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Research Article

Monteggia Fracture-Dislocation: Past and Present

Burnei G[1, 2*], Raducan ID [3, 4], Lala CG[5], Klinaku I[6], Marti TD[3, 7] and Burnei C[8,9]

[1]Macta Clinic, Constanța, Romania

[2]Tinos Clinic, Bucharest, Romania

[3]"Vasile Goldis" Western University of Arad, Arad, Romania

[4]Medical Center ART, Arad, Romania

[5]National Institute of Research and Development in Mechatronics and Measurement Techniques (INCDMTM), Bucharest, Romania

[6]Clinical University Center (Q.K.U.) Prishtina, Prishtina, Kosovo

[7]County University Hospital Arad, Arad, Romania

[8]"Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania

[9]Clinical Emergency Hospital, Bucharest, Romania

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2. Key words

Monteggia-type injuries; Bado classification; The dislocation reduction is everything - Stanciulescu; Walton predictive therapeutic indicators.

1. Abstract

1.1. Background: Monteggia fracture is the oldest medical eponym commonly used today. It was described in the era preceding the introduction of X-rays in medicine, thanks to G. B. Monteggia, an orthopaedist, who was under the rule of clinical sense. Its conceptual individualization, the subsequent studies of Bado, Malgaigne, Stancilescu, Walton and countless other studies have reduced the number of undiagnosed cases and therefore the number and severity of complications.

1.2. Purpose: let us outline the methods for diagnosis, the therapeutic algorithm and complications in various aspects; what has been taken from the past and how to proceed in the present.

1.3. Study Design: it is a synthetic and retrospective statement of fact accumulated from personal medical practice combined with the opinion of other authors.

1.4. Methods: The diagnosis briefly shows the essence of radiological and imaging data and the treatment aims at the therapeutic stages to be completed in the acute phase and the necessary interventions in the chronic phase. The statistics, briefly presented, include 19 patients with acute injuries and 7 with chronic injuries.

1.5. Results: The classical data bases, the standardized therapeutic algorithm and therapeutic options have highlighted the most effective and the safest steps to be taken and the methods of treatment with the best results.

1.6. Conclusions: The best results are obtained by non-surgical treatment done in the first 6 hours after trauma. Currently, the concept of Monteggia-type injuries includes all orthopaedic injuries, not only the traumatic ones, which have in common the luxation of the radial head associated with other diseases located in the forearm: fibrous dysplasia of the ulna, multiple exostoses, etc.

3. History

This traumatic injury is known in the international literature as the Monteggia fracture after the Italian surgeon Giovanni Battista Monteggia (1762 - 1815) as a fracture of the proximal 1/3 of the ulna accompanied by radial head dislocation [1-3]. He initially described this lesion as a proximal ulna fracture and the ventral dislocation of the proximal radius epiphysis in 1814 [4] as the Monteggia type l fracture is now known, after Bado classification [5]. Later, this theory was modified by other authors. Malgaigne reported in 1855 that the ulna fracture at various levels was accompanied by the proximal dislocation of the radius [5, 6] and the idea that Hamilton had enunciated it in 1850 [5, 7]. Following this communication, many authors believed that Monteggia fracture-dislocation was described by Malgaigne, but Bado [8] and many other authors showed that these types of lesions were described by Monteggia.

Monteggia's merit is indisputable all the more as he described this lesion before the radiological era. The highly developed clinical

***Corresponding Author (s):** Burnei Gheorghe Professor, Head of the Department pediatric Orthopaedic Surgery,Macta Clinic, Constant, Romanin, E-mail: mscburnei@yahoo.com*

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sense that many doctors had at that time should be appreciated.

Monteggia fracture remains difficult to diagnose clinically and once left undiagnosed Monteggia-type lesions induce lesions that can evolve into complications, if the treatment is not done initially, in an emergency room [9].

Bado, from Uruguay, classified these fractures in 1967 according to the direction of movement of the radial head and, as a practical utility, he established maneuvers for reduction [8].

The association of ulna fracture with the dislocation of the radial head, as presented by Monteggia, was well studied by Stancilescu (Thesis, Paris, 1880). He pointed out that "reducing dislocation is everything"[4]. The actuality of this quote remains valid today, too.

The stable anatomical reduction of the ulna fracture is the result of the anatomical reduction of the dislocated radial head [10]. In Romania the Monteggia-type injuries are known and recorded in books and articles as the Monteggia-Stanciulescu fracture.

In 1943 Sir Watson-Jonas wrote that "no fracture causes so many problems" "there is no injury with greater difficulty" "no treatment is characterized by a general failure". This critical attitude is unjustified because the accurate diagnosis and appropriate treatment is followed by obtaining excellent results [11].

Some doctors believe that those recorded by Watson-Jonas are a consequence of the fact that the eponym Monteggia had the effect of expressing frustration. I do not know very well the context of the situation but my opinion is different from several points of view.

Since recently, Walton has predicted markers to select Monteggia fracture cases, to be operated, from those to be treated non-surgically [12].

Currently the concept of Monteggia-type injuries includes all orthopedic injuries, not only traumatic ones, which have in common the dislocation of the radial head associated with other diseases located at the level of the forearm: fibrous dysplasia of the ulna, multiple exostoses, etc.

4. Biomechanics

Biomechanically, Monteggia fracture-dislocation occurs through direct impact that acts on the ulnar edge and and causes the fracture of the ulna. If the intensity of the traumatic vector is high and is not blurred, after the fracture, the radial head dislocates. The final lesion can also result in a radius fracture resulting in an lV Bado type fracture. The ulna fracture can be short oblique most commonly, but also transverse and comminuted. The proximal fragment is arranged in flexion under the action of the brachial muscle and the distal one fixed to the radius through the interosseous membrane, follows the radius in its cranial movement, either ventral, dorsal or lateral and overlaps the proximal fragment.

There are also Monteggia-type lesions different from the classical form, ulna fracture and dislocation of the radial head. The ulna fracture can be associated with a Haris-Salter I fracture of the radial head and the radius metaphyseal moves similarly to the radial head [4, 13].

5. Incidence

The highest frequency is found in the age group between 5 and 15 years and has a frequency of 1-1.7% of the total of the forearm fractures. It can be associated with the olecranon dislocation fracture, the radial head fracture, the coronoid process fracture or the terrible elbow triad.

In adults, Monteggia fracture occurs less frequently.

6. Diagnosis

6.1. Anamnestically

The most commonly it is identified with the mechanism of a direct impact on the ulna and less frequently, hyperpronation and hyperextension.

6.2. Clinical

Examination reveals the signs of a fracture: pain, swelling, deformity and functional impotence. Skin continuity solutions appear less frequently: in this case the fracture is treated as an open fracture, according to the Gustillo classification.

Deformation frequently outlines an angulation on the ulna. These symptoms and signs allow the diagnosis of fracture and guide us to the ulna. On an incomplete examination the dislocation may go unnoticed.

Careful examination of the patient may reveal a swelling that extends above the elbow. This suggests that in addition to the ulna fracture, there may be other lesions. First the position of the radial head is explored and then the condyle and epicondyle.

A complete examination establishes that, in the radial fossa, the radial head is not palpated, the epicondyle seems enlarged ventro-dorsally and the condyle is stable and the pain does not amplify on palpation.

Elbow mobility is painful and limited. In ventral dislocation the flexion is considerably limited. Pronation and supination are limited.

6.3. Radiologically

Frontal, profile and oblique images are useful, sometimes required. They should cover the entire forearm overlying and underlying joints.

Warning! Dislocation of the radial head may remain unnoticed although the fracture of the ulna is obvious. Normally, the anatomical axis of the radius passes through the center of the condyle (Figure 1).

Radiologically, the movement of the ulnar fragments and the proximal extremity of the radius is noticed. If the lesion occurs in young children, the ulna fracture may be associated with the

Haris-Salter l fracture, and the femoral head, remaining in contact with the sigmoid fossa is not radiologically identified. The ossification nucleus of the radial head appears between 3 and 6 years, differentiated by sex [14].

The apex of the angled ulnar fracture indicates, in most cases, the direction of movement of the femoral head. When we find the presence of an ulna fracture, in the proximal ½, it is meticulously followed if there is also the dislocation of the radial head. The more proximal the ulna fracture, the greater the likelihood of dislocation. What we are looking for, radiologically:

1. The radial-condylar anatomical axis (radial-capitellum). This axis must pass through the center of the humeral condyle. An eccentric trajectory of the radial axis indicates the dislocation (Figure 2).

The edge of the ulna which is normally rectilinear and overlaps the ulnar cortex. When the ulna is dysplastic, its edge is not rectilinear (Figure 3).

Walton and colleagues propose the analysis of predictive indices that should answer the question when treating non-surgically or surgically the Monteggia lesions [12]. Radial Head Displacement Index (Radial Head Displacement Index RHDI) and Proximity Index (IP) can be determined on radiological images (Figure 4).

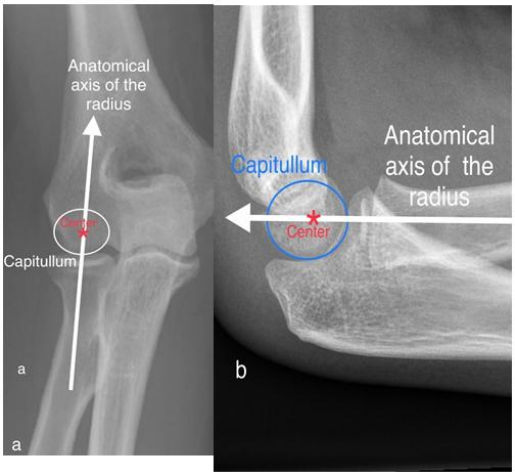

Figure 1: The anatomical axis of the radius intersects the center of the humeral condyle on
a) Frontal radiography of the elbow and on b) Profile radiography

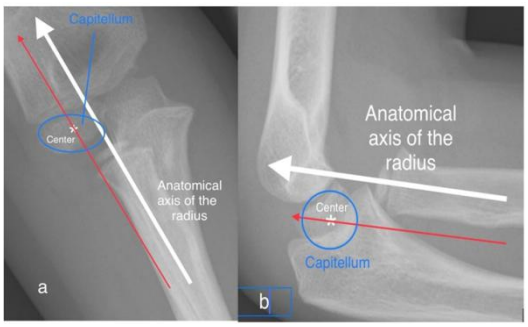

Figure 2: The anatomical axis of the radius passes eccentrically from the center of the condyle.

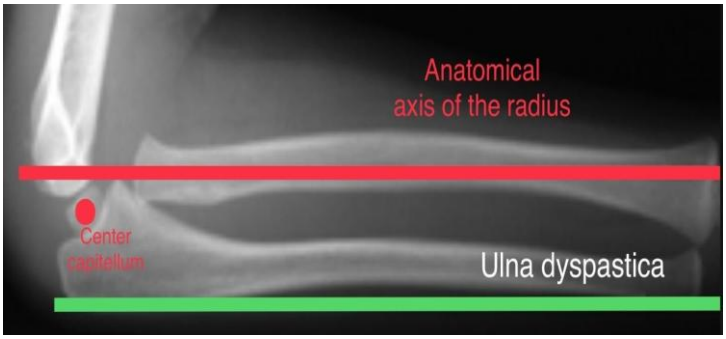

Figure 3: Type I Monteggia lesion. The abnormal configuration of the ulna induces the dislocation of the radial head. The anatomical axis of the ulna does not pass through the center of the condyle. The ulna is dysplastic and the marginal rim is not rectilinear.

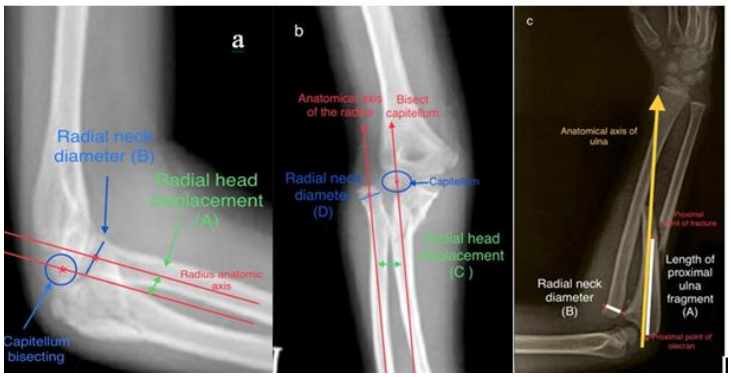

Fig. 4. Walton indices, prognostic therapeutic indices. a) and b) Radial head displacement index (IDCR).
a) The profile incidence of the elbow and
forearm. The distance between the 2 lines (red), the anatomical axis of the radius and the parallel passing through the center of the femoral condyle, measures the movement of the radial head and is denoted by A. B represents the diameter of the radial head.
b) On the profile incidence, the same dimensions are calculated, distance between the 2 lines (red) marked with C and the diameter of the radial head marked with D. IDCR = A/B + C/D/2.
c) Proximity index (IP). The profile image shows the distance between the proximal point of the ulna fracture and the proximal point of the olecranon and is denoted by A. This line represents a
fragment of the anatomical axis of the ulna. The maximum diameter of the radial neck is denoted by
B. IP = A/B.

These 2 indices together with the cominutive
metaphyseal fracture of the radius at any level or the cominutive fracture of the ulna are markers of the instability that recommends the surgical intervention. The same authors claim that the paralysis of the posterior interosseous nerve was predictable by the movement index of the radial head. The presence of 2 or more instability markers is followed by erroneous treatment if no surgical treatment is performed. He expects a new classification that takes into account the degree of stability of Monteggia-type lesions and that makes the prediction of patients who need internal fixation. The study is limited but a systematic, relevant analysis of several authors can be eloquent and can answer the author's questions.

This study shows us that:

- An IDCR (RHDI)> of 45 increases the incidence of

interosseous nerve palsy

- IDCR (RHDI) is not relevant in therapeutic errors
- The incidence of interosseous nerve palsy depends on the direction of movement of the radial head according to the Bado classification.
- Two or more instability factors increase the rate of therapeutic errors: surgical interventions are performed on those with 2 or more instability markers.

CT-scan is useful in complex fractures that also include the fracture of the coronoid, olecranon or radial head.

MRI has a rare indication in lesions assimilated to Monteggia disorders when the individualization of Haris-Salter fractures of the femoral head or the healing of these fractures is sought if the decision of orthopedic reduction is made.

7. Clasification

7.1. The Bado classification is the most complete and the most used classification of the Monteggia fracture-dislocation and has in the foreground the radial component. 4 types of lesions are described, depending on the position of the apex of the ulna fracture and direction of movement of the radial head [8, 15, 16].

Type l: anterior dislocation of the radial head; is the classic fracture-dislocation originally described by Monteggia in 1814. Type l lesions represent 75% of all Monteggia lesions. The ulna fracture may be short oblique, in "greenstick" or the ulna may be dysplastic and its configuration facilitates dislocation of the head. Type l is treated orthopedically and the reduction of the ulnar fracture in this type is the key to success [17].

Type lI: posterior dislocation of the radial head. The diaphyseal fracture is located proximally diaphyseal. It occurs in 10% of cases.

Type lII: lateral dislocation of the radial head and has a frequency of 15%. The ulna fracture is more frequently metallized distal to the coronoid process.

Type lV: anterior dislocation of the radial head and proximal fracture of the ulna and radius. It occurs extremely rarely. Ha describes a Monteggia lV-type lesion that could not be reduced orthopedically and surgery was performed: open reduction of the ulna and fixation and the radial head was stabilized by skin clamping [18].

Jupiter classifies type ll fractures according to the level of the ulnar fracture into 4

7.2. Groups

II a coronoid level

II b the diaphyseal metaphysical junction

ll c distal to coronoid

ll d the fracture extends into the distal half of the ulna

8. Treatment

8.1. Non-surgical treatment

Non-surgical treatment is essential in the treatment of Monteggia fractures. The Stanciulescu concept according to which "reducing dislocation is everything" must be strictly observed. The reduction of the radial head also induces the reduction of the ulnar fracture. The treatment performed in the first 6 hours after trauma ensures the therapeutic success in over 90% of the cases. The prognosis decreases significantly if diagnosis and treatment are delayed.

8.1.1. The Reduction is done under general anaesthesia and gentle manoeuvres are used, which have corresponding radiological images.

- Longitudinal traction with the elbow in extension and the forearm in supination.
- The elbow is slightly flexed with the left hand and with the right hand the elbow is caught and with the right thumb the radial head is palpated and kept under control. At 60 degrees of flexion, the brachial biceps partially relaxes and allows control of the radial head, which is pushed gently down and back, up to a 90-degree flexion when the biceps relaxes completely; under the control of the thumb, the pressure increases and the head enters the joint through the rupture of the capsule. Then the doctor feels that he has lost control of the radial head; sometimes a small click is felt.
- The prono-supination movements facilitate the restoring.
- A moderate pressure on the ulnar fragments completes the reduction.
- the elbow is kept flexed and the stability of the reduction is tested at 90-110 degrees for type l and 60-70 degrees for type II fractures.

8.1.2. The Immobilization is done in a plaster splint with the elbow in flexion and with fluoroscopic verification of the position of the radial head. The plaster must be well molded and ensure a good containment. The forearm will be immobilized in an intermediate position or slightly supination. Complete supination can lead to loss of reduction. Immobilization will be maintained for 4-6 weeks depending on the patient's age. Warning! Regardless of the therapeutic method, non- surgical or surgical, the evaluation of the position of the radial head is made within 7-10 days from the reduction or surgery, preferably 10-12 days, because after 14 days the risk of reluxation is reduced to a minimum. By strictly observing these data we can maximize the effectiveness of non-surgical treatment. Rigorous monitoring reduces the number of complications.

8.2. Surgical Treatment

8.2.1. Dislocation is Irreducible or Unstable: Through the interposition of soft parts. If the orthopedic reduction fails, after

2-3 attempts, surgical treatment is resorted to. First, the humero-radial joint is approached, which is fixed, if necessary, with a wire transcondylarly arranged, with the elbow bent at 90 degrees, to stabilize the radial head and then the ulnar fracture which is fixed with the TEN rod.

8.2.2. Dislocation by Secondary Movement, Under the Plaster Cast: The reduction was insufficient due to the interposition of soft parts. The stability of the reduction must always be checked; instability by interposition, even if fixed with transcondylar wire, leads to subluxation or reluxation. Instability requires open reduction of dislocation for removal of fibrous tissue or reconstruction of the annular ligament and then transcondylar fixation with the wire. In these cases, in the first time, the ulna is refractured or, if callus is formed, an ulna osteotomy is performed and then the dislocation is reduced. The ulna is fixed or re-fixed with an elastic rod.

8.2.3. Undiagnosed dislocation at the initial moment : After the suppression of the plaster, applied for the ulnar fracture, at 4-6 weeks, the deformation of the elbow and the dislocated radial head are found. In the evolution of these cases the lesions are amplified and the flexion and prono- supination movements are limited.

Resection of the radial head is contraindicated in children because in evolution, it develops in the valgus elbow. Ulna fracture associated with Haris-Salter ll radial head fracture is treated surgically because the reduction is always unstable. The fracture of the ulna was stabilized with an elastic rod, the radial head fixed with a wire passed through the condyle-head-neck and the radial shaft.

The vicious consolidation of the fracture leads to a severe complication: subluxated magna- eccentric radial head.

9. Discussions

In children and adolescents the results of treatment are better than in adults. This is due to the remodelling ability, the small angular deformities and the short healing time. Non-operative treatment has a basic indication and is done depending on the type of ulnar fracture [10, 19].

Most patients, 83%, are treated non-surgically with good results. An ulnar angle greater than 36.5 degrees is an important, predictive landmark to ensure stability through surgery. In general, good results and some major complications are obtained [20]. The best results are obtained by non- operative treatment.

Walton et al. [12] shows that posterior interosseous nerve palsy was predictable by IDCR (RHDI). In Waltnon's evaluations it must be taken into account that the radio-condylar axis does not invariably pass through the ⅓ average of the humeral condyle in children with normal elbows. This axis has an abnormal trajectory in 15, 6% of cases. Therefore, this axis is suggestive for radial head dislocation, not pathognomonic [21]. The presence of 2 or more instability markers is followed by an inappropriate treatment, if no surgical treatment is performed. He expects a new classification that takes into account the degree of stability of Monteggia-type lesions and to predict the patients requiring internal fixation.

If orthopaedic reduction is ineffective and the radial head remains irreducible or unstable, open reduction and excision of the interposed tissues is necessary. The intervention is done by Koher or posterior approach. During the surgery, the forearm is positioned in pronation to avoid damage to the posterior interosseous nerve.

Open reduction and reconstruction of the annular ligament are rarely necessary if orthopaedic reduction is practiced in the first 6 hours after trauma.

In the plastic deformities of the ulna and incomplete fractures, "in greenstick", orthopaedic reduction and immobilization in a plaster splint with flexion elbow at 100-110 degrees and forearm in supination, for 4-6 weeks is practiced. If reduction of the dislocation is not possible, an open osteotomy of the ulna is used. Complete fractures require open reduction and internal fixation. Short oblique fractures are stabilized by intramedullary fixation with TEN rod. Long comminutive or oblique fractures are fixed with plates or screws [9].

In cases of old and neglected fractures, reconstructive surgery is performed: sclerotic tissue excision from the radiohumeral joint, proximal ulna osteotomy, reduction of the radial head and reconstruction of the annular ligament.

Late reconstruction of chronic Monteggia-type lesions can be complicated and unpredictable [10]. The best results are obtained in children who have not exceeded 4 years of age from the initial moment and are under 10 years of age [22].

Lengthening of the ulna [23] or shortening of the radius [24] if there is a risk of excessive growth, especially in the case of an old dislocation, these are interventions indicated in cases of chronic Monteggia fractures. Surgical intervention in adolescents with hypertrophied radial head has a poor prognosis because there is no obvious reshaping capacity [25].

Correction of subluxation or dislocation of the radial head by minimally invasive approach to the ulna followed by the implantation of an external fixator provides substantial flexibility to achieve optimal positioning of the ulna. Osteotomy can be fixed with a plate to facilitate efficient operation. This attitude is a safe and effective method to treat Monteggia fracture-dislocation in children who have been diagnosed late [26].

The treatment of chronic disorders in Monteggia fracture remains

controversial in immature skeletal patients. Ulnar osteotomy followed by the application of an Ilizarov mini-fixator is a viable option, which is less invasive than plate fixation. The results can be excellent [27].

Ulnar osteotomy and progressive traction-angulation by unilateral external fixator can obtain satisfactory results in Monteggia fracture-dislocation where the dislocation has gone unnoticed, if a meticulous surgical technique is applied; care must be taken regarding the level of osteotomy and progressive traction-angulation. The flexion-extension arch improved significantly postoperatively and was positively correlated with angulation [28]. Good results can be obtained after open reduction with osteotomy with wedge-shaped opening. Clinical and radiological results appear after 6 months. Radiological results seem better in children under 6 years of age [29].

Radial head subluxation can persist with long-term consequences if these fractures are not treated. After open reduction of the fracture good results can be obtained by open reduction of the ulna and ulnar osteotomy with dorsal wedge-shaped opening.

Additional procedures such as annular ligament reconstruction, trans-condylar passed K- wire and radio-ulnar fixed K-wire increase the stability of the radio-condylar joint if performed after ulnar osteotomy and correction of ulnar deformity [30].

Stable anatomical reduction of ulna fracture is the result of anatomical reduction of dislocated radial head [9, 10].

We treated 19 patients with acute Monteggia-type lesions and 7 with chronic lesions, 6 taken-over from other hospitals, these being initially treated in other hospitals.

Those with acute injuries were between 3 and 16 years old, with the exception of a new-born patient with Silverman syndrome. Follow-up periods in 11 patients ranged from 2 to 7 years. In 9 patients the results were good and excellent and in 2 satisfactory and deficient respectively. In two patients with unstable dislocation, open reduction was used. They had the ascending angle of the radial head (Figure 5) greater than 20 degrees; 3 out of 8 had this angle over 20 degrees and only 2 out of 3 had unstable dislocation. In a case of type III fracture, a 2.5 / 1.5 cm capsular flap was discovered, with the radius insert preserved, which had at the free end a bone fragment of 1.5 / 0.5, a parcel fracture by tearing. In this case, the flap was fixed with a non-absorbable wire passed through the humerus, transosseous; transversal; the bone fragment allowed a well-anchored suture of the flap and the dislocation has stabilized. In the other case, with a type II lesion, an intact annular ligament was highlighted, which was interposed to the reduction and the dislocated femoral head was replaced being passed intraligamentally.

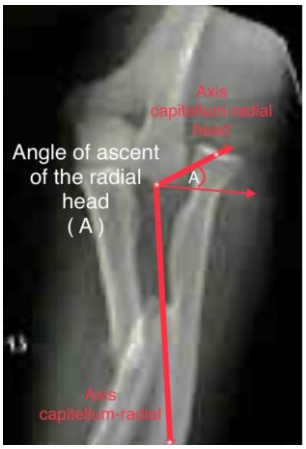

Figure 5: The ascending angle of the radial head (A). The radial condyle-head axis forms an angle perpendicular to the condyle-radius axis, which has consequences for the instability or irreducibility of the dislocation if it is greater than 20 degrees. The radial condyle-head axis joins the most distal point of the condyle with the middle of the radial head diameter and the condyle- radius axis joins the same point with the middle of the distal radial metaphyseal diameter.

In a new-born with Silverman syndrome we recorded a Monteggia-type fracture associated with a Haris-Salter l fracture of the distal extremity of the humerus. The increased degree of instability imposed an open approach and fixation of the humerus fracture with wires; radial head dislocation and ulna fracture decreased. At the age of one year, radiologically, no changes occurred and elbow mobility was normal.

Patients with chronic lesions were treated with a minimally invasive approach followed by implantation of an external fixator. In a group of 4 patients, ulnar osteotomy and progressive traction-angulation were performed on the external fixator. The adjustment of the opening angle was done, in 2 cases, under anaesthesia in order to have the certainty of reducing the dislocation. The results were good and satisfactory. The group of the other 3 patients were treated by lengthening the ulna and reducing the radial head on a traction pin. The results were satisfactory in 2 cases and unsatisfactory in one case.

10. Complications

In the last 20 years, the recognition of the Monteggia fracture has improved and the complication rate has dropped a lot.

Late diagnosis is the most common complication**.**

Radial head re-dislocation. One of the most common complications is radial head re- dislocation that can be predicted and avoided by evaluating the therapeutic indices. Radial head re-dislocation after reduction draws attention to the fact that sometimes they have not been well investigated [31]. Technological progress in radiology and research has helped to better define Monteggia lesions to appear classifications that allow a better therapeutic orientation [9, 28] and therapeutic evaluation indices [12].

The anatomical alignment of the radial head is obtained by osteotomy of the ulna and its open reduction.

Interosseous nerve palsy or radial nerve palsy in cases where the displacement of the radial head is ventral and occurs in 10% of cases. Patients are kept under observation. No exploration required**.**

Paralysis usually subsides spontaneously. If after 2-3 months, the spontaneous resolution does not occur, investigations are made and it is treated.

Pseudarthrosis of the ulnar fracture occurs especially in cases where surgery is needed on the ulna.

Radiohumeral ankylosis and radioulnar synostosis are formidable complications present in neglected cases and which remain untreated.

Ossifying myositis occurs in neglected cases for long periods of time.

The subluxated magna-eccentric radial head (Figure 6) is a severe complication induced by the vicious consolidation, in lag, of a Haris-Salter l fracture within a Monteggia lesion complex ulna fracture and dislocation of the proximal radius extremity after Haris -Salter l fracture.

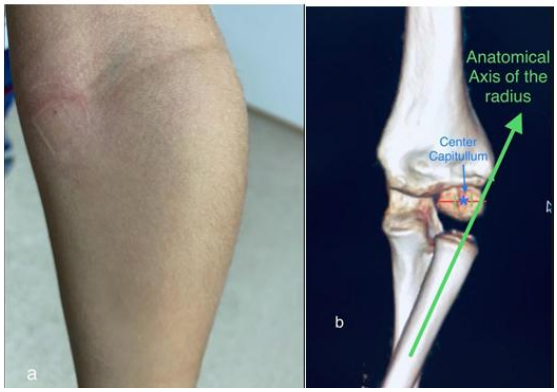

Figure 6: Radial head subluxated magna-eccentric in an 8-year-old child. At the age of 4 he presented a Monteggia-type fracture; proximal ulna fracture with Haris-Salter detachment fracture l radial head and dislocation of the proximal extremity of the radius. After orthopedic treatment, the radius strengthened viciously
a). The width of the elbow is much increased and
b). the anatomical axis of the radius does not pass through the center of the radial head. The axis of the radius intersects the ulna in maximum supination.

11. Conclusions

The essential motto in the treatment of fracture-dislocation Monteggia remains early diagnosis and non-surgical treatment. The best results are obtained by non-surgical treatment done in the first 6 hours after trauma. In cases presented late and in chronic lesions, good results are obtained by reconstructive surgery. External fixators are effective and must be used rigorously.

The treatment considers three major desideratums: the reduction and stability of the dislocation, the correction of the ulna fracture and the minimization of the forces that can determine the recurrence of the dislocation.

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