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Original Article

Predictive role of scintigraphy (BS) in bone union induction using extracorporeal shock wave treatment (ESWT)

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ABSTRACT

Aims: Pseudoarthrosis and delayed bone union are the main complications in the healing process of long bones fractures. The surgical intervention is currently the treatment of choice, but there is a number of non-operative interventions are being developed, such as extracorporeal shock wave therapy (ESWT). There is a range of issues related to the proper qualification, monitoring, and outcome assessment measures. Bone scintigraphy (BS) exclusively allows the assessment of the bone turnover dynamics in non-invasive, semi quantitative method.

Methods: The study group comprised of 31 subjects with bone healing complications. The study population was divided in two subgroups as related to the treatment outcome assessed 24 weeks after ESWT procedure. Group I ($n = 19$) included the cases with no complete bone union. Group II ($n = 12$) covered the subjects with complete bone union. BS was performed right before ESWT and 2 weeks after the procedure.

Results: Increase of agent uptake after ESWT procedure was noted in both groups which proves that ESWT increases bone metabolism dynamics in most patients. Significantly higher uptake increase was noted in patients with complete bone union. In patients with unsuccessful treatment the agent uptake before ESWT was much higher.

Two weeks after ESWT procedure BS reveals an increase in bone metabolism in the area of complicated fracture proving positive reaction of bony tissue on mechanical waves.

Conclusion: Scintigraphy may facilitate qualification patients with bone union disorders for further mode of treatment. One can suppose that positive bone reaction is achievable only in bone where the metabolism is lowered.

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1. Introduction

Pseudoarthrosis and delayed bone union are the main complications in the healing process of long bones fractures.¹ As surgical intervention is currently the treatment of choice in the ones it has several limitations and may not lead to the successful outcome. Thus, a number of non-operative methods are being developed, such as electrical, electromagnetic, and ultrasound stimulation of the fracture site.²

The general idea behind fractured bone stimulation treatment approach with extracorporeal shock wave treatment (ESWT) is to produce shock wave supposed to result in: callous formation, neovascularization and increased expression of angiogenic growth factors inducing differentiation as well as proliferation of cultured osteoblasts along with the regulation of genes involved in osteoblast proliferation and differentiation processes.³⁻⁶

However, ESWT still has a range of issues related to the proper qualification, monitoring, and outcome assessment measures that require systematic appraisal along with guideline formation.² Bone scintigraphy (BS) exclusively allows the assessment and visualization of the bone turnover in non-invasive method. It enables both the evaluation of metabolic processes rate in the bone tissue as well as the diagnostic differentiation in the imaging of pathological processes that may affect healing process. BS is characterized by high sensitivity. However, its specificity is low.⁷ It mainly results from the limitation of that method being quantitative evaluation measure with no standardized procedure. That issue arises with the majority of the studies and requires study-specific, semi-quantitative assessment of hyperactive focuses as compared to the normal bone uptake of the tracer.

The aim of this study was to evaluate the metabolic changes in bone fracture healing with BS in chronological course of the medical intervention before and after ESWT. The secondary study outcome was to assess of usefulness of BS in predicting the procedure's efficacy in the treatment of bone union complications (pseudoarthrosis and delayed bone union) in scope of guidance for the practical method implementation.

2. Patients and methods

The study group comprised of 31 subjects, 11 women aged 31-68 (mean 51, ± 3) and 20 men aged 21-72 (mean 45, ± 4) with long bone union complications. Twenty-two patients were diagnosed with pseudoarthrosis, 9 with delayed bone union. The patients characteristics is demonstrated in Table 1.

Before ESWT procedure all patients were inefficiently treated using conventional operative and non-operative methods. During the procedure 26 patients had bony fragments stabilized with metal uniting material.

The inclusion criteria to the study were patients' informed consent, pseudoarthrosis and delayed long bone union with unsuccessful treatment with conventional operative or non-operative methods. Patients were also qualified on the basis of clinical examination and CT images. The exclusion criteria were osteitis in the location close to the place of the treatment, neoplasm, pregnancy, breastfeeding, coagulopathy, osteomyelitis, neuropathy, peripheral vascular disease.

The study population was divided in two subgroups as related to the treatment outcome assessed 24 weeks after ESWT procedure. Group I ($n = 19$) included the cases with no complete bone union. Group II ($n = 12$) covered the subjects with complete bone union.

Thirty-one patients were treated with extracorporeal shock wave therapy (ESWT) at a single referral trauma center in an attempt to determine the feasibility and factors associated with the use of ESWT in the treatment for long-bone nonunion. In Table 2 the fractured bones are listed.

ESWT was performed with electrohydraulic lithotripter Econolith 2000 (Medispec, USA) set on the delivery of 3000 impulses at 20-21 kV with post-treatment immobilization of the bone. The probe focused the treatment waves on the area of 8×50 mm, where it triggered pressure impulse of 300 bars during 1 ms. The impulse frequency was 60-120/min.

BS was performed right before ESWT and 2 weeks after the procedure. Scintigraphy was performed using Multispect (Siemens, DE) gamma camera, in supine position after intravenous administration of 600-800MBq of ^{99m}Tc -MDP. AP and PA bone scans of affected region were obtained 3 h p.i.

Scintigraphic tests analysis was based on semi-quantitative assessment. In order to categorize data obtained a semiquantitative scale of degree of accumulation of the radiopharmaceutical in fractured area was created: 0) no accumulation - 0 points, 1) poor accumulation, but higher than in healthy, homonymous bone - 1 point, 2) intensive accumulation, but not dominative - 2 points, 3) intensive accumulation, dominative, but comparable with accumulation in another hyperactive anatomic structure - 3 points, 4) intensive, dominative accumulation - 4 points. The average evaluation measurements from three independent observers were calculated using the scale described above.

Twenty-four weeks after the procedure patients were subjected to clinical and radiological evaluation in order to perform follow-up observation.

The study used descriptive and quantitative statistic methods. Compatibility analysis among three independent

Table 1 – Groups of patients.

Group (treatment)	n	Time since injury (weeks)	Sex		Mean age	Type of complication	
			F	M		Pseudoarthrosis	Delayed bone union
Group I (unsuccessful)	19	109.89	6	13	47.2	14	5
Group II (successful)	12	71.33	5	7	47.9	8	4

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