



Validation of the Non-Union Scoring System in 300 long bone non-unions



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ABSTRACT

Introduction: Non-union of long bones is a significant consequence of fracture treatment. The ideal classification for non-union of long bones would give sufficient significant information to the orthopaedic surgeon to enable good management of the treatment required and to facilitate the creation of comparable study groups for research purposes. The Non-Union Scoring System (NUSS) is a new scoring system to assist surgeons in the choice of the correct treatment in non-union surgery. The aim of this study was to determine the evidence supporting the use of the NUSS classification in the treatment of non-unions of long bones and to validate the treatment algorithm suggested by this scoring system. **Materials and methods:** A total of 300 patients with non-union of the long bones were included in the clinical study.

Results: A radiographic and clinical healing was reached in 60 of 69 non-unions (86%) in group 1 (0–25 points), in 102 of 117 non-unions (87%) in group 2 (26–50 points), and in 69 of 84 (82%) in group 3 (51–75 points). The mean time to clinical healing was 7.17 ± 1.85 months in group 1, 7.30 ± 1.72 months in group 2 and 7.60 ± 1.49 months in group 3. The mean time to radiographic healing was 8.78 ± 2.04 months in group 1, 9.02 ± 1.84 months in group 2 and 9.53 ± 1.40 months in group 3.

Discussion: There are few articles in the scientific literature that examine the classification systems for non-union.

Conclusions: A statistical analysis of the first results we have obtained with the use of NUSS showed significant rates of union in all the evaluated groups. This indicates that NUSS could be an appropriate scoring system to classify and stratify non-unions and to enable the surgeon to choose the correct treatment.

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Introduction

Definition

Non-union refers to a fracture that will not heal without an additional surgical or non-surgical intervention (usually by 6–9 months). According to the US Food and Drug Administration (FDA), the diagnosis of non-union may be established “when a minimum

of 9 months has elapsed since injury and the fracture shows no visible progressive signs of healing for 3 months”. The timeframe, however, is different for each kind of fracture: a fracture of the tibial shaft is usually not considered a non-union until at least 9 months, whereas a fracture of the femoral neck can be defined as a non-union after only 3 months. Among the long bones, the tibia is the most common site for the development of non-union. The current failure rate in non-union surgery is approximately 20% [1]. To address all the factors that may be implicated in fracture non-union, several elements need to be considered, including the cellular environment, growth factors, bone matrix and mechanical stability; these comprise “the diamond concept” [2], which has further evolved into “the regenerative pentagon” when vascularisation is also considered [3].

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Classification

The most widely used classification for non-union is the Weber–Cech system, which classifies the non-union according to radiographic appearance, and this correlates with the biology of the fracture [4]. The Weber–Cech classification recognises the following types of non-union: hypertrophic non-union, which has excellent healing potential due to abundant callus formation and hypervascularity; oligotrophic non-union, which is vascularised with no callus formation; and atrophic non-union, in which there is an absence of callus formation, atrophic bone stumps and deficient bone vascularity.

Another classification was made by Ilizarov, who classified non-unions into two categories: lax and stiff [5]. Radiologically, a “lax non-union” has an atrophic bone stump that exhibits a pathological movement more than 7° and a shortening of more than 2 cm. A “stiff non-union” has a hypertrophic bone stump, a pathological movement of less than 7° and a shortening of less than 2 cm. A further classification was described by Paley and Herzenberg in terms of clinical mobility and has two main types: type A, which is bone defect of less than 1 cm, and type B, which is bone defect of more than 1 cm [6].

The current authors have recently defined different risk factors that are implicated in the pathogenesis of fracture non-union. These risk factors can be separated into general factors (sex, age, diet, diabetes, osteoporosis, muscular mass, smoking, alcohol, drugs) and local factors (fracture personality, type of fracture, exposure, infection, multiple trauma/fractures) [7–12]. The purpose of this exercise is to develop a new scoring system that considers all the risk factors to assist surgeons in the complex analysis of non-unions before conducting surgery. In 2008, we published a new classification for non-unions: the Non-Union Scoring System (NUSS) [13]. For too long patients with non-union were hardly compared with each other. With our new classification, we have attributed precise clinical and radiographic values to compare the outcomes of patients with fractures of similar complexity. The NUSS considers the bone quality, typology of primary injury, number and invasiveness of previous interventions, adequacy of previous surgery, Weber–Cech classification, bone alignment, presence of bone defect, state of the soft tissues, American Society of Anaesthesiologists (ASA) grade of the patient, and specific clinical characteristics of the patient, including clinical infection status, smoking status, use of drugs, parameters of specific blood tests (white cell count, erythrocyte sedimentation rate, C-reactive protein) and diabetes. The total score is multiplied by two. All the factors included in the scoring system have an impact on the complexity and difficulty of treatment of any non-union [14–17] (Table 1).

The NUSS recognises four groups according to severity (Fig. 1):

- Score from 0 to 25 should be considered a straightforward non-union and should respond well to standard treatments; usually the problem is mainly mechanical. The common aim of treatment is to improve stability, usually choosing a different system of fixation.
- Score from 26 to 50 should require more specialised care; usually the problem is both biological and mechanical. The treatment requires the correction of the fixation associated with a biological stimulation obtained with pulsed electromagnetic fields (PEMF), extracorporeal shock wave therapy (ESWT) or biotechnologies, such as mesenchymal stromal cells, growth factors or scaffold, in monorail therapy [18–30].
- Score from 51 to 75 requires specialised care and specific treatments. The problem is complex and is characterised by impairment of both biological and mechanic conditions.

Table 1

Non-Union Scoring System (NUSS). The total score is multiplied by two; it provides an index of severity of non-union from 0 to 100 points. A high score indicates a greater complexity.

	Score
Bone	
<i>Quality of the bone</i>	
Good	0
Moderate (e.g. mildly osteoporotic)	1
Poor (e.g. severe porosis or bone loss)	2
Very poor (necrotic, appears avascular or septic)	3
<i>Primary injury-open or closed fracture</i>	
Closed	0
Open 1° grade	1
Open 2°–3° grade (a)	3
Open 3° grade (b–c)	5
<i>Number of previous interventions on this bone to procure healing</i>	
None	1
<2	2
<4	3
>4	4
<i>Invasiveness of previous interventions</i>	
Minimally-invasive: closed surgery (screws, k-wires, etc.)	0
Internal intra-medullary (nailing)	1
Internal extra-medullary	2
Any osteosynthesis that includes bone grafting	3
<i>Adequacy of primary surgery</i>	
Inadequate stability	0
Adequate stability	1
<i>Weber and Cech group</i>	
Hypertrophic	1
Oligotrophic	3
Atrophic	5
<i>Bone alignment</i>	
Non-anatomical alignment	0
Anatomical alignment	1
<i>Bone defect – gap</i>	
0.5–1 cm	2
1–3 cm	3
>3 cm	5
Soft tissue	
<i>Status</i>	
Intact	0
Previous uneventful surgery, minor scarring	2
Previous treatment of soft tissue defect (e.g. skin loss, local flap cover, multiple incisions, compartment syndrome, old sinuses)	3
Previous complex treatment of soft tissue defect (e.g. free flap)	4
Poor vascularity: absence of distal pulses, poor capillary refill, venous insufficiency	5
Presence of actual skin lesion/defect (e.g. ulcer, sinus, exposed bone or plate)	6
The patient	
<i>ASA grade</i>	
1 or 2	0
3 or 4	1
<i>Diabetes</i>	
No	0
Yes (well controlled hba1c < 10)	1
Yes (poorly controlled hbac1 > 10)	2

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