction and sufficient fixation of the fracture is the key of treatment of forearm shaft fractures, which give satisfactory functional outcomes.

Key words: forearm shaft, fracture, radius and ulna, treatment, ORIF, intramedullary nailing, elastic-stable intramedullary nailing, ESIN

2 Sažetak

Naslov: Razlike u liječenju prijeloma podlaktice u dječjoj i odrasloj populaciji

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Prijelomi srednjih dijelova podlaktičnih kostiju su česti u svim dobnim grupama. Odabir odgovarajućeg liječenja je važan zbog očuvanja pokreta u podlaktici, pogotovo supinacije i pronacije. Ograničenje u tim pokretima može znatno sniziti kvalitetu života u pacijenata. Način liječenja ovisi o vrsti frakture i o dobi pacijenta. Predškolska djeca se liječe uglavnom konzervativno. Školska djeca sa stabilnim frakturama se isto tako liječe konzervativno, dok se u slučaju nestabilnih fraktura primjenjuje repozicija i minimalno invazivna kirurška tehnika primjene stabilnog elastičnog intramedularnog čavla (ESIN). ESIN se može koristiti samo u djece do adolescencije. Djeca blizu koštane zrelosti i odrasli u ovom slučaju zahtijevaju otvorenu kirurgiju frakture s rigidnim pločicama i šarafima. Frakture ulne bez pomaka se mogu liječiti konzervativno. Anatomska redukcija s optimalnom fiksacijom frakturnih ulomaka predstavlja najvažniji dio liječenja prijeloma srednjih dijelova kostiju podlaktice, te omogućuje zadovoljavajući povrat funkcije.

Kjučne riječi: podlaktica, prijelom, radijus i ulna, liječenje, ORIF, intramedularna osteosinteza, elastično stabilno intramedularno osteosinteza (ESIN)

3 Preface

Upper limbs are one of the most important parts of human body. With them we do most of the actions and fine movements in our life. Upper limbs have great range of movement and high precision. With injured upper limb we have great problems with many of our daily activities. In this work literature and comparison of different treatment methods in children and adults will be analyzed.

Forearm shaft fractures are relatively common fractures. Approximately 50% of them are produced by falls and around 40% of all forearm shaft fractures occur in children under 15 years of age and their incidence has increased markedly in recent years (1). They are more common in summer months and occur outdoor on a sunny day half time more common than on a rainy day (2).

3.1 Anatomy of the forearm

Forearm shaft consists of two bones, straight ulna and curved radius, which are connected with interosseous membrane of the forearm and are articulating between each other in proximal and distal joints. Proximally compound elbow joint consist of distal humeral articulate surface, which articulates with proximal articulate surface of ulna and head of radius. Ulna and radius articulate with each other in proximal radio-ulnar joint and are connected by annular ligament. On the distal end of parallel positioned radius and ulna there is distal radio-ulnar joint (DRUJ), which is a pivot joint and connects ulna and radius to the wrist in the radio-carpal joint (3,4).

Through the whole length radius and ulna are connected with the interosseous membrane of the forearm, which tightens both bones together to prevent parallel displacement of both bones and transfers compression forces from distal radius to ulna to reduce stress on a single bone (3,4,5).

The function of both proximal and distal radio-ulnar joint together with interosseous membrane of the forearm is pronation (rotation of radius around the ulna) and supination (bones lie parallel to each other), we could also say rotation of the hand. The angle of supination/pronation is around 175° in males and 180° in females (3,4).

3.2 Clinical assessment of the of the forearm

As already said ulna is straight and radius is bow shaped. Any loss of shape or malposition of those two bones can result in restricted pronation and supination and loss of function. Therefore patient history and clinical examination should be performed in a way to assess forearm with radius and ulna as a unit.

First we need to know what happened and where exactly is the injury. Is the presentation of "injury" traumatic or atraumatic? Was injury due to high energy trauma (car accident) or low energy (fall from standing)? Depending on those answers we will define if we need more local or more extended evaluation of the patient. Further, we need to assess proximal and distal joint in relation to the injured part of the forearm. We have to check for bone as well as for soft tissue injury or open fractures. We try to feel the continuity and shape of both bones, ulna and radius and their relation. By testing the movements of the forearm we test for limitation in movement or for crepitus of the fractured bone. We should not produce any additional pain with our assessment. We need to check for swelling of the forearm and developing of the compartment syndrome. At the end we also have to assess neurological and circulatory status distal to the injury. We need to test sensory and motor function of ulnar, radial and median nerve in the hand. We need to palpate radial pulse and test capillary refill to the fingers (5,6).

First test of choice is x-ray of the forearm in lateral and AP views. We need to see elbow as well as radio-carpal joint. We can also order additional x-rays of different projections or of the specific part of forearm we are more interested in.

In the forearm we can find different types of fractures. There can be a single bone fracture (radius or ulna) or some other associated injury of second bone or joint. In McRae's orthopaedic trauma book forearm fractures are divided to (5):

- **radial Fractures:**
  - isolated radial shaft fracture
  - Galeazzi fracture-dislocation - radial shaft fracture with DRUJ injury
- **ulnar fractures:**
  - isolated ulnar ('night stick') fracture
  - Monteggia fracture dislocation - ulnar shaft fracture with radial head dislocation
- **both bones forearm fracture.**

In children bone is immature and more elastic, therefore we can find some specific fractures. Greenstick fracture is common in young children whereas in older children we can find completed or short oblique fractures (7).

4 Treatment of forearm shaft fractures

When we confirm fracture of the forearm shaft, our goal is to treat the fracture in a way patient will recover quickly, with the least complications and to regain maximal functionality, which should be close to anatomy from pre injury time.

In order to regain functionality the physician must take care of the physiological bow of radius, intaction of interoseous membrane and proximal and distal radio-ulnar joints. If the radial bow is not regained inside 5% of pre injury level there is high probability that there will be 20% loss of forearm rotation. But any malposition or angulation can cause functional deficit of the forearm (6).

The goal in management of diaphyseal fractures is described by T. P. Rüedi et al, which are stating "Restoration of length, axial alignment, and rotation is essential, and also anatomical reduction in a case of radius and ulna fracture is necessary for normal limb function" (8). Therefore first we have to reduce the fracture and than we should fixate it in order to promote healing in anatomical position.

We divide treatment of the forearm shaft to conservative (nonoperative) treatment with a cast or functional brace and operative treatment, which can be done by different surgical techniques.

4.1 Fracture reduction

Percise fracture reduction is important for good functional outcomes. Satisfactory fracture reduction is to regain anatomical position close to bone position prior the fracture. Fracture reduction can be closed or open. Closed reduction is done by manipulation with indirect pressure of the both ends of the fracture bone in order to align them into anatomical position. Open reduction is done by surgically by

opening the fracture site exposion of fracture site and direct manipulation of the fractured bones. Reduction is done under anasthessia. It could be local anasthesthetic injected into the fracture site regional nerve block or general anasthesia. Last is used especially with children and is helpful also due to muscle relaxant effect (5).

In children with incomplete fractures such as greenstick and bowing fractures closed reduction without traction is advised (9). In order to understand how to reduce fracture, physician has to understand mechnanism of fracture. Reduction should be done in the opposite way of mechanism of fracture to return broken parts of the bones to their anatomial position. Supination fractures should be pronated by pronating the distal part of fracture and pronated fractures should be reduced by supinating the distal end (10). We repair angular deformity by using three-point manoeuvre. Many authors suggest to maintain position of bones in greenstick fractures in order to maintain stability (7,11).

Complete and unstable fractures are reduced with sustained traction which release contracted muscles. By this manuevre we can correct shortening as well as angular and rotational deformation (12).

4.2 Conservative treatment

Nonoperative treatment, usually by casting has its advantages and disadvantages. It can be used for temparary or as a definitive treatment. The most commonly used material is Plaster of Paris but we can also use different newer synthetic material such as polyethilene. The advantage of treatment with cast is that the patient does not need to go to surgery, which decreases chances of infections, surgical complications and needs less equipment which decreases cost of the treatment. However there is longer time needed for a bony union and there are higher risks of malalignment, malunion and increased stiffnes of the adjacent joints due to prolonged fixation in the cast. Complications such as angulation of the fracture may be controlled by a well applied

cast, it may, however, be difficult to control rotation and shortening of the fractured bones (8).

Some of the fractures are best treated conservatively. This is true in a case there is minimal or no displacment and no rotational malaligment (8). Usually those fractures are stable. In adults the conservative treatment is used rarely and is mainly reserved for isolated ulnar shaft fracture also called "nightstick" fracture. This is a fracture made by direct blow to the ulnar shaft due to self deffense mechanism with forearm protecting the head against direct hit with a pole or stick of attacker. We treat isolated ulnar shaft fractures with a cast in a case there is less than 50% displacement of the dyaphyseal width and if there is less than 10 degrees angulation. Proximal ulnar third fractures are known to have greater loss of pronation, therefore they are more commonly treated surgically. The rule is that more proximally that ulnar fracture is, the closer anatomical reduction is required (6).

After reposition of the fracture long-arm cast in a elbow-in-flexion is prefered over elbow in extenion due to practical reasons for patient (10,13). The plaster should imobilize volar and dorsal aspects of forearm, should maintain the corrected reposition by three point fixation to prevent muscles, especially pronator and supinator muscle forces of distorting position. Further it should also support the tension of the interosseous membrane to prevent collapse of interoseous space (4,7,14). General rule of thumb is that proximal third fractures are casted in the supination, middle third fractures in the netural and distal third in the pronation position. However we should always decide depending on what works best in every presented case and depending on fluroscopy findings of reposition stability (7,15).

We should not apply the same rules to the isolated radius fractures because these frctures are more commonly unstable and have in addition also rotational and angular component that is transmitted through the interosseous membrane. Therefore we should also suspect concomitant DRUJ injury in a case of isolated radial shaft fracture, but there may be spontaneous reduction of DRUJ joint. However isolated stable radial shaft fractures can also be treated conservatively, but common radiographic checkups are needed (6,16).

In isolated distal ulnar fracture with less than 50% displacement and less than 10 degrees of angulation the immobilization that limits forearm rotation but permits elbow flexion and extension is suggested. The cast which immobilize elbow was shown that decreases the number of good and exellent results (6).

The displaced fractures of radius and ulna and the isolated radial shaft fractures are known as unstable fractures, associated with shortening and angulation and are therefore indicated for surgical treatment. In that case casting is used for temporary treatment till surgery to support and stabilize the fracture and to relieve some pain produced by movment of the fractured limb. Well padded dorsal-volar plaster splint is usually used with an interosseous mold (6).

In children we more commonly decide for conservative treatment due to increased remodeling capacity in young bone. However remodeling capacity should not be overestimated as the angular deformation repairs 1° per year utill bone maturity (17). For the children of less than 8 years of age the maximum angulation accepted is 10°-15° and 5°-10° for children more than 8 years of age (13,18). Maximum displacement should should be less than bone diameter, and rotational malformation under 45° in children less than 9 years of age and less than 30° in children older than 9 (11,19).

In consrevative treatment of stable forearm fractures we usually give long arm cast for 6-12 weeks with the elbow flexed to 90 degrees and the wrist in neutral rotation (20). Radiologic follow-up of fracture in cast is advised after 1st week of cast and than also after 3rd, 6th week and also after cast removal in order to check for proper healing or any malunion and nonunion. After 3rd week we can change long arm cast to below-elbow cast in order to improve cast comfort and to promote elbow flexion and extension but only in cases of nondisplaced fractures due to low risk of redisplacement. Six weeks of cast is usually enough if there were no complications during that time (21).

Satisfactory healing with callus after 6 weeks allows light mobilization of arm but full loading and sports activities should be prohibited for another 4-6 months,

since there is still not full recovery of bone strenght and refracture is common in that time (22). Physiotherapy has not ben used in the past but nowadays we can find it's benefits, especially in treating contractures resulting in decrease in range of motion (23).

4.3 Surgical treatment

Surgical treatment is indicated in all diapihyseal fractures of the forearm except for stable fractures of nondisplaced or minimally displaced ulna or radius (24,25,26). The goal of surgical treatment is to restore bone lenght, rotation and curvature of radius and ulna as well as the interosseous space. Further we want to achieve early stability to promote early range of motion (27).

In general we have three types of surgical treatment. ORIF (open reduction, internal fixation) treatment is the most common method in adults. It requires relatively large incision to expose the fracture site. The fracture is reduced and plate is fixed on bone, fixing both ends of the fracture together. Second technique is intramedullary nailing which requires only small incisons to make access to metaphysis of bone for placement of intramedullary nails. Third technique is external fixation which fixate fractured bone outside the body by parallel connection of fixated pins in both parts of fractured bone. This technique is used seldom due to increased risk of skin andsoft tissue infection around inserted pins and rigid external aparate. However it is very useful in open fractures when there is an abundand soft tissue injury or infected wound (5,6).

4.3.1 Surgical approaches

To understand surgical aproaches for radius and ulna we have to understand anatomy of the forearm. The easiest way is to divide muscles of the forearm into three

main groups, each supplied by its own nerves. Therefore each of three aproaches divides two muscle groups and proceeds through an internervous plane (4,6):

1. Henry's (volar) approach for radius divides brachioradialis muscle inervated by the radial nerve and flexor carpi radials (FCR) muscle inervated by the median nerve
2. Thompson's (dorsal) aproach for radius divides extensor carpi radialis brevis (ECRB) muscle inervated by the deep radial nerve and extensor digitorum communis (EDC) muscle innervated by the posterior interosseous nerve
3. Ulnar subcutaneous approach divides flexor carpi ulnaris (FCU) innervated by the ulnar nerve and the extensor carpi ulnaris (ECU) innervated by the posterior interosseus nerve

4.3.2 Radius shaft fractures - surgical treatment

4.3.2.1 Galeazzi fracture - dislocation

Surgical treatment is needed in all Galeazzi fracture-dislocations. This is special type of fracture-dislocation pattern which can be easily missed on x-ray. It consists of middle or distal third radius fracture with disruption of the DRUJ. DRUJ can be present with any radial fracture and also with additional ulnar fracture (5,6).

Most common surgical treatment for this type of fracture is ORIF (open reduction, internal fixation). We can approach the fracture from volar or dorsal site. For middle and distal third radial fracture, Henry's (volar) approach is usually prefered. For the proximal third radius fractures dorsal aproach is prefered. The fracture is exposed, reduced anatomically and fixated with a compression plate. Restoration of radial bow is crucial. After the DRUJ is assesed clinically and fluoroscopically and managed according to the stability (5).

In case that DRUJ is intact and stable and there is full ranege of pronation and supination without crepitations and dislocations, the DRUJ is intact and there is no

need for surgery. In case DRUJ is unstable and ulna is displacing dorsally during the pronation and supination the DRUJ needs surgical stabilisation.

In case there is an ulnar styloid fracture present, this has to be reduced and fixed with a Kirschner wire, small screw or transosseous suture. If TFCC (triangular fibrocartilage complex) is intact joint will gain stability. If fixation of ulnar styloid is not effective than a k-wires or a small fragment screw is used to fixate distal radius and ulna. Inserted wires or screws should be removed after 6 weeks.

There is also posibility that DRUJ is not stable but can not be reduced. That happens due to soft tissue entrapment between distal radius and ulna, most often extensor carpi ulnaris tendon. In this case joint has to be accessed with incision dorsally with a special care of dorsal branch of ulnar nerve, removed tissue from articular space, reduced and than stabilized as described above (5).

4.3.3 Ulnar shaft fractures - surgical treatment

Ulnar shaft fractures commonly result from the direct blow to the ulna. There should always be suspected Monteggia injury until proven otherwise. We treat unstable ulnar fractures which have angular or translational companent with ORIF compression plating.

4.3.3.1 Monteggia fracture-dislocation

Monteggia fracture-dislocation most often consists of proximal ulna fracture combinded with radial head dislocation. By Bado classification we divide those fracture-disslocations in different types (5,6):

1. anterior dislocation of the radial head with anterior angulation of the ulnar fracture
2. posterior dislocation of the radial head with posterior angulation of the ulnar fracture
3. lateral dislocation of the radial head with the metaphyseal ulnar fracture

4. anterior dislocation of the radial head with accompanied ulnar and radial fracture

In Monteggia Fracture-dislocation injury we would first access ulnar fracture by ulnar subcutaneous approach which divides the flexor carpi ulnaris muscle and the extensor carpi ulnaris muscle. Then anatomical reduction is done and fixation with compression plate and screws is made.

With the reduction of ulnar fracture, radial head in most cases reduces by itself. If this is the case and the radial head is stable with full range of movment in elbow fexion, extension supination and pronation, than no further surgery is required. When radial head remains displaced it could be due to failed anatomical reposition of ulna. In rare cases there could be interposition of annular ligament or other soft tissue in the joint. In that case open exploration of radiocapitellar articulation through Kocher approach should be made. After retriving the annular ligament and soft tissue removed the radial head also gain its anatomical position. There could also be radial head fracture. In that case radial head should also be anatomically reduced and fixed or prothesis should be implanted (5,6).

4.3.4 Both-bones fracture of forearm

Symultaneous radius and ulna fracture usually happen due to high energy trauma. Most of the fractures are displaced and unstable and surgery is always indicated. We should carefully inspect skin for any lacerations to identify open fractures. Forearm may be highly deformed. Grossly angulated and deformed forearm should be gently realigned. There is increased risk of compartment syndrome. Any weakening of pulsations, disproportional pain and increasing paraesthesias are surgical emergency. In high energy trauma there is also increased risk for injuries on other parts of the body and we have to try to identify them to start treating them symultaneously (5,6).

There should be first stabilisation of ulna, since ulna is straight bone and we can much easier regain the lenght (6). After ulna, radius is accessed through a separate incision and again anatomically reduced together with its bow and than fixated with compression plate and screws. After fixation of both bones clinical asessment of movement of forearm pronation and supination must be done. In case of restricted movement we should reassess the fixations and reductions we made. Loss of movement is most commonly caused by malaligment of fractured bones (5).

4.3.5 Intramedullary nailing

Intramedullary nailing of ulna and radius is as in other long bones an atractive option with minimal incisions and some good functional and cosmetic outcomes. However researches showed that there are inferior results compared to ORIF. There is weaker angular and rotational stability of intramedullary fixation of radius and ulna in adults which does not permit early mobilization of forearm. Some researchers report sucessful treatment with intramedullary nails but this approach is reserved for special cases with abundand soft tissue injury where it can be used as a primary method of fixation (28,29,30). Ulna is better bone for intermedullary fixation than radius due to easier access to the intramedullary canal at the olecranon and due to its straightness (31). Hybrid fixation of forarm using ORIF for radius and intramedullary nailing for ulna can combine both methods succesfully (28).

4.4 Operative treatment in children

Treatment of forearm shaft fractures in children mainly depends on the age of pediatric patient. Younger than the patient is, more elasticity bone has, and also more remodeling potential. Therefore we rarely operate fractures of children younger than preschool age (32). Further all stable fractures in children of any age are primarily treated conservatively with cast. Operative treatment is the treatment of choice in all

evidently unstable diaphyseal forearm fractures, open fractures, comminuted fractures, concominant dislocations, floating elbow and fractures with severe soft tissue complications. The principle of primarily definitive fracture care with early mobilisation of the forearm is the goal (33).

Unstable forearm shaft fractures describe complete fractures of both bones, ulna and radius, usually on the same level with oblique fracture lines. Anatomical reposition and stable fixation is of major significance for satisfactory functional outcome. Conservative treatment may be tried out but close follow up with x-rays should be mandatory as those fractures are unstable in principle and tend to be insufficiently fixated by cast and tend to displace frequently. Therefore surgical stabilization treatment is preferred. Fractures in the proximal third of the forearm are especially complex since correction with growth is minimal due to minimal growth potential of proximal growth plates. We have to follow anatomical reposition strictly with maximum malalignment of 10 degrees. Fractures in the distal third however will benefit from growth from distal epiphyseal growth plates, which constantly correct malalignment during further growth. A displacement of fracture of up to 20 degrees till the age of 12 years may be accepted (34).

4.4.1 Elastic stable intramedullary nailing (ESIN)

In children from preschool age till adolescence minimaly invasive surgical treatment with elastic stable intramedullary nailing (ESIN) is prefered (35,36,37). Treatment of forearm shaft with ESIN is a good alternative between cast and ORIF with plate and srews. There is no extensive skin and soft tissue cuts, only small incisions for elastic nail insertion into the bone lumen and sometimes additonal aproach for fracture reposition. Further the forearm is mobile early after the surgery like in ORIF (33).

ESIN stabilizes fractures by nails made from titanium or stainess steel (38). Nails have to be about 40-60% of diameter of the narrowest part of the bone lumen.

Thin nails by themselves do not produce satisfactory stabilization of fractured bone (17,34,39). However stability of ESIN method is based on the bending of the nail inside the intramedullary canal and producing tension frame in the forearm (40). ESIN method does not produce absolute stabilisation but relative that allows micromovements of the fracture, which promotes ossification (41). Adolescents with completed skeletal maturation or close to it have to be operated by convenient ORIF method by anatomical hairline reduction and fixation with plate and screws (42). ORIF as well as ESIN have the same funcional results and the risk of complications appears to be similar in children (43,44,45). We tend not to remove ESIN before 6 months and plate with screws 12 months after the surgery. The risk of refracture is increased prior to that time (46,47).

Complications of treating prediatric forearm shaft fractures with ESIN increase with children age, especially after age of 10 (19). In older patients near skeletal maturity, treatment by rigid fixation with plate and screws is the treatment of choice (33). External fixator is again preferred treatment of comminuted, open fractures with abundant soft tissue destruction in older children and adolescents (34). Fractures in distal diaphysis or metaphysis of the forearm can also be stabilized with two k-wires (34).

4.4.2 Operative techniques of ESIN

ESIN technique of the forearm shaft fracture consist of retrograde (ascending) nailing of the radius and retrograde (ascending) or anterograde (descending) nailing of the ulna. Descending nailing of radius is not recommended due to high risk of injuring the deep radial nerve (48,49). Nails have to be about 40-60% of diameter of the narrowest part of the bone lumen. In both bone fractured we have few approaches which bone to stabilize first. Some surgeons stabilize first the bone with simplier fracture in order to easier regain anatomical lenght. Others prefer to start with more difficult nail, which is radial one in most forearm fractures. For ascending nailing of radius we can use lateral approach, which is in close proximity of the superficial radial nerve, or a

dorsal approach at the Lister's tuberculum radii. The nail is pushed ascending to the bone canal, through the fracture, manipulated into proximal segment of the bone and further into strong cancellous bone at the proximal metaphysis. Bone fracture should be in that time manipulated to reduce the fracture to anatomical position by indirect reduction. If closed reduction is unsuccesful than aditional small incision should be done to directly manipulate and reduce the fracture. The ulnar nail is inserted by aproach through distal medial metaphysis (ascending) or from the proximal lateral plane of olecranon (descending) and advanced into strong cancellous bone of the opposite metaphysis. The tips of the nails should be turned against each other in order to produce the tension on the lateral surface of radius and ulna in order to open interosseous membrane. After satisfactory position of the nails, the remainig portion of nails should be cut and burried under the subcutaneous tissue. In dorsal radial insertion special attention should be given to the tip of the nail to be outside of the tendon compartment to prevent any tendon injury by continous friction over the nail ends (6,34). Cast after ESIN is not needed but injured arm should not be exposed to loads greater than lifting a glass of water. Movements of injured arm are promoted. X-ray 4 weeks after the surgery usually shows sufficient callus formation for sports activities and after 3 months we can see bone remodeling. ESIN can be removed 6 months after the surgery (34).

5 Discussion

When assessing forearm injuries we have to be aware of possibility that forces can be translated from hand through the forearm all the way to the elbow. Therefore we can have injury in the whole lenght of the forearm. There can be injury to any type of tissue. Taking history of the event help us understand injury and after by clinical examination we assess the clinical picture.

X-ray is great for cheking skeletal injuries but is unable to directly show soft tissue, ligamentous and cartilage injuries. Very fresh hairline fractures can also be missed and seen only after some time when bone reacts to the fracture and increases local calcium concentracion. Nonossified parts of bones in children are also not seen on x-ray and have to be assessed by clinical examination or CT scan when there is high susspicion of injury. When we have fracture of one bone of the forearm we have to assess elbow joint for range of movement, especially radial head could have aditional fracture or could be dislocated or unstable due to ligamentous aparatus injury. We also have to assess distal radioulnar joint with TFCC. Injury of TFCC manytimes can't be seen on x-ray but could be diagnosed clinically.

Preschool children forearm shaft fractures are usually treated conservative with cast. Only highly complex fractures are operated. Preschool children have very high remodeling potential that allows fast healing with great remodeling capabilities of broken bones.

In the past diaphiseal forearm fractures of school children till skeletal maturation were also commonly treated conservative but this treatment many times resulted in functional loss of forearm supination/pronation movement. Therefore we may treat conservatively only nondisplaced, stable fractures. All other fractures we have to treat surgically by minimally invasive ESIN technique or by ORIF with plate and screws. ESIN technique is used in children with still open growth plates in radius and ulna.

With patients approaching skeletal maturity ESIN in not treatment of choice due to lack of angular and rotational stability and limitied remodeling of broken bone. Therefore patients with skeletal maturity usually need to have conventional surgery with ORIF with plate and screws. The only indication for treatment with cast would be nondisplaced stable ulnar shaft fractures. Open fractures are at the beginning treated by external fixator in all ages and than treatment may be converted into some other technique when soft tissue improves.

Forearm fractures are common fractures and can be find in all ages. Anatomic reduction is important to regain mobility of forearm. Pronation and supination movements of the forearm are important movments for high quality of living. Therefore surgery by open approach and plate and srews is standard in adult population.

Treatment of forearm shaft fractures in children was revolutionized by ESIN technique, which gives great results with minimal tissue damage by surgery and comparable functional outcomes to ORIF tecnique.

In future we can expect some breakthrough discoveries in even more boosting biochemical mechanisms of fracture healing to promote fracture healing by some fractors or local injections into the fracture. Further we should also revolutionize adult treatment of forearm shaft fractures as it was done in children. There were some trials by using different nails in adults but so far results were worse than in conventional ORIF treatment.

At the end it should be emphasized to emphasize that forearm shaft fractures have great success in treatment. We have to pay attantion to make right diagnosis and choose right treatment. Wrong treatment of forearm shaft injuries can also have poor results with big loss of functionallity of patients fractured forearm.

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8 Biography

Lenart Andrej Zore was born in Ljubljana, Slovenia in 1991 as the eldest of five children in a family to father physician and mother microbiologist. He finished Diocesan Classical Gymnasium (St. Stanislav Institution) in Ljubljana in 2010. Same year he enrolled into study of business and finance at the Business Sciences School in Ljubljana. His primary wish was to study medicine and after two years of trying to enroll into Ljubljana Medical School in parallel he was accepted into Medical Studies in English at Zagreb Medical School, Croatia in 2012. In 2013 he completed the 1st year of medical school as well as 3rd year of business school symultaneously and gained bachelor of economics degree in 2014 with excellent grade. During the medical studies he started voluntering at the emergency department in Ljubljana clinical hospital mostly on weekends and learnt basic surgical skills and gained his interest in trauma surgery. He is collaborating with Clinical hospital Zagreb and Ljubljana clinical centre trauma departments. In 2016 he was a student intern at Center for Advanced Heart Failure, cardiothoracic surgery at Memorial Hermann health system in Houston, TX, USA for a month. Next year (2017) he did two months of rotation as a student intern at Unfallchirurgie (trauma department) in Aachen clinical hospital in Germany. In 5th and 6th grade of medical studies he was a member of organizing comitee of Zagreb Student Surgical Society where he organized and held many surgical lectures and workshops such as suturing courses, open fracture managment course, laparocopic course, etc.

Lenart loves to perform many outdoor sports. He has been practicing whitewater kayaking since his primary school years. He won several national titles as well as 3rd and 4th place at Junior Whitewater Canoeing World Championship in 2009. He is happy to enjoy the nature no matter if he is skiing, hiking, surfing, jogging or kayaking. Many years he was also a member of Scouts, where he voluntered when natural disasters happened in Slovenia.

Part of his free time he also dedicates to photography, which is his passion and brigs some art into his life. During his highschool years he was photographing for a major Slovenian newspaper covering many cultural and sports events. Ocassionly he also takes some corporate pictures for companies and some weddings.

Lenart is happy to live in time where medical science is improving rapidly and hopes that he could take part in an enthusiastic medical team with research as well as clinical knowledge and forward gained knowledge to younger generations.