HIGH FREQUENCY PULSED ULTRASOUND THERAPY – AN ALTERNATIVE TREATMENT IN PSEUDARTHROSIS

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Keywords: *ultrasound, nonunion, fracture*

Abstract: *Surgical debridement and bone grafting is ,,the gold standard" in the treatment of fractures nonunion. Recent studies are committed to find new alternative treatment with lower morbidity and human and material costs. An alternative starting to show efficiency is high frequency pulsed ultrasound therapy. This study purpose is to show the effect of a portable device that emits such ultrasound, in the treatment of fractures nonunion performed in ambulatory or patient's home.*

Cuvinte cheie: *ultrasunete, pseudartroză, fractură*

Rezumat: *Cura chirurgicală cu grefare osoasă constituie și astăzi ,,standardul de aur" în tratamentul pseudartrozei. Studiile recente se orientează spre găsirea de noi alternative de tratament cu morbiditate și costuri materiale și umane mai puține. O alternativă care începe să-și arate eficiența este terapia cu ultrasunete cu frecvență pulsatorie înaltă. Studiul de față își propune să arate efectul unui aparat portabil, care emite astfel de ultrasunete, în tratamentul pseudartrozei efectuat în ambulator sau la domiciliul pacientului.*

INTRODUCTION

Fracture's characteristics and patient's particularities may impair fracture's healing, making of fracture nonunion the final result. Spontaneous healing possibilities of it are very low, even to 0%. Surgery consisting of debridement of nonunion area, internal or external fixation with bone graft used in most of the cases are so-called ,,the gold standard" in the treatment of fractures nonunion, even if the primary treatment was similar at the beginning.

Nonunion current treatment possibilities are multiple: surgical treatment, conservative treatment, electrical stimulation, shock wave therapy and ultrasound with low intensity and pulsed high frequency (cold).

Data from the literature shows that the success rate is 85% for surgical treatment of nonunions, 60-76% after electrical stimulation and 62-67% after therapy with shock waves. Together with electrical stimulation and shock wave therapy, ultrasound therapy is cold biophysical methods to stimulate the healing of nonunion fractures. They have the noninvasive advantage to the gold standard surgical treatment. Another feature is the absence of contraindications for these treatment alternatives.

At the beginning, there was an absolute contraindication for the use of ultrasound for therapeutic purposes. This is due to numerous animal studies that have shown extended or even prevent bone healing (7,135), despite other studies that have shown the opposite.(49,151

Ultrasound works exclusively by creating a very low intensity mechanical excitations on mesenchymal cells. Thus is excluded thermal, electrical or electromagnetic factors action, as the electric shock, using ultrasounds emission, at high energy, for crushing gallstones or urinary stones.(94,118,141)

The therapeutic effect of ultrasounds in nonunions treatment depends on their intensity. Low intensity ultrasounds, accompanied by a high pulsatory frequency, acts on fracture healing during daily irradiation. Resulting pressure produces vibration of mesenchymal cell walls, resulting an acceleration of cellular metabolism. In addition to faster transformation of mesenchymal cells into osteoblasts and then osteocites, it was found that sonic impulses act also on bone canaliculi opening through which calcium ions entering easier in bone cells.(94,118,181)

PURPOSE

This study aims at presenting the effect of a portable device that emits such ultrasound, in the treatment of fractures nonunion performed in ambulatory or patient's home.

METHODS

The study included nonunions resulting from fractures treated in the Orthopaedics and Traumatology Clinic of Emergency County Hospital of Sibiu between 2009-2012.

Inclusion criteria in the study were:

- patients with nonunion regardless of bone interest or type of initial treatment of fracture;
- aged 18 years;
- at least 3 months after the fracture;
- absence of radiographic healing (minimum three cortical bridges) fracture visible on radiographs made at least two planes.

Exclusion criteria from the study were:

- known abuse of alcohol, tobacco or drugs;
- presence of neuropathy, active malignancy or chronic metabolic diseases affecting bone formation;
- septic nonunion with active infection;
- treatment with hormones, steroids, anticoagulants or bisphosphonates.

Ultrasounds treatment was performed using a portable device, a variant of the devices that stimulate new bone production, using low intensity ultrasound radiation, but high pulse frequency.

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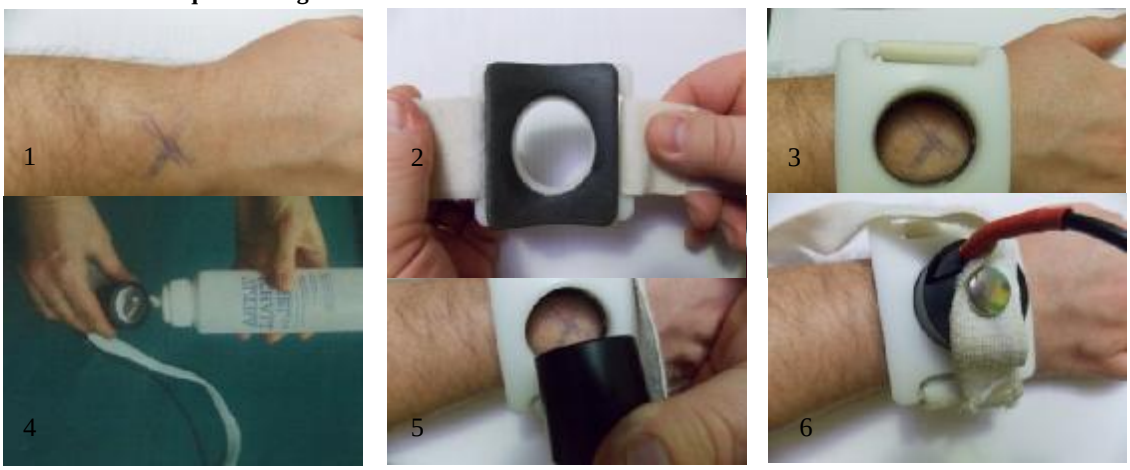
Using the device is simple because it has been designed so that it can be used in ambulatory and can be mounted and applied by the patient himself. This is facilitated by the small size and weight that makes it easy to handle.

The device should be applied to the skin, near the fracture site, whether a metal implant is nearby.

The technique of using device is simple and includes the following steps (figure no. 1):

1. marking on the skin the place where we will apply the device;
2. bracket bonding pad on the bottom of the ultrasound transmitter guiding device;
3. closely guiding device application on the skin, with fastening tape;
4. application of gel on ultrasounds transmitter;
5. placing of ultrasounds transmitter through the guide ring;
6. ensuring intimate contact skin - ultrasounds transmitter.

Figure no. 1. The technique of using ultrasound device



Each patient in the study used the ultrasounds device 60 days, 20 minutes daily, the time of the therapy session being indicated acoustically and visually.

Nonunions were considered to be healed if they meet the clinical (no pain at mobilization or weight bearing, possibility of weight bearing without help, absence of functional impairment) and radiological criteria (presence of callus bridging on at least 3 of 4 cortices on the radiographs made in two planes: anterior-posterior and lateral).

RESULTS AND DISCUSSIONS

Between 2009-2012 were treated with cold ultrasound 6 patients diagnosed with fractures nonunion, who met the inclusion and exclusion criteria presented in the previous section.

We used three parameters for diagnosis nonunions:

1. clinical elements: pain on the fracture site, limb functional impairment, inability to walk without aid (crutch /cane) in case of lower limb fractures;
2. radiographs: no callus on radiological images (minimum 3 periosteal or endosteal cortical bridging)
3. minimum of six months between fracture moment and diagnosis.

The average age of the study group was 39.5 years, the extreme ages were 24 and 58 years. Two cases were women, the remaining four are men. Bone nonunions interested area was: tibia-3 cases, femur-1 case, humerus-1 case and scaphoid-1 case. In two cases the fracture was open (both tibia fractures), the other two fracture sites were opened during surgery, a case was not operated (scaphoid fracture) and one was operated without opening the fracture (humerus fracture). For the fracture fixation were used following implants: locked intramedullary nails (two tibial fractures), plates and screws (femur fracture and one tibial fracture) and K intramedullary pins (humerus fracture).

The average time between injury and initiation of ultrasound therapy was 313 days, with a minimum duration of 176 days, and maximum of 742 days.

After ultrasounds therapy was performed, clinical and radiological reassessment of patients was made.

In 5 (83%) cases the nonunions of fractures were fulfilled the clinical and radiographic criteria of healing. The only case of not healing nonunion was an open tibial fracture. It was treated by medullary canal reaming and locking nail synthesis.

CONCLUSIONS

1. Radiography is essential and should be performed and interpreted in the correct clinical context, to establish the diagnosis of nonunion.
2. Reliability clinical signs of nonunion (pathological mobility on the fracture site, bone crepitation, interruption of the continuity of bone) may be missing in case of synthesised fractures, making diagnosis of nonunion more difficult.
3. Tibia is the most at risk of nonunion because of its anatomical and structural particularities and that is the most frequently bone involved in open fractures
4. Ultrasounds therapy was not influenced by the localization of the initial fracture.
5. Opening the fracture, because of trauma or surgery, anatomical and vascularity particularities of bone, insufficient or inadequate fixation of fracture and infection are factors that favour the fracture to nonunion.
6. Ultrasound therapy has proven to be an alternative in treatement of nonunion fractures.

REFERENCES

1. Arden NI Jr, Janes JM, Herrick JF. Ultrasonic energy and defects in bone. J Bone Joint Surg Am. 1957;39:394-402.

2. De Nunno R. L'azione degli ultrasuoni sulla formazione del callo osseo (ricerche sperimentali). Ann Ital Chir. 1952;29:211-20.
3. Heckman JD, Ryaby JP, McCabe J, Frey JJ, Kilcoyne RF. Acceleration of Tibial fracture-healing By Non-invasive, Low-Intensity Pulsed Ultrasound, J. Bone and Joint Surg, Jan 1994;76-A:26-34.
4. Kristiansen TK, Ryaby JP, McCabe J, Frey JJ, Roe LR. Accelerated healing of distal radius fracture with the use of specific low intensity ultrasound. A multicenter, prospective, randomised, double-blind, placebo controlled study, Am JBJS. 1997;79:961-973.
5. Maintz G. Tierexperimentelle Untersuchungen über die Wirkung der Ultraschallwellen auf die Knochenregeneration. Strahlentherapie. 1950;82:631-8.
6. Mayr E, Laule A, Suger G, Ruter A, Claes L. Radiographic results os callus distraction aided by pulsed low-intensity ultrasound, J Orthop Trauma Aug. 2001;15(6):407-416.
7. Murolo C, Claudio F. Influenza degli ultrasuoni nei processi riparativi delle fratture. G Ital Chir. 1952;8:897-903.
8. Rubin C, Bolander M, Ryaby JB, Hadjiargyrou M. The use of low intensity ultrasound to accelerate the healing of fractures, J B J S. 2001;83-A(2):259-270.