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RECOVERY OF THE DIAPHYSEAL FRACTURE OF THE HUMERUS BY KINETIC MEANS

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Abstract: *The article presents the importance of the occurrence of diaphyseal fracture of the humerus, as a common fracture with a percentage of up to 3-5%, and their treated callus rate reaches the threshold of 67% to 98%. Inadequate treatment of humerus diaphyseal fracture contributes to stiffness and pain on movement, as well as deterioration of quality of life, which leads to surgical intervention. Traditionally, the intervention to treat this condition is based on closed reduction, but the causes that lead to surgical intervention are multiple: neurovascular injuries, prolongation of joint fractures, polytrauma, open fractures, pathological fractures, etc. The purpose of the article is based on highlighting the importance of physical exercise in the recovery of humerus diaphyseal fracture. Thus, it can be used to monitor the patient's return to normal range of motion.*

Key words: *humerus diaphyseal fracture, kinetic exercises, individualized recovery program.*

1. Introduction

Humerus diaphyseal fracture accounts for approximately 3% to 5% of all possible fractures. The callus rate of humeral shaft fractures treated conservatively is 67% to 98%.

Nonunion of humerus diaphyseal fractures will cause lasting pain, impaired quality of life, and loss of function that will require surgical treatment. Traditionally, the first treatment in humerus diaphyseal fractures has been closed reduction and splinting. The indications that lead to surgical interventions are neurovascular injuries, lengthening of articular fractures, polytrauma, open fractures, pathological fractures and failure of conservative treatment. Nonoperative treatment is based on the ability to compensate for the angular and rotational deformity of the shoulder. Long-term immobilization is necessary in the non-operative method. This method of treatment has several implications, including delayed loss of range of motion in the joints and also delayed return to work. Moreover, skin and soft tissue complications are observed between 1% and 9.5% during the immobilization period. Recently,

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orthopedic surgical technology has made considerable progress that allows patients to be more active, and patients no longer want to break away from their regular lives for a long time [9].

The tasks of the research consist in finding the highest possible efficiency of physical exercise in the recovery of the diaphyseal fracture of the humerus through various methods of its application. Physiotherapy has the potential to reduce the painful processes that occur after the trauma, to restore the movement capacity for the affected anatomical segment, to increase muscle strength. For humans, the function of the upper limb is particularly important, and for this reason it is necessary that the recovery takes place in optimal conditions, reaching a result that confers high satisfaction.

Bone elements:

a. Presentation of the humerus

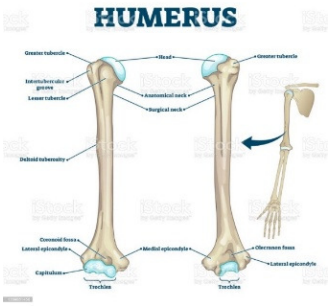

Fig. 1. *Bone Humerus* [12]

From the point of view of the structure of the settlement, the humerus bone presents multiple particularities. This is the largest bone of the upper limb and connects the shoulder to the arm. The ligament articulates proximally with the glenoid fossa through the glenohumeral joint and distally with the radius and ulna bones at the elbow joint. The proximal extremity of the humerus articulates with the scapula, its head being a smooth and rounded articular surface at the upper pole of the humerus.

b. Presentation of the scapula

The scapula is anatomically and biomechanically involved in shoulder function and arm movement. In the process of movement, the shoulder and arm work together to achieve a change in the glenohumeral position, and this allows sports and everyday activities to be carried out. To achieve correct three-dimensional motion of the shoulder joint and upper arm, the scapula superiorly rotates, posteriorly tilts, and externally rotates, the clavicle elevates and retracts, and the humerus elevates and externally rotates. The scapula, shoulder, and arm are either stabilized or moved from a specific position to generate, absorb, and transfer forces that perform work or athletic tasks. A change in scapular position at rest or during arm movement may be associated with lesions that create clinical shoulder dysfunction [5].

c. Presentation of the clavicle

The appearance of the clavicle is like a long, double-curved and paired bone, which forms the anterior portion of the scapular girdle, being a link between the axial and appendicular skeletons. Even though they are not as strong as bones, they are the supporting structure. They have the role of significant function and have a very large range of motion of the upper extremity. All these aspects form the pectoral girdle. The sternal (medial) extremity of the clavicle with the sternum makes a sternoclavicular joint.

In terms of stability, the intraclavicular ligament connects the ipsilateral and contralateral clavicle. Laterally, the clavicle articulates with the acromion, forming the acromioclavicular ligament,

which is found on the upper side of the capsule. Being a planar synovial joint between the acromial end of the clavicle and the medial border of the acromion of the scapula, which provides an attachment for the joint capsule of the shoulder. The sternoclavicular joint is the joint capsule that joins the articular surfaces and is lined internally by synovium and reinforced by four ligaments: the anterior sternoclavicular ligament, the posterior sternoclavicular ligament, the costoclavicular ligament, and the interclavicular ligament [6].

1.1. Humerus fracture-Generalities and mechanism of production

While most humerus fractures occur secondary to low-impact injuries, the mechanism of fracture is directly related to the age of the patient. The condition occurs most frequently in the elderly population and in the vast majority of cases the injuries occur as a result of a fall on the outstretched hand from a height close to standing in patients over 60 years of age. Younger patients without osteoporosis generally sustain a humerus fracture after road traffic accidents, after falls from more than one meter height, convulsions or electric shock. The biomechanics of the fracture and the overall bone quality of the patient tend to produce varied injuries to the humerus.

Fractures generally occur either as a direct blow to the upper limb or as a result of indirect force transfer from a fall on an outstretched hand. The impact drives the humerus into the glenoid cavity resulting in significant energy transfer to the humerus. In most cases the glena is harder and has a higher bone density than the arm bone, therefore an “anvil” mechanism occurs whereby the humerus is affected/impacted. A combination of impact direction, bone quality and also soft tissue traction is responsible for producing different fracture patterns. Associated medical comorbidities increase the risk of fracture and may also determine the type of fracture that occurs [1].

Fracture is the interruption of the bone structure and can be classified according to the appearance of the skin: closed fracture and open fracture. Another classification is based on the site on the bone where the actual fracture took place and is divided into simple fractures (where the bone broke in one place) and comminuted fractures (the bone fractured in several places). From the point of view of the biomechanics of humerus diaphyseal fracture deviations, the fracture line occurs above the insertion of the pectoralis major muscle, and the proximal fragment will be deviated in adduction and external rotation due to the action of the rotator cuff muscles.

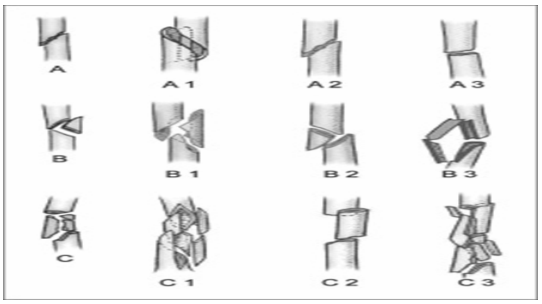

Fig. 2. *Classification of fractures, [2]*

1.2. Concepts of fracture management

Treatment of fractures can be done using reduction and medical splints. Reduction is printed when there is no distal pulse or actual skin penetration and is performed with adequate pain control and without patient sedation. Using splints, they will be applied to one side and the other of the affected limb, keeping the position so that the fractured bone must be immobilized. For a humerus fracture, a long arm splint or a chest brace that covers the shoulder area will be used. Immobilization of the humerus fracture can be done 10 to 12 days after the injury. This period represents the time required to recover from the trauma. Importantly, transverse fractures heal better than spiral fractures. However, realignment and union of the affected area is very important. From the typology of the mentioned fractures, we can state that the humerus diaphysis fracture takes four months to heal and has a non-union rate of 1-12%. If these percentages of the rate are exceeded, then fractures are associated with transverse fractures, inadequate mobilization of the shoulder, and soft tissue interposition [3].

Operative and non-operative treatment strategies both have pros and cons. Operative fracture fixation allows early mobilization, which may lead to earlier functional recovery and reduced pain. However, surgical complications and fixation failure can occur. Nonoperative treatment may be associated with more pain (because the fracture is not stabilized) and discomfort (due to pain and immobilization) in the first few weeks and may be associated with a higher risk of poor union due to lack of fracture realignment. Longer immobilization may delay functional recovery.

Complications of operative and nonoperative treatment overlap and data are lacking to determine the relationship between treatment. Non-union occurs in 15-30% after operative treatment versus 2-23% after non-operative treatment (for which most patients require secondary surgical treatment). The most feared disabling complication is radial nerve palsy, which occurs in 2-17% of all patients [7].

2. What does the physical therapy program entail?

Humeral fractures can be treated surgically or conventionally with a specific splint. Conservative treatment emphasizes compliance with the acceptable radiological limits of movement of the fragments of the proximal humerus with the application of immobilization. Taking into account the periods of immobilization to be able to initiate motor rehabilitation. Surgical treatment focuses on osteosynthesis through open reduction and internal fixation with implants. Whatever the medical intervention, a program of motor rehabilitation of the function affected by the fracture will have to be created. The kinetotherapeutic program will have the role of improving the functional state, reducing pain and increasing the range of motion of the affected limb following the fracture [10].

In the post-fracture recovery treatment, physical therapy plays an essential role considering the following objectives:

- Regaining and maintaining the ability to move in the joints adjacent to the fracture point.
- Regaining trophicity and tone of muscle elements.

• Regaining joint stability, movement control and skill.

The kinetic program has as its starting point the passive mobilizations that can be started after the end of the immobilization period. Active mobilizations are performed carefully taking into account the particularities of the immobilized member. After an adequate muscle tone has been obtained through passive and active movements, the kinetic program can be continued with movements with external resistance. It is recommended that the active exercises performed involve all planes of motion, and when the joint mobility allows passing the line of the shoulders, support on the wall or on the steps of a trellis can be used. During the execution, it is indicated to involve the adjacent upper limb to avoid compensations arising from the trunk level [4].

There has been little direct comparison between nonoperative and operative management of humeral shaft fractures. The study by Westrick et al. aimed to compare union rates and complication rates between these two treatment modalities.

Thus, conservative treatment of humerus shaft fractures has a higher rate of nonunion, while operative treatment is associated with a low incidence of iatrogenic nerve palsy but higher rates of infection [11].

3. Material and Methods

The case study was carried out at the subject's home and took place over a period of approximately 3 months.

This study included the initial treatment as well as the maintenance period, after the end of the study period observational meetings continued.

After the accident, radiographs and computer tomography were performed to assess the nature of the polytraumatism produced, and after the surgical intervention consisting in the closed reduction of the humeral diaphysis fracture with internal fixation, radiographs were again performed to ensure the correctness of the intervention. Before the start of the treatment period, joint amplitude, muscle strength were evaluated and the VAS scale was also used. The treatment consisted of passive mobilizations, autopassive mobilizations, passive-active mobilizations, active mobilizations, Kabat diagonals, the Codman method, exercises with external resistance and exercises with the help of various household objects and possibilities.

3.2. Individualized recovery program

During the period when the home recovery program was carried out, the following objectives were pursued:

• Inducing relaxation;
• Posture correction;
• Improving the mobility of the scapulohumeral joint and the elbow;
• Improving the muscle strength of the right upper limb;
• Improving muscle endurance;
• Re-education of coordination;
• Respiratory re-education.

Treatment sessions typically had a frequency of three days per week, with one day of treatment followed by one day off. The duration of a session at the beginning of the recovery period was approximately one hour, as the sessions progressed the duration of the treatment session increased to approximately 90 minutes of physical therapy. Before the

start of each physical therapy session, the patient performed a warm shower with insistence on the muscles and joint segments of the right upper limb in order to have better malleability and better pain tolerance during the kinetic techniques.

Month 1

In the early phase of the treatment period, passive mobilization of the elbow in the flexion/extension movement and passive mobilization of the scapulohumeral joint in all directions of movement was started. The maneuvers were performed gently and had a progressive manner considering the occurrence of moderate muscle stretching without entering the pain zone. The fist joint could be actively mobilized on flexion and extension, the same was applied to the fingers. Pronation and supination movements were performed passively within tolerance. The spiked ball was used to stimulate sensitivity throughout the upper limb by rolling it over the surface of the skin. Also, Kabat diagonals on the upper limb and some neuropropioceptive facilitation techniques were applied within tolerance, without entering the pain zone because it was particularly intense. At each session, breathing exercises were performed to improve lung capacity affected by rib fractures.

During free time the patient was instructed to adopt postures with the help of pillows to increase flexion and abduction of the left shoulder. Gradually, the mobilizations became passive-active, later active-assisted, reaching the active mobilizations on the entire left upper limb assisted against the background of the improvement of muscle tone and joint mobility towards the end of the current month.

Example of exercises performed, [8]:

- Finger flexion and extension, figure 3
- Grip the foam ball, hold for 5 seconds, figure 4

Fig. 3. *Finger flexion and extension*

Fig. 4. *Clutching the foam ball*

Month 2

In the intermediate phase of the recovery period, the subject's condition improved and it was possible to introduce a new palette of exercises and techniques adapted to current needs and possibilities. The exercises became active with a slight load in some situations, the pain threshold and the fatigue threshold being more permissible. Active exercises were

performed with the gymnastic stick in all directions of movement in the shoulder joint with the maintenance of the maximum price point for 5-10 seconds, the advantage was the assistance of the homologous upper limb, the range of motion being greater. The same exercises were performed with the foam ball.

Kabat diagonals have gained a longer stroke. The cane was again useful in active pronation and supination movements in the fist joint. Biceps and brachial triceps were toned, elbow flexion and extension were actively performed with a 0.5 liter water bottle in hand for the first repetitions, then the weight increased. For the abduction of the upper limb, the "mouse on the wall" was a valuable exercise, allowing a slow and controlled movement.

Towards the end of the session, the minibike was used, the pedaling rhythm being a slow one, thus achieving a smoother exit from the effort. The subject was encouraged to involve the left upper limb in all daily activities within the limits of mobility and without the appearance of pain during free time.

Example of exercises performed, [8]:

• Standing at a distance with the cane grasped of the heads, raising the stick to the head, holding for 6 seconds at the maximum point, slow return.

• Standing apart with the cane fixed in open palms by pushing with the homologous upper limb, shoulder abduction is achieved, hold for 6 seconds, slow return.

Month 3

In the latter part of the recovery period the exercises were focused more on the development of strength and skill. The mini bike was used in the warm-up part, gradually increasing the pedaling pace. With the help of the elastic band, strength and muscle resistance exercises were performed with moments of muscle isometry. Manual dexterity exercises aimed to improve ordinary daily activities. Being a subject with a desire for the best and most effective recovery, he also performed complementary exercises outside of meetings with the therapist.

The regaining of independence, professional reintegration was gradually pursued, the subject being observed at weekly intervals in terms of the recovery and maintenance program, thus achieving a gradual exit from the intervention program.

Example of exercises performed, [8]:

• From orthostatism with the elastic band passed under the soles, the flexion-extension movement of the forearm is performed on the arm.

• Therapist face to face with the subject, in orthostatism, the band held by one end of the therapist, and from the opposite end the subject pulls the band performing the retroduction movement.

• Vass scale

During the kinetic treatment, the research subject provided feedback on how the pain manifested, as well as on its intensity.

Pain assessment was done in 3 moments. An important difference in pain intensity can be observed in the research subject.

At the initial time of the research according to the Vass scale the pain was grade 8-9, at the intermediate evaluation the grade was 5-6, and the final evaluation the pain grade was 3. The difference between the initial evaluation and the final evaluation is 6 points, table 1.

Table 1

The obtained values – VASS Scale

Subject	Initial testing	Intermediate testing	Final testing
N.D.	8-9	5-6	3

• VRS scale

Using the VRS scale, pain intensity was assessed at the beginning and end of the treatment period, figure 5.

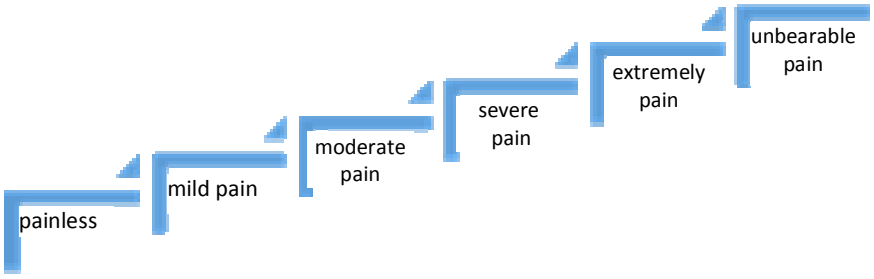

Fig. 5. *Pain assessment scale VRS*

4. Results and Discussions

At the time of evaluation at the beginning of the treatment period, the pain was categorized as very severe, and at the final phase of the treatment, the pain was assigned as being moderate.

With the help of a goniometer, the articular balance was performed at the

• Joint balance

beginning and at the end of the treatment.

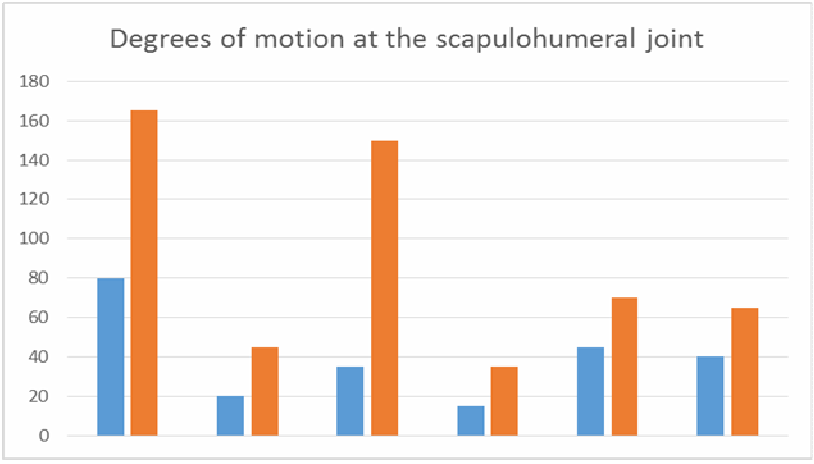

Fig. 6. *Initial and final degrees of motion at the scapulohumeral joint*

A significant difference can be seen for the better in flexion and abduction movements. In flexion, the subject went from 80° to 165°, so an increase in aptitude of 85°. In abduction, the subject reached from 35 ° to 150 °, so an increase in amplitude of 115 °.

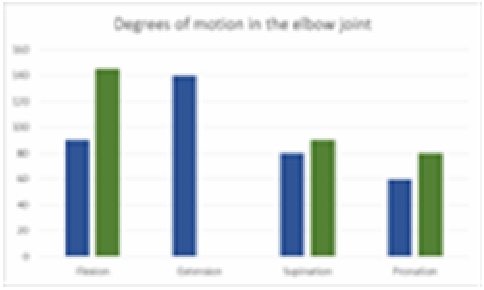

Fig. 7. *Initial and final degrees of motion at the elbow joint*

As for the elbow joint, flexion and extension movements have completely regained their articular amplitude. The final amplitude in flexion is 145 °, and in extension 0 °.

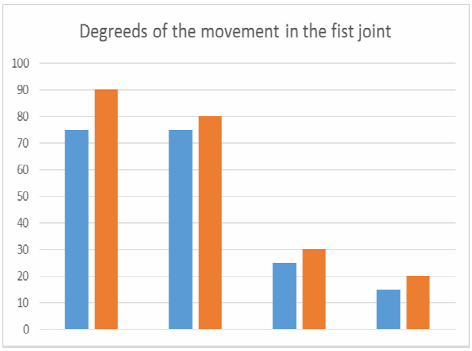

Fig. 8. *Initial and final degrees of motion at the fist joint*

Also, at the level of the fist joint, progress was made in all areas of movement.

• Muscle balance

The muscle balance was performed at the beginning and end of the therapeutic program and the rating system was used with values between f0 (where the force is considered zero) and f5 (where the force is considered normal). Test maneuvers were performed at the level of the scapulohumeral joint and at the level of the elbow joint.

The research subject made progress in muscle testing by being able to go from being able to move by eliminating gravity to performing the move against gravity.

5. Conclusions

Thanks to the physical therapy procedures performed at the patient's home, a significant improvement was observed in all aspects of the research subject. Physical exercises had a positive impact on joint mobility, at the beginning of the recovery period it registered 80 ° in the joint balance at the shoulder flexion movement, and at the end it registered 165 °. Shoulder abduction in the initial phases 35°, at the end of treatment 150°. A significant increase in joint mobility can be seen.

In terms of muscle strength, progress was also recorded here, on the flexion and abduction movement in the shoulder joint at the initial level the strength recorded was F2, respectively F1, at the end of the treatment they reached a rating of F4, thus managing to perform the anti-gravitational movement.

In this research work, only techniques, exercises and procedures from the field of physical therapy were used due to the nature of the researched condition as well as due to the location where the recovery program took place.

Knowledge of the functional anatomy and biomechanics of the upper limb is vital in the development and implementation of the kinetic recovery scheme. It is recommended for people who suffer a humerus diaphysis fracture to adopt a healthy, active lifestyle after recovery, to use the upper limb in all physical and daily activities, and to avoid lifting substantial weights, overstraining the affected limb.

The physical therapy program was shown to be successful, with the research subject feeling much better during and after the treatment, making progress in all tests, the hypothesis stated at the beginning of the paper being a fulfilled one.

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