EVALUATION OF ORTHOPEDIC TREATMENT IN COMPARISON WITH SURGICAL TREATMENT IN SUPRACONDYLAR FRACTURES OF HUMERUS AT CHILDREN'S - summary

The elbow is a complex joint essential to the functionality of the upper limb, as it serves as a mechanical link between the arm and forearm, controlling the range of extension and position of the hand in space, as well as a support point for the forearm.

Elbow fractures are common and varied in the pediatric emergency room and can be difficult to diagnose because of their subtlety and the ever-changing anatomic features of the immature skeleton. The diagnosis and treatment of elbow fractures in children can be challenging. Familiarity with the anatomy of the elbow, which includes the secondary ossification centers unique to children, is necessary for an accurate diagnosis of elbow injuries.

The normal range of motion is from 0 degrees to 145 degrees in flexion-extension, 85 degrees in supination, and 80 degrees in pronation.

To be able to perform everyday activities, it is necessary to have a minimum range of motion in flexion-extension from 30 degrees to 130 degrees, as well as 50 degrees for supination and pronation (total range of at least 100 degrees of pronation- supination).

Therefore, an alteration of any of these parameters can lead to loss of joint function.

* In order to understand the biomechanics and function of the elbow joint, as well as the pathologies resulting from the damage to any of its parts (or all), it is necessary to know

in detail the anatomy of each structure that composes it, both bony and soft tissues (capsulo-ligamentous and tendinous).

The function of the elbow joint is to regulate the position of the hand by approach or retraction, this is the role of flexion-extension, and to orient the hand, this is the role of pronation-supination.

* The elbow consists of three anatomically different joints, united by a single joint capsule. This common complex includes:

- The humero-ulnar joint, the most important joint, ensures and controls flexion and extension movements. It consists of the humeral trochlea and the articular surface of the olecranon.
- Humero-radial joint: it is condylar and plays an accessory role in flexion and extension movements. It consists of the humeral capitulum and the radial head.
- The proximal radioulnar joint is a pivot-type uniaxial trochoid joint, and together with the lower radioulnar joint, forms the pronation and supination complex.

Any morphological change in one of the three component joints of the joint complex can affect the overall function of the elbow.

* The elbow joint is also called the humero-radio-ulnar joint, it is a congruent and stable joint. Passive and active stabilizers ensure biomechanical stability in the elbow joint.

Passive stability results from both the congruent articulation between the humerus and ulna and the tensioning of the soft tissues.

Active stability is due to joint compression forces caused by muscles.

* The flexion-extension movements are performed at the level of the humero-ulnar joint and the pronation-supination movements at the level of the upper radioulnar joint coupled with the lower radioulnar joint.

-> Flexion has an amplitude that varies between 140° and 160°. It is limited by the bearing of the coronoid in the lower part of the coronoid fossa and the tension of the posterior bundles of the lateral ligaments.

-> Full extension is evaluated at 0. In this position, the antebrachial segment is directed outwards relative to the brachial segment: this is the physiological valgus of the ulna, which varies between 3° and 29° and is classically more pronounced in women.

-> The lateral movements have a very small amplitude, of 2° to 5°, due to the blocking of the ligaments, the shape of the articular surfaces and the obstacle represented by the ulna.

-> Prono-supination is the rotation of the forearm around a longitudinal axis.

* Pediatric bone can absorb more energy before failing compared to adult bone due to its porosity.

Speaking relative to time, the force applied slowly to the bones of the forearm initially bends the bone to its elastic limit and can lead to traumatic buckling, i.e. plastic deformation. When the amount of applied force is increased, it can cause a greenwood fracture that lies between plastic deformation and complete fractures and is seen on radiographs as a tear in one, two, or three corticals with preservation of some bony continuity.

In addition to the problems common to all long bone fractures, diaphyseal fractures of the radius and ulna present specific problems. In addition to regaining length, apposition, and axial alignment, achieving normal rotational alignment is necessary if good range of pronation and supination is to be restored.

Supination and pronation movements of the forearm involve a rotational movement about a vertical axis at the proximal and distal radioulnar joints. The axis of this rotational movement passes through the head of the radius and through the attachment of the apex of the triangular articular disc. During pronation, the entire radius moves around the ulna through the longitudinal axis of the forearm.

Pronation is performed by the pronator teres and pronator quadratus, and supination is performed by the biceps brachii and supinator. Supination is the stronger of the two movements, due to the strength of the biceps muscle. Maintaining interosseous space is essential for pronation and supination.

The biceps and supinator exert rotational forces on fractures of the proximal third of the radius. Distally, the pronator teres at the mid-axis and the pronator quadratus at the distal quarter of the radius axis exert both rotational and angular forces. Fractures of the distal radius tend to tilt toward the ulna through the action of the pronator quadratus and the pull of the longus anterior muscles. Rotational deformity will limit radioulnar motion.

* There are several classifications of supracondylar fractures. These are based on the type and extent of displacement. Also, they depend on the production mechanism.

In the French literature, the classification used for FSC in extension is that of the 1962 report of LagAmplitude of variation and Rigault, which takes into account frontal and profile radiographs. This allows the stability after reduction to be predicted:

- Stage 1: Only the anterior cortex and the periosteum are affected. There is no displacement. The fracture is stable.

- Stage 2: Both cortices are involved with a small displacement, often posterior; the intact posterior periosteum allows stability of the fracture in flexion.

- Stage 3: Displacement is significant, periosteal stripping is anterior and medial. The fracture is quite unstable after reduction.

- Stage 4: there is no contact between the bone fragments, the posterior periosteum is not always completely broken, often detached from the height of the humerus. The reduced fracture is unstable.

- Stage 5: this stage includes rare diaphyseal fractures.

In Anglo-Saxon literature, there is a classification into 3 groups. This is Gartland's classification, taken over and modified by Wilkins, who also insists on the anatomical structures affected and proposes possible surgical approaches:

Type I. Fracture without displacement.

Type II. Displaced fracture in one plane, with angulation but no translation between fragments. The posterior cortex remains intact.

Type III. Major displacement fracture – in two or three planes. There is no contact between fragments. Depending on the direction of translation, two subgroups are distinguished:

Postero-internal and Postero-external.

Type IV. Fracture with complete periosteal disruption, unstable in flexion and extension. Usually diagnosed under anesthesia during surgery.

* The most common fracture mechanisms of the elbow are hyperextension, which is associated with a supracondylar fracture of varying degrees of complexity and extreme valgus, leading to dislocation or fracture of the radial head, with or without involvement of the olecranon, and if the force involves the humerus, it can damage the lateral or medial epicondyles.

* Supracondylar fractures of the humerus are the most common injuries in children. It represents for approximately 16% of all pediatric fractures and over 60% of elbow fractures in children. It usually requires early treatment to avoid complications, so routine surgical management is recommended for any type of displaced fracture.

* The time elapsed between the traumatic event and the moment of the surgical intervention is also very important, observing a causality between complications and delays over 24 hours.

* In addition to the classic classifications of supracondylar fractures of humerus, we also have anatomopathological varieties, which include:

◊ Extra-articular fractures and

◊ Intra-articular fractures

- Fractures of the olecranon and

- Fractures of the radial head.

1- Fractures of the humeral blade

a- Extra-articular fractures

a 1- Supracondylar fractures

They account for more than 50% of elbow fractures and are usually seen by age 8.

◊ Mechanism: a distinction is made between:

Extension fracture (95%), resulting from a fall on the hand, the elbow in hyper-extension; the blade moves back.

Flexion fracture (5%) as a result of a direct impact on the bent elbow; blade displacement is anterior.

◊ Fracture line

In most cases (85%), it transversely crosses the fragile portion of the blade in its middle part, above the growth cartilage.

In the frontal plane, it is concave in the upper part. In profile, it is obliquely down and forward.

◊ Displacement

Elementary displacements in supracondylar fractures determine the therapeutic attitude. There are 4 types of movement that can be isolated or combined:

Tilt: is a displacement in the sagittal plane around a transverse axis. It is posterior in 97.5% of cases.

Displacement or rotation: Occurs around the humeral diaphyseal axis with, most often, a backward displacement of the medial spine of the blade.

Lateral angulation: occurs in the frontal plane around an anterior-posterior axis. A distinction is made between:

√ Varus: deviates the vertical axis of the epiphysis medially from the diaphyseal axis.

√ Valgus: deviates it outwards.

Translation: mass displacement of the epiphysis without deviation of its axes. It can be internal or external, anterior or posterior.

-> Evaluation of neurological damage should be done carefully in children. It should be documented by recording the onset, degree and possible progression of neurological damage. The specialized literature states that the most frequent nerve injury associated with supracondylar fracture (by hyperextension) is the anterior interosseous nerve (IA) (43), a

branch of the median nerve, the radial nerve being the second most frequent. In flexion fractures, the ulnar nerve is most commonly affected.

-> Between 10 and 20% of patients with supracondylar fractures present with peripheral pulse deficiency, but after reduction and immobilization or osteosynthesis, normal circulation is usually restored.

-> A 2008 study noted that the incidence of traumatic and iatrogenic nerve injury in supracondylar fractures of the distal humerus was recorded as 12-20% and 2-6%, respectively. The median nerve, particularly the anterior interosseous nerve, was found for 52% of injuries and the radial nerve for 32% of injuries. The literature also states that almost all cases of nerve palsy usually resolve spontaneously within about 2.5 months of trauma but may take up to 6 months.

-> Infections of the fracture site and the operative wound are always a possible complication when we talk about patients with supracondylar fractures of the distal humerus. The reported frequency of infection ranges from 3.6 to 77.0%.

-> This variability in the incidence of infections could be related to the patient's living conditions, the type of pins used, the use of preoperative antibiotic therapy, protocols for caring for surgical wounds, and the duration of retention of pins in the fracture site until extraction.

-> The compartment syndrome rate varies between 0.1% and 0.3% in supracondylar fractures in children. The incidence is higher with increasing complexity and displacement of the fracture. (e.g., Floating elbow). Therefore, children who require immobilization in the emergency department or postoperatively will be placed with the elbow flexed up to 90° or less. If compartment syndrome is diagnosed more than 6 hours after onset, the progression is towards ischemic contracture: the elbow in flexion, the forearm in pronation, the fist in flexion, and the thumb in adduction with MCP joints in extension and PIP in flexion.

-> According to Oetegen, due to the gradual ossification of the distal humerus, younger patients with a higher percentage of cartilaginous tissue may have less stable fixation with percutaneously inserted pins, leading to subsequent loss of fracture reduction. However, the age limit at which the risk decreases could not be determined, but it has been observed that the majority of secondary displacements occurred in children under 8 years old. Additionally, a significant increase in the risk of displacement has been documented among type III fractures compared to type II (4% versus 0.3%).

-> Another possible cause of secondary displacement is represented by inadequate pin placement technique or insufficient fracture reduction. Common errors include failure to secure bone fragments with at least two bicortical pins and a too small distance between the two pins at the fracture site - at least 2mm in two different planes.

-> Cubitus varus is the most common long-term complication of supracondylar humerus fractures and requires extensive corrective approaches. Modern surgical techniques

(e.g., closed reduction with percutaneous fixation) have reduced the frequency of cubitus varus from 58% to approximately 3% in children with supracondylar fractures.

-> Ossifying myositis is a rare complication of supracondylar fractures. These ossifying changes can impair elbow functionality, leading to stiffness.

-> Decreased range of motion or stiffness is one of the complications of supracondylar fractures. Restoring the normal functional range of motion of the elbow joint is a very important treatment goal. Elbow joint mobility is gradually restored, reaching 93% within the first 6 months and increasing to 98% within the first year.

Epidemiological characteristics

The aim of the research topic is to improve the outcome and prognosis of supracondylar humeral fractures by selecting the best therapeutic option to ensure the best possible elbow joint functionality.

We conducted an observational, prospective study of pediatric patients consulted, diagnosed and treated for supracondylar humerus fractures from January 2017 to December 2022 at the County Emergency Clinical Hospital of Constanta.

The study group consisted of 164 patients, with both socio-demographic characteristics and aspects related to the medical history, fracture evaluation, treatment modalities and subsequent evolution being evaluated.

Data were recorded in patient observation sheets and where applicable, in operative protocols, which were subsequently used for this research.

For statistical analysis, we used specific methods for descriptive statistical analysis, describing the number of cases, average value, standard median deviation , minimum and maximum values and range of variation. For categorical variables, these were presented as the number of cases and percentages.

For analyzing the relationships between variables, we used the Chi-square test (and where conditions were not met, likelihood ratio) to test the statistical significance of the association between two variables. For comparing two continuous numerical variables, we used the t-test, and in the case of comparing more than two variables, we used the ANOVA test. If the ANOVA test was statistically significant, it was followed by a post-hoc analysis, for which Bonferroni correction was used to determine statistical significance. Considering the significant number of cases, we considered the distribution of cases to be normal. For conducting the analyses and creating the graphics, we used Microsoft Excel and IBM SPSS Statistics version 27.

The threshold to consider a statistically significant test was set at $p < 0.05$.

During the study period, 164 fractures that met the inclusion criteria were identified. The study spanned six years, including cases from 2017 to 2022. Pathological bone fractures and iterative fractures were excluded from the study.

- Throughout this period, a constant increase in the number of cases was observed, with the fewest cases observed in 2017-2018 (14%) and the most in 2022 (21.3%). These data are somewhat unexpected, considering the pandemic period of 2020-2021, where expectations would have been for the number of incidents to be lower due to national health protection measures.

- Regarding the annual periodicity, it was noted that there is a presence, with a higher proportion of cases seen in the summer months. The fewest cases were treated in the winter months compared to radius fractures.

- Patients included in the study ranged in age from 1 to 15 years. The average age of patients was 7.08 years (median 7 years), with variability assessed by the standard deviation of 3.125 years.

- In terms of age distribution, children aged 4 to 10 years were the most predisposed, accounting for over two-thirds of cases, with the peak in the 8-10 age group.

* Analyzing the age of patients according to the year they were treated indicates differences, with the average age ranging from 6.13 years (2018) to 8.04 years (2019).

We analyzed the data to determine if there were statistically significant differences between years in terms of patient age. The result of the ANOVA test was not statistically significant ($p = 0.362$), so this is indicating that the observed variation between years is not statistically significant.

* In terms of patient sex, almost two-thirds of the patients were male (63%).

* The average age for males was 7.64 years, with a standard deviation of 3.41 years, while for females, the average age was 6.13 years, with a standard deviation of 2.29 years. Regarding the maximum age, it was found that the maximum age for female patients was 11 years, while for male patients, it was 15 years. Thus, there is a trend that male patients included in the study tend to be older than female patients.

* The T-test is statistically significant ($p = 0.001$), indicating that the observed differences between the two sexes in terms of age are statistically significant. The average age difference is 1.51 years, with a 95% confidence interval ranging from 0.62 to 2.39 years.

* Approximately two-thirds of the patients (66%) came from urban areas. Analyzing the data in the context of Constanta County, it indicates a higher percentage of patients from urban areas. This aspect is explained by the population distribution in the county, where, according to the most recent data, approximately 80% of residents live in urban areas.

* Analyzing the data over the years, significant differences in sex proportions were observed. These differences varied from year to year. Specifically, in 2022, 2019, and 2018, a significantly higher presence of male patients was observed, with percentages of 68.6%, 76%, and 73.9%, respectively. In 2021 and 2017, the proportions were approximately equal, with a slight predominance of male patients (54.8% and 56.5%, respectively). In 2020, which coincided with the period of movement restrictions imposed by the COVID-19 pandemic, an increase in the percentage of female patients was observed, reaching 51.9%.

To investigate whether there is an association between study years and the sex distribution of patients, a Chi-square test was conducted. The obtained result did not indicate statistical significance ($p = 0.2$), suggesting that there is no significant correlation between study years and the sex distribution of patients.

* In terms of distribution based on the patient's origin environment, two distinct stages can be distinguished. The period from 2017 to 2019, where the proportion of patients from urban areas ranged from 74% to 78%, and the period from 2020 to 2022, where the percentage of patients from urban areas significantly decreased, being at a minimum of 48.1% in 2020 and a maximum of 64.5% in 2021. These two identified periods can also be associated with the pre-pandemic and pandemic periods.

The Chi-square test applied to assess the statistical significance of the association between the year and the proportion based on the origin environment has a non-statistically significant result ($p = 0.17$), indicating no association between the two variables.

When patients are grouped into the two periods, namely Pre-pandemic and Pandemic (2017-2019 and 2020-2022, respectively), their distribution indicates a predominance of patients from rural areas included in the study during the pandemic period. It can be concluded that during the pandemic period, there was a significant increase in the proportion of patients originating from rural areas.

Values related to medical-surgical aspects:

* During the study period, it was found that fractures of the right upper limb predominated, accounting for nearly 60% of the total.

* The majority of cases (157 out of 164) presented with closed fractures, accounting for approximately 96% of cases.

* The seven open fractures were examined and evaluated using the Gustilo-Anderson classification. Thus, in three cases (42.9%), they were classified as "Type 1". Injuries classified as "Type 2" and "Type 3A" were encountered twice each.

* In the majority of cases, fractures occurred through arm extension (151 cases, representing approximately 92%), with the remaining cases being caused by flexion trauma.

* Most often, the mechanism of injury involved falling from the same level, observed in 106 cases, representing approximately 65%. Falls from a different level accounted for approximately one-third of cases (34%), with two cases where the mechanism of injury was crush injury and road traffic accidents.

* To assess the degree of association between the mechanism of injury and the type of trauma, a contingency table was constructed. In cases where the mechanism of injury was crush injury or road traffic accidents, the type of trauma in both situations was extension. In extension trauma cases, two-thirds of cases involved falling from the same level. In cases of flexion trauma, 44.2% occurred from the same level. Falling from a different level was identified in 32.5% of cases where the type of trauma was extension, while in flexion cases, it was 53.8%. This reveals a disproportion, with falls from the same level being more common in extension traumas, while falls from a different level are more common in flexion traumas.

* Following the evaluation, the presence of local complications was identified in approximately 18% of cases. The main complications were post-traumatic hematoma and edema in the elbow region.

* Some cases also presented associated bone injuries. Besides the main diagnosis of supracondylar fracture of the humerus, six additional cases were identified: three cases (1.8%) with radial head fractures, one case of medial epicondyle fracture, and two olecranon fractures. These injuries are important in therapeutic management.

* For the majority of cases, two-view X-ray imaging was sufficient for diagnosis. However, approximately 5% of cases required a CT with 3D reconstruction for accurate diagnosis of the lesions, degree of comminution and rotation of bone fragments.

* Nerve complications were identified in 11 cases, representing a cumulative 6.7% of encountered situations. Nerve complications consisted of radial nerve injury (5 cases, 3%) and ulnar nerve injury (6 cases, 3.7%). All nerve complications were identified at the time of presentation in the emergency room and reported in the observation sheet.

* From the perspective of vascular complications, these were identified in four patients (2.4%). We observed a higher incidence of brachial artery compression in flexion traumas compared to extension traumas.

* Furthermore, we assessed the degree of association between vascular and nerve complications. The result indicated that in none of the analyzed cases were there associations between the two types of injuries. Thus, there were no cases where both vascular and nerve complications coexisted. Vascular-nerve impairments were resolved upon fracture reduction, and no residual lesions developed.

* Depending on the type of trauma, we noticed that in flexion cases, the percentage of nerve injuries (both radial and ulnar nerves) was statistically significantly higher.

Aspects related to intervention and its outcomes:

- Upon evaluating the cases, three types of treatments were identified, tailored specifically to each case. Thus, 14% of patients were treated conservatively, 36% required orthopedic reduction maneuvers, and surgical reduction methods were necessary in approximately half of the cases.

- Orthopedic reduction was performed upon admission, with almost all patients undergoing this procedure requiring only one day of hospitalization, except for two cases, which required two and four days of hospitalization, respectively.

- Among the 81 patients treated with surgical reduction and osteosynthesis of the fracture, the average number of hospitalization days was 5.19, with a standard deviation of 0.89 days. The hospitalization duration ranged from a minimum of four to a maximum of eight days.

- Analyzing the distribution of cases, it is observed that the majority were hospitalized for five days (approximately 38%), followed by those with six days of hospitalization (32%), and patients hospitalized for four days (25%). The percentage of those with a hospitalization period longer than six days, respectively seven or eight days, is less than 5%. The duration of hospitalization is in line with the severity of the fracture, with surgically treated patients having a longer hospital stay.

* The most commonly used osteosynthesis material was Kirschner wires, utilized in over 96% of cases. There were three patients in whom the surgical intervention was performed through a posterior approach to the elbow with olecranon osteotomy and anatomical locking plate fixation, with one case using the anatomical locking plate on the lateral column and two cases using the anatomical locking plate on both columns.

* Descriptive statistical analysis for the timing of surgical intervention indicated an average duration of 2.8 days, with a standard deviation of 0.64 days. From a distribution

standpoint, in the majority of cases, surgical intervention occurred on the third day, representing over half of all cases treated by surgical reduction and osteosynthesis.

* The duration of hospitalization was significantly shorter when using the surgical technique involving Kirschner wires, with an average of 5.1 days and a standard deviation of 0.8 days. However, it should be noted that due to the very small number of cases using other surgical techniques (three cases in total), comparisons cannot be made to evaluate the statistical significance of differences observed between various surgical techniques.

* An important aspect in patient management is the duration of hospitalization. Thus, we evaluated how the timing of intervention influences the length of hospital stay. Surgical interventions were delayed for 3-4 days until local complications remitted.

* Depending on the type of surgical procedure, it can be observed that approximately one-third of cases (37%) were approached using the closed reduction technique, while the remaining approximately 63% were treated through an open reduction procedure.

* For closed reduction interventions, the average duration of hospitalization was significantly shorter, at 4.5 ± 0.68 days, compared to open reduction surgeries, where the average duration of hospitalization was 5.59 ± 0.75 days. For closed reduction, the hospitalization duration ranged from four to six days, with a median of four days, whereas for open reduction intervention, it varied from 4 to 8 days, with a median of six days.

* The observed differences are statistically significant, determined by applying the T-test, with a significance level of $p < 0.001$, showing an average difference of 1.08 days (with a 95% confidence interval of the difference ranging from 0.75 to 1.42 days).

* General anesthesia with oro-tracheal intubation (OTI) was the preferred method, used in over half of the cases. The second most commonly used method was loco-regional anesthesia of the brachial plexus under ultrasound guidance, utilized in 42% of cases. The least frequently used method of anesthesia induction was intravenous (IV) general anesthesia, used in just over 6% of cases.

* We analyzed how certain types of anesthesia are associated with the type of fracture. Regardless of the type of surgical intervention, we found no differences regarding the type of anesthesia used.

* Regarding the surgical approach, the majority of cases were resolved through a lateral and medial approach (60.5%), or through a lateral approach only (35.8%). For three cases (3.7%), the approach was posterior.

* Comparing the lateral approach with the lateral and medial approach, differences in the distribution of cases can be observed, with loco-regional anesthesia being more frequently used in the lateral approach, while OTI general anesthesia was more commonly used in the lateral and medial approach. For all three cases with a posterior approach, OTI general anesthesia was used.

* The observed differences were not statistically significant enough, with $p = 0.109$.

* From the total fractures included in this study, the majority could be classified as Grade II in the Gartland-Wilkins classification, representing approximately 37% of cases. A similarly high percentage was observed for fractures classified as Grade IV (32%). Grade III and Grade I fractures were encountered in 18% and 14% respectively.

* Analyzing how fractures were treated based on the Gartland-Wilkins classification, a strict adherence to therapeutic protocols is evident. Grade I fractures were entirely treated conservatively through cast immobilization, Grade II fractures were entirely treated through orthopedic reduction, and Grade III and Grade IV fractures were entirely treated through surgical reduction.

* We further evaluated the relationship between the Gartland-Wilkins classification and the length of hospitalization. For patients with type I fractures, as the treatment was strictly conservative, hospitalization was not necessary. In the case of type II fractures, they were also not included in the calculation as they were completely resolved through orthopedic reduction, which required one day of hospitalization (emergency admissions were made for orthopedic reduction). The average duration for type III fractures was 4.45 ± 0.63 days, while for patients with type IV fractures, the average duration of hospitalization was over a day longer, specifically 5.6 ± 0.75 days. The observed differences are statistically significant, with p calculated through the t-test being less than 0.001, with a mean difference of 1.15 days and a 95% confidence interval of the difference ranging between 0.821 and 1.475 days.

* For Gartland type III fractures, the majority of them (all except one case) were surgically resolved via closed reduction. In the case of patients with Gartland type IV fractures, the majority of cases (except for two cases) were resolved through surgical intervention via open reduction. The Chi-square test result is statistically significant, with $p < 0.001$.

* The approach type is significantly influenced by the Gartland-Wilkins classification. Thus, for type III fractures, the majority had a lateral surgical approach, while for type IV fractures, in most cases, both lateral and medial approaches were preferred. The differences are statistically significant ($p < 0.001$).

Evolution Tracking

* The average immobilization period was 3.45 weeks, with a standard deviation of 0.51 weeks, with immobilization periods ranging from three to six weeks. Most cases, more than half, were immobilized for a period of three weeks. Cases immobilized for a period of four weeks followed in frequency. Only one case out of a total of 164 was identified with a duration of five weeks.

* The shortest immobilization period was observed in conservatively treated patients, with a duration of three weeks in all analyzed cases. Orthopedic reduction required fewer weeks of immobilization (3.13 ± 0.34 weeks) compared to patients requiring surgical reduction, for whom the average number of weeks was higher, specifically 3.8 ± 0.43 weeks.

* In the case of patients treated with surgical reduction, we compared hospitalization durations based on Gartland-Wilkins type III or type IV. We found that patients with type IV required a longer immobilization period. The result is statistically significant, $p < 0.001$. To determine the existence of differences between the various Gartland-Wilkins Grades, we also conducted a Post-Hoc analysis, applying the Bonferroni correction. In addition to the statistically significant expected differences, between type I and types III and IV, respectively, and between type II and types III and IV, it was of interest to evaluate the difference between patients with type III and patients with type IV fractures. Thus, for this situation, the result is statistically significant ($p=0.005$), with a mean difference of 0.349 weeks and a 95% confidence interval ranging between 0.08 and 0.62 weeks.

* The average duration of maintaining osteosynthesis material was 3.88 weeks with a standard deviation of 0.45 weeks. Most cases had the osteosynthesis material maintained for a period of 4 weeks (over 78%). There was a percentage of 16.7% for which the maintenance of the osteosynthesis material lasted three weeks, and a number of 4 cases, representing 5.1%, for which the osteosynthesis material was maintained for a period of five weeks.

* Depending on the type of focus, the average duration of maintaining osteosynthesis material varied, from 3.77 ± 0.5 weeks in the case of closed focus usage to 3.96 ± 0.41 weeks in the case of open focus. The differences are not statistically significant ($p=0.08$).

* The majority of cases, almost 90%, did not present postoperative complications. There were a total of 8 postoperative complications, of which 5 cases (6.5% of the total) presented cutaneous septic complications.

* We further analyzed how postoperative complications are associated with the Gartland-Wilkins Classification. Out of the total cutaneous septic complications, 60% were encountered in type III patients. For the other types of complications, represented by 3 cases, two were diagnosed in type IV patients. The results are not statistically significant and not similar to the literature due to the fact that in specialized works the frequency of complications is higher in type IV fractures that required open focus treatment.

* Regarding surgical approach and the occurrence of postoperative complications, existing data were only available for the lateral approach and lateral and medial approaches. For the three cases where the surgical approach was posterior, no postoperative complications were reported. Thus, in the case of the lateral approach, complications were not reported in 82% of cases. In the case of the lateral and medial approach, the percentage of interventions without postoperative complications was 93.6%. After applying the Chi-square test, we found

that the observed differences are not statistically significant (p=0.173), thus, the occurrence of postoperative complications was not associated with the type of surgical approach used.

* Postoperative complications were diagnosed in total for approximately 17% of patients who underwent closed focus interventions, while for those undergoing surgical interventions on an open focus, the percentage of those with postoperative complications was lower, around 6.5%.

* Distant complications were observed in five patients treated surgically. These included cubitus varus and joint stiffness.

* For a total of 11 cases, the displacement of the fracture focus after orthopedic reduction was evaluated. The result indicated that for eight cases, representing 63.6%, secondary displacement was identified. Surgical intervention after orthopedic reduction was performed for four patients (approximately 37% of those specifically evaluated for post-orthopedic reduction displacements).

* A statistically significant higher percentage of patients requiring surgical re-intervention was observed in those with type IV fractures. In ten patients, due to relatively satisfactory osteosynthesis and focus instability, a reintervention was necessary to achieve a firm and stable reduction.

* Throughout the evolution, all patients were clinically and radiologically evaluated at seven days post-treatment, regardless of the type of treatment (conservative, orthopedic reduction, surgical reduction), followed by clinical and radiological evaluation at approximately one month.

* It was noted that at the two-month evaluation, not all patients were compliant, with approximately 96% of them attending the evaluation. During this assessment, approximately 12% of patients exhibited joint stiffness, and approximately one in ten patients had extension deficits.

* We analyzed how the type of treatment influenced the issues identified at the two-month evaluation. Consequently, it was found that in cases of conservative treatment, as observed in previous analyses for patients with type I supracondylar humerus fractures (Gartland-Wilkins classification), there were no identified issues in their recovery, with all patients progressing without identified problems.

For patients with orthopedic reduction, treatment exclusively performed on type II fractures, the identified issues were minimal, with one patient showing joint stiffness and two patients showing extension deficits. Together, they represented approximately 5% of all patients treated through orthopedic reduction procedures.

In cases of surgical reductions, where fractures were classified as type III and IV, the percentage of those with identified issues was significantly higher, reaching approximately 40% of cases, with approximately 21% experiencing joint stiffness and 17.5% having extension deficits.

Thus, considering the observed values, it is evident that as the severity of the fracture increases, the number of potential issues that may arise in recovery also increases. The obtained result is statistically significant ($p<0.001$).

* Clinical evaluation at six months was performed on nine patients, with the remaining patients lost to follow-up, failing to attend the scheduled appointments.

* From the studied group, three cases of type IV supracondylar fractures were identified, occurring 2 and 3 years ago, surgically reduced and stabilized with K-wires. Subsequent checks revealed elbow deformation with varus deviation. Patients are scheduled for CT examination with 3D reconstruction to establish further therapeutic strategies.

* Approximately half of the patients (50.6%) underwent medical rehabilitation. Comparing the data, it is noted that with conservative treatment, approximately a quarter of patients participated in medical rehabilitation programs. For patients undergoing orthopedic reduction, the participation rate in rehabilitation programs was 50%, while for those treated with surgical reduction, the participation rate was the highest, reaching 58%.

The observed differences are statistically significant, $p=0.026$, indicating a higher participation rate in medical rehabilitation programs with increasing fracture severity and the use of more complex treatment methods.

DISCUSSION

The number of supracondylar humerus fractures is continuously increasing from year to year. Even during the Covid-19 period, we report increasing values contrary to the protective measures, which contradicts international statistics. The spring and summer months have a high proportion of elbow injuries compared to winter months due to school and preschool activities, weather conditions, and social environment. Our patient cohorts confirm what the specialized literature supports.

The average age of study participants is 7.08, which is natural given musculoskeletal development, ligament laxity, and elbow recurvatum. This age is one of maximum flexibility and hyperextension of the elbow.

In our study cohort, this type of fracture predominated in males, with the maximum age in females being 11 years and in males being 15 years. From a statistical point of view, the right upper limb was affected in 60% of cases, compared to the left, which was affected in 40%.

Although they have a low rate in elbow traumatic pathology, open fractures deserve special attention in the treatment algorithm. The Gustilo-Anderson classification is used as a basis in the development of medical-surgical treatment. Vascular-nerve lesions were not identified in these cases.

We emphasize that each subject diagnosed with an open fracture received antibiotic therapy initiated upon admission to the medical center, as well as the administration of ATPA (anti-tetanus passive immunization). This element cannot be excluded from the optimized therapeutic protocol.

The fracture focus was stabilized by both medial and lateral pinning, taking into account the evolving risks of the fracture, within the first 8 hours of admission, thus adhering to specialized guidelines with sanctity.

I mention that external fixators were not used in the treatment algorithm for open fractures.

According to our study, the primary mechanism of supracondylar fractures is hyperextension (92%) of the elbow, closely related to the bone architecture at the level of the distal humeral metaphysis, which is thinned and narrowed.

Local post-traumatic complications can delay the primary treatment, which is why a thorough clinical examination is performed with careful notification of soft tissue changes.

Associated bone injuries are in a reduced percentage, but they complicate the therapeutic approach. Regarding elbow imaging, the standard is elbow X-rays in at least 2

views, following the Baumann angle, humero-ulnar line, metaphyseal-diaphyseal line, and anterior humeral line. Tomographic examination with 3D reconstruction is used in complex fractures to assess comminution, fragment rotation, associated bone injuries, but also for selecting the optimal osteosynthesis material.

The type of treatment is specific to each patient or group and differs depending on the classification. Type I according to the Gartland-Wilkins classification remains conservative through cast immobilization. Type III and IV are exclusively surgical. The current international discussion regarding type II is balanced between orthopedic reduction and surgical treatment due to the risk of secondary displacement.

Optimal results were obtained when Grade II, III, and IV fractures were reduced within the first 8 hours of hospitalization, those requiring surgical intervention or delayed until edema reduction and hematoma organization. Exceptions were made for open fractures and fractures associated with vascular-nerve injuries, which were reduced and operated on immediately.

The main osteosynthesis material used was Kirschner wires, representing the standard of surgical treatment. A separate type of osteosynthesis material used in 3 cases is represented by anatomically locked plates that allow screw locking in the plate, thus offering good stability and allowing the immediate postoperative resumption of passive movements of the affected limb.

The length of hospital stay is closely related to the type of treatment. Patients undergoing surgical intervention have a longer hospitalization period due to the obligation to monitor postoperative evolution and prophylaxis of possible local and general complications. Modern trends regarding the timing of surgical intervention suggest a delay of 3-4 days until surgery to reduce local inflammatory factors.

Ultrasound-guided loco-regional brachial plexus anesthesia is increasingly used due to prolonged analgesia, minimal neurotoxicity compared to general anesthesia, and dose induction. However, this type of anesthesia remains dependent on the anesthetist's experience and patient compliance. No correlation has been identified between loco-regional anesthesia and the type of fracture.

From a practical and strictly operative team perspective, loco-regional anesthesia achieves a "silencing" of nerve conduction, and for this reason, intraoperative maneuvers that accidentally interact with neighboring nerve structures around the fracture focus cannot be identified (there is no reflex muscle contraction). Unlike adult patients with the same pathology, where loco-regional anesthesia is the choice, in pediatric patients, the fragile psycho-emotional status necessitates mandatory sedation.

For differentiated approaches, we opted for the following variants:

1. Postero-lateral approach of the elbow: for fracture reduction and stabilization, it is simple and safe, ensuring anatomical reduction of the fracture as well as highlighting any bony interpositions. It is essential in addressing fractures with radial nerve injury.

2. Medial approach of the elbow: by exposing the epicondyle and ulnar nerve, it reduces the risks of iatrogenic nerve injuries and provides good visibility for inserting wires.

3. Posterior approach of the elbow with olecranon osteotomy: exceptional in pediatric orthopedics, reserved for supra-intercondylar fractures, and "T" fractures. This approach allows careful identification of bone fragments and good bone reconstruction.

Transmuscular posterior and anterior approaches were not used in the surgical treatment in this study.

Treatment of fractures according to the Gartland-Wilkins classification follows standard protocols while respecting therapeutic indications. However, Grade II fractures with possible risk of displacement remain under discussion. Current trends lean towards surgical intervention per primam.

The length of hospital stay is closely related to the type of treatment applied. There is an attempt to reduce the duration while also avoiding potential complications.

Surgical treatment by reduction and fixation with Kirschner wires, for closed fractures, is the mainstay in therapeutic management. However, considering the type of fracture, rotational instability, interfragmentary interpositions, vascular-nerve injuries, and fracture reduction, open approach is essential in surgical management.

Patient immobilization varies according to the type of treatment applied and is closely related to the outcomes of orthopedic and surgical reductions.

The osteosynthesis material represented by Kirschner wires is removed after 3-6 weeks depending on the therapeutic approach. However, the surgeon's assessment of the applied treatment is essential in reducing or extending the duration of wire retention.

Clinical and radiological evaluation after orthopedic reduction allows us to identify secondary displacements. In the present study, there were patients who required re-orthopedic reduction followed by surgical intervention.

No patients developing compartment syndrome were identified in the studied group.

Clinical and radiological evaluation was performed according to the standard protocol of the Pediatric Surgery and Orthopedics Clinic in Constanța. The 7-day follow-up checked the stability of the fracture focus in the context of orthopedic reduction or performed osteosynthesis.

Clinical and radiological follow-up at 2 months allows identification of potential distant complications of supracondylar fractures and establishes the therapeutic approach. Cubitus varus is a formidable complication that requires surgical intervention through corrective osteotomy to correct elbow axiality.

Post-supracondylar fracture medical recovery does not have a definite indication. Current studies demonstrate that there is no higher efficacy in patients undergoing this therapy compared to others.

CLINICAL CASE

- Male patient

- Age: 15 years old

- Trauma: Fell from a bicycle

- Clinical presentation: pain and functional impairment

deformation in the region

present distal radial artery pulse, sensation, and motility

- Paraclinical: Laboratory tests, anteroposterior and lateral X-ray images, CT scan with 3D reconstruction

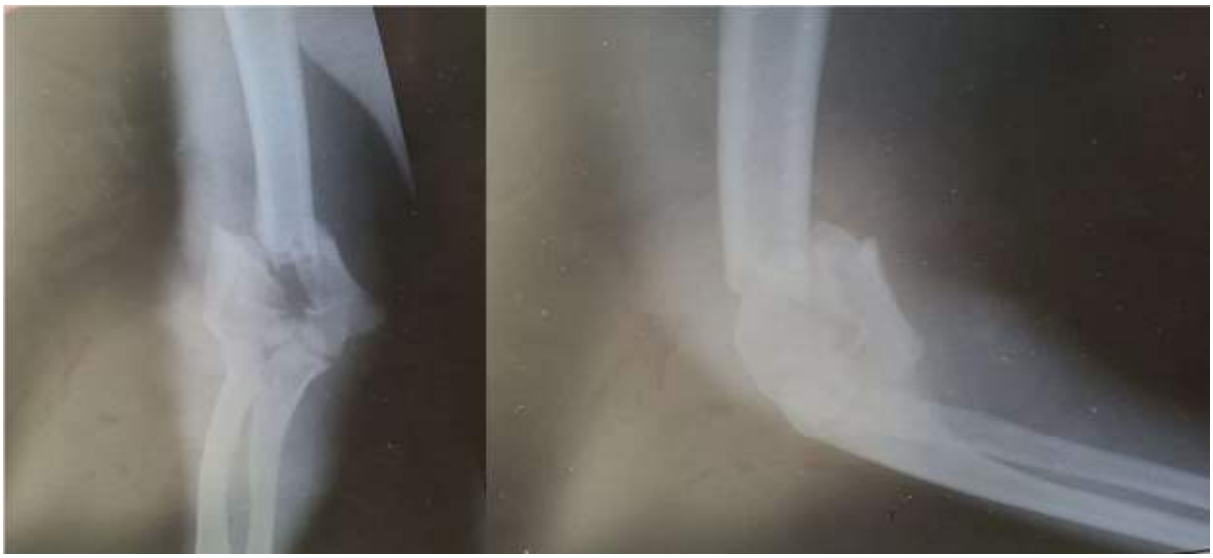

Fig. 61 Cominutive supraintercondylar fracture with deviation

Due to the complexity of the fracture, a CT scan with 3D reconstruction was performed to assess the fragmentation of the fracture site, the rotation of the fragments in the axial plane, and to establish preoperative planning regarding the surgical technique and options for osteosynthesis.

Fig. 62 3D reconstruction of the fracture with assessment of comminution, fragment displacements and their rotation

Choice of osteosynthesis material:

- pre-contoured locked plates for the distal humerus on the medial and lateral sides
- reconstruction plates
- Kirschner wires, screws

- surgical intervention was scheduled for 5 days after admission, preceded by partial resolution of local edema and pre-anesthetic preparation.

- general anesthesia with endotracheal intubation (ETT)

- posterior approach to the elbow and right arm with olecranon osteotomy, patient in prone position with the elbow flexed at 90 degrees

- as osteosynthesis material, we selected pre-contoured locked plates with screws to achieve anatomical reduction of the fracture and articular surfaces, as well as superior stability.

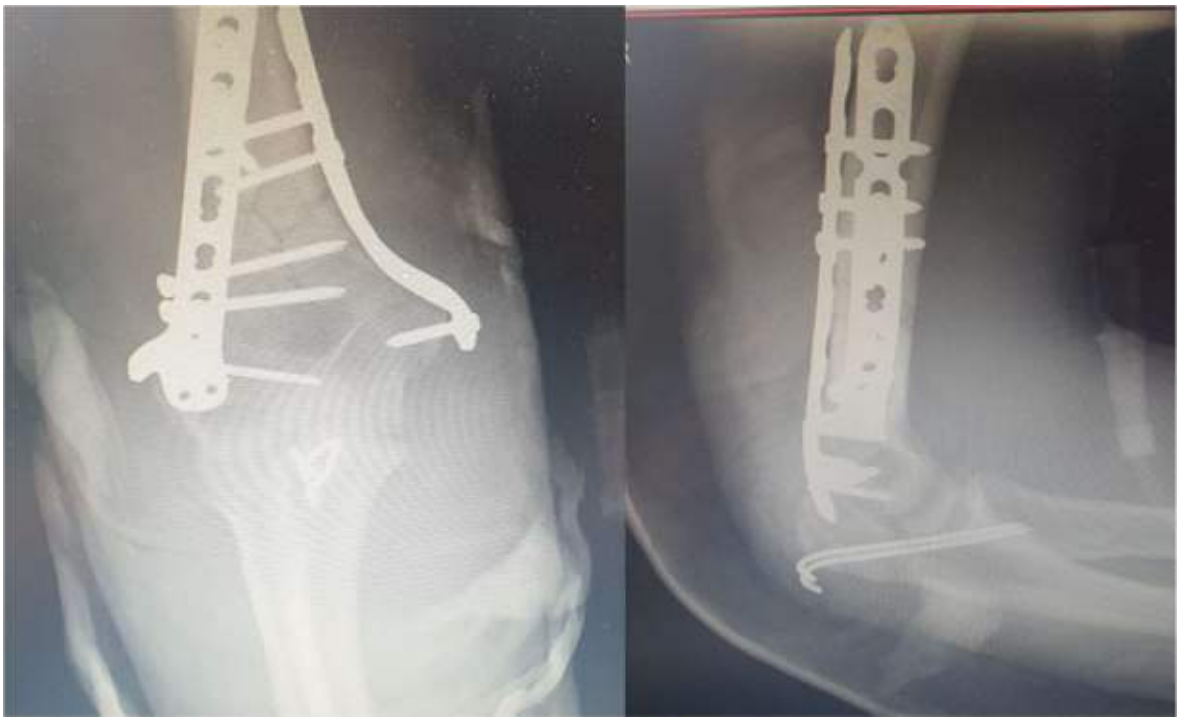

Fig. 63 Fracture reduction and stabilization with anatomic locked plates

- brachio-palmar splint immobilization for 3 weeks.

- orthopedic reevaluation at one month, three months, and one year.

- removal of the splint at one month.

- complete removal of osteosynthesis material at one year with persistent extension deficit, contrary to intensive functional rehabilitation.

Fig. 64 Fracture consolidation

Conclusions:

- the consolidation of the fracture focus is linked to the stability of the assembly.

- anatomically locked plates for distal humerus represent the optimal material in supra-intercondylar fractures in patients over 14 years old.

- without an intensive rehabilitation program, patients may remain with joint dysfunctions.

- the choice of the opportune surgical moment is strictly dependent on the soft tissue aspect, typically 5-7 days post-trauma.

CONCLUSIONS:

- The frequency of supracondylar fractures is increasing.

- The treatment algorithm is closely related to the type of fracture and associated complications.

- Instability of the fracture focus or unsatisfactory orthopedic reduction of the fracture changes the treatment algorithm.

- Early identification and treatment of potential complications significantly reduce the risk of sequelae.

- Vascular and nerve complications remain the most formidable, posing a challenge for the surgeon.

- Regional anesthesia allows for prolonged analgesia and reduces complications associated with general anesthesia.

- Treatment of supra-intercondylar fractures permits the use of anatomically locked plates and reduces the immobilization period.

- CT with 3D reconstruction accurately evaluates the fracture focus, associated bone lesions, and assesses the types of osteosynthesis materials used.

- Postoperative immobilization of the fracture is included in the therapeutic protocol but remains at the discretion of the surgeon.

- Remote bone complications lead to sequelae and alter bone architecture.