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Reliability of the Radiographic Union Score for Tibial Fractures

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Objective: The aim of this study was to investigate the correlation between the recently developed Radiographic Union Score for Tibial Fractures (RUST) scoring system and clinical outcomes in tibial fractures.

Methods: The study included 41 patients with tibia shaft fractures who underwent intramedullary nailing between 2005 and 2010. Mean follow-up period was 26.32 (range: 12 to 48) months. Clinical outcomes were measured using the Karlström-Olerud physical function scale, VAS score and SF-36 physical function and pain scores during follow-up. RUST scores were noted after radiological evaluation.

Results: RUST scores accurately reflected healing and union of the bone ($p<0.05$). RUST scoring also showed significant correlation with widely used physical and pain scoring systems (SF-36, VAS and Karlström-Olerud).

Conclusion: The RUST scoring system appears to be a reliable tool for the evaluation of clinical outcomes in management of tibial fracture.

Key words: Nailing; intramedullary; fracture; RUST; scoring; tibia.

The tibia is the chief load-bearing bone of the leg and is under consistent mechanical stress. Deformities due to malunion, length discrepancy, arthrosis of the knee or ankle joints and other related complications emphasize the significance of appropriate management in tibial fractures. There are several treatment methods available for tibia shaft fractures, including open reduction-internal fixation, external fixation with plasters, functional brace, plaque, screws or intramedullary nailing.[1]

In 1985, Panjabi et al. reported that cortical persistence in the fracture line was the most important indicator of fracture union and this prospect has become widely accepted.[2] In 2010, Whelan et al.[3] reported a study conducted by orthopedic surgeons on the reliability of the radiological union scoring system. Despite its simplicity and consensus of its use, no studies about the correlation of this scoring system with the patients' clinical condition have been conducted. Therefore, its clinical reliability has not yet been proven.

The aim of this study was to determine the reliability of the utilization of the Radiographic Union Score for Tibial Fractures (RUST) system in routine practice and its correlation with clinical outcomes.

Patients and methods

Approval was granted by the Ethical Committee of Dokuz Eylül University. All participants completed and signed an informed consent form. Demographic data

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and other information about patients were recorded into data sheets.

Patients with tibia shaft fractures who underwent intramedullary nailing at Dokuz Eylül University, Faculty of Medicine between 2005 and 2010 were included in the study. Exclusion criteria were; history of chronic disease, peripheral neuropathy, vascular disorder or high grade arthritis as these pathologies are known to complicate bone healing process. Patients with previous fractures of the same tibia were also excluded. A total number of 41 patients were included in the study. Mean follow-up period was 26.32 (range: 12 to 48) months.

Clinical examinations were performed on both lower extremities of all patients. Functional results were documented according to the Karlström-Olerud criteria (Table 1).[4] The Visual Analog Scale (VAS) was utilized to evaluate qualitative data. Patients were asked to score their pain at the fracture site during rest and activity.[5-7]

Patients were also evaluated using the Medical Outcomes Study Short Form Health Survey (SF-36). The validity of the SF-36 was studied in Turkey by Koçyiğit et al. in 2011. Only the physical function and pain subscales of the SF-36 scale were included in the study as to correspond with our study design.[8,9]

After clinical examination, true orthogonal anteroposterior and lateral radiographs were taken and evaluated according to the RUST system. Four cortices in the tibial lines of the anteroposterior and lateral radiographs were evaluated for the persistence of fracture lines and their visibility in all cortices. Scores of 12 were the highest and 4 the lowest (Table 2 and Fig. 1).[3,10]

Statistical analysis was performed using the SPSS for Windows v15.0 (SPSS Inc., Chicago, IL, USA) software. The paired t-test was used for intragroup comparison of the parameters with normal distribution, the chi-square test for comparison of the qualitative data, the Kruskal-Wallis test for intergroup comparison of parameters without normal distribution and the Mann-Whitney U test for the detection of the group causing the difference. Results were evaluated within 95% confidence interval and p values of less than 0.05 were considered statistically significant.

Results

Mean age was 43.10 (range: 18 to 80) years. Eleven patients were female (26.8%) and 30 were male (73.2%)

Table 1. Karlström-Olerud's functional evaluation criteria.

	3 points	2 points	1 points
Pain	None	Slight	Severe
Difficulty in walking	None	Moderate	Severe limping
Difficulty in climbing stairs	None	With help	Unable
Difficulty in previous sports activity	None	Some sports	Unable
Occupational limitation	None	Moderate	Unable
Skin	Normal	Different color	Ulcer/fistula
Deformity	None	Mild	Significant
Muscle atrophy (cm)	<1	1-2	>2
Shortening of the leg (cm)	<1	1-2	>2
Movement loss in the knee (°)	<10	10-20	>20
Movement loss in the ankle (°)	<10	10-20	>20
Subtalar movement loss (°)	<10	10-20	>20

Points are given and added up based on the above criteria. Results are evaluated as follows. 36 points: excellent, 35-33 points: good, 32-30 points: acceptable, 29-27 points: moderate, and 26-24 points: poor.

Table 2. Radiographic Union Scale for Tibial fractures.

Cortex	Fracture line visible, no callus Score=1	Visible fracture line and callus Score=2	No fracture line, visible callus Score=3	Total score Minimum: 4 Maximum:12
Anterior				
Posterior				
Lateral				
Medial				

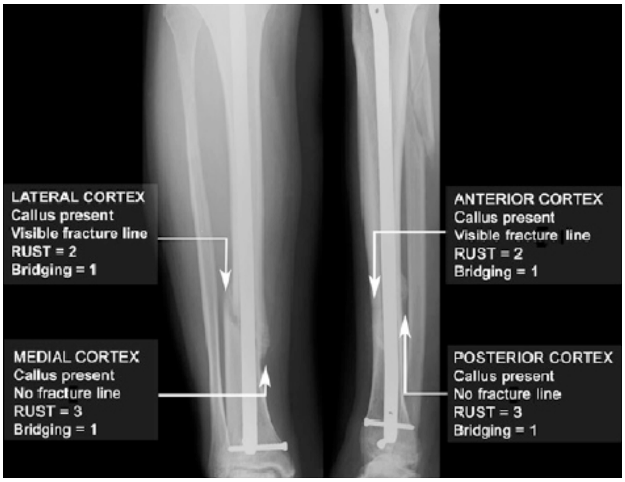

Fig. 1. Scoring of Radiographic Union Scale for Tibial fractures.

(Fig. 2). Twenty-six patients had left sided fractures (63.4%), and 15 had right sided fractures (36.6%).

Majority of the patients (28 patients [68.3%]) had additional injuries such as; ipsilateral femoral fractures (3 cases 7.3%), humeral fractures (2 cases 4.9%), radial fractures (2 cases 4.9%), and additional acetabular fracture, wrist injury (laceration), clavicular fracture, ipsilateral malleolar fracture, metatarsal fracture or ulnar fracture in 6 separate cases (2.4%).

Thirty-one patients (75.6%) had tibial shaft fractures, 6 (14.6%) had 1/3 distal tibial fractures and 4 (9.8%) had 1/3 proximal tibial fractures.

All patients with tibial shaft fractures had concurrent fibular fractures. According to the AO/OTA classification, the three most common types of fractures were 42A33 in 12 patients (29.3%), 42A22 in 11 (26.8%) and 42A23 in 7 (17.1%).

The 14 open fractures (34.1%) were classified using the Gustilo-Anderson system; 3 (7.3%) were Type 1 open fractures, 6 (14.6%) were Type 2, 3 (7.3%) were 3A and 2 (4.9%) were 3B. The remaining 27 patients had closed fractures.

Two patients (4.9%) experienced superficial infections that regressed with frequent dressing, 1 (2.4%) experienced a deep infection at the entrance site of the nail and no other complications occurred in the follow-up period after a proper debridement. Implant failure in the interlocking screws distal to the intramedullary nails occurred in 3 patients (7.3%). Fracture union was successful in all these 3 cases and no additional intervention was required.

Radiographic union scores were as follows; 12 in 17 patients (41.5%), 11 in 7 patients (17.1%), 10 in 3 patients (7.3%), 9 in 4 patients (9.8%), 8 in 4 patients (9.8%), 7 in 1 patient (2.4%), 6 in 4 patients (9.8%) and 5 in 1 patient (2.4%). All radiographic images were evaluated by the same physician (Fig. 3).

Karlström-Olerud physical function scores were 36 in 13 patients (31.7%) and in the good range of 33 to 35 in 7 (17.1%). Acceptable results (30 to 32) were found in 3 patients (7.3%), moderate (27 to 29) in 6 (14.6%) and poor (<27) in 12 (29.3%) (Fig. 4).

The VAS was performed in two sections. In the first section we asked the patients to score their pain near the fracture site during rest. Twenty-seven patients (65.9%) reported no pain, 9 patients (22%) marked 2, 2 patients (4.9%) marked 3, 2 patients (4.9%) marked 4 and 1 patient (2.4%) marked 1 in the scale. Visual analog scale scores about pain during daily activities ranged between 1 and 8 points (from the least to worst pain)

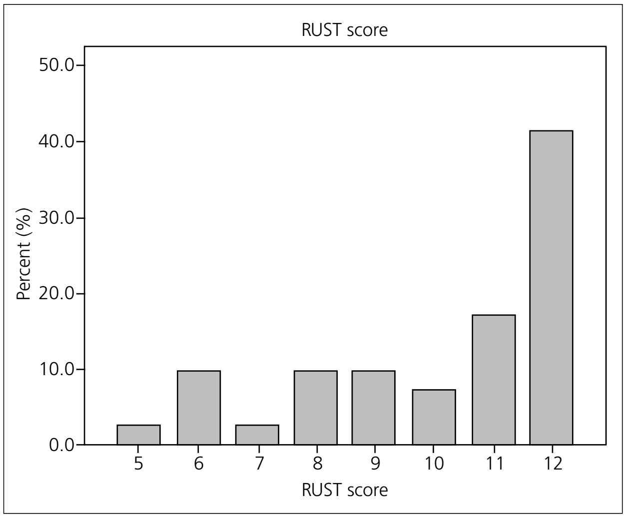

Fig. 2. RUST score distribution.

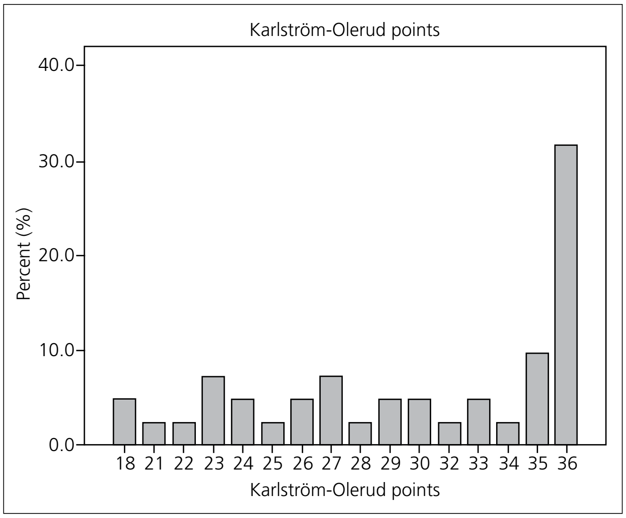

Fig. 3. Karlström-Olerud score distribution.

and were marked by 28 (68.3%) patients. Thirteen patients (31.7%) reported no pain.

SF-36 physical function and pain scores were also measured. Physical function and pain scores of 100 were reported in 11 patients (26.8%). The other 30 patients' scores (73.2%) demonstrated a wide distribution between 0 and 85 (Figs. 2 and 5).

Among the patients with the highest (12 points) RUST scores, the lowest Karlström-Olerud score was 24, the highest VAS resting score 0, the highest VAS activity score 7, the lowest SF-36 physical function score 75 and the lowest SF-36 pain score 41.

In patients with the lowest RUST score (5 points), the Karlström-Olerud score was 22, the VAS resting score was 4, the VAS activity score was 8, the SF-36 physical function score was 0 and the SF-36 pain score was 12.

Karlström-Olerud score demonstrated a correlation with the RUST score (p=0.000). The p value between these two parameters was significant (Fig. 6).

When the RUST score was compared to the VAS resting and activity scores, the coefficient of correlations were -0.463 and -0.541, respectively. P values were 0.002 and 0.000, respectively. The higher the RUST score, the lower VAS resting and activity scores were (Fig. 7).

P values were also zero when the RUST score was compared to the SF-36 physical function and pain scores separately. The correlation coefficients were 0.710 and 0.702, respectively. According to these data, significance was observed between the RUST and the SF-36 scoring systems (Figs. 8 and 9).

Karlström-Olerud score, VAS resting and activity

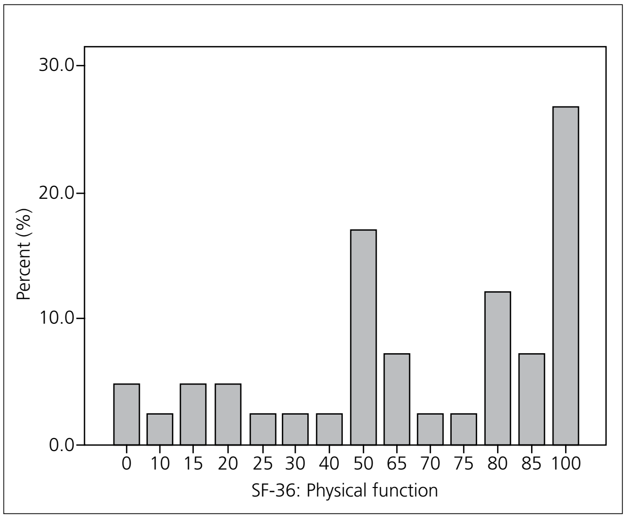

Fig. 4. Distribution of physical function scores.

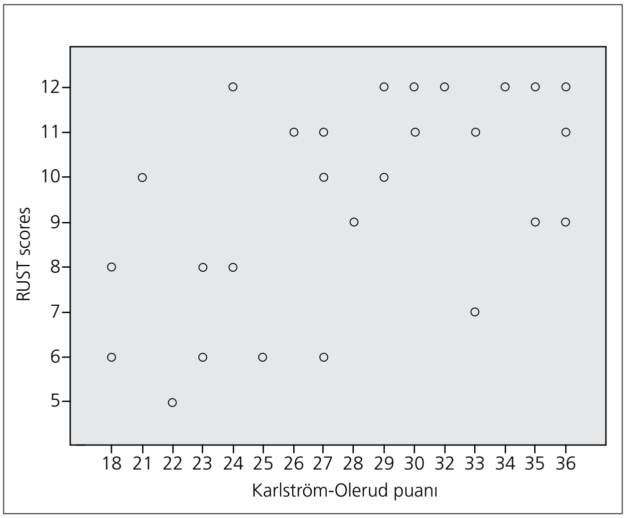

Fig. 6. Comparison of RUST scores with Karlström-Olerud scores.

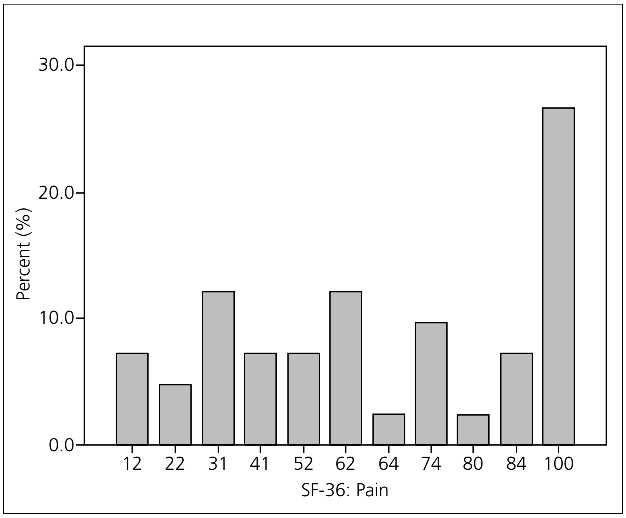

Fig. 5. Distribution of SF-36 pain scores.

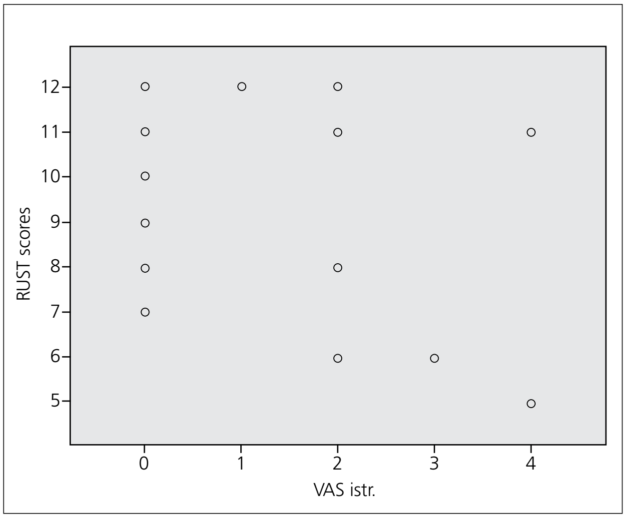

Fig. 7. Comparison of RUST scores with VAS resting scores.

scores and SF-36 physical function and pain scores were all cross-analyzed to investigate the compliance within each parameter, despite the significant correlation between parameters and the RUST score (Table 3) (Fig. 10, 11 and 12).

No statistical significant difference was observed between other parameters. Generally, those with high Karlström-Olerud score had low VAS resting and activity scores and high SF-36 physical function and pain scores.

Discussion

While various studies have tried to reveal the success of different scoring systems in defining the union of fracture site, no consensus has been achieved.[11-14]

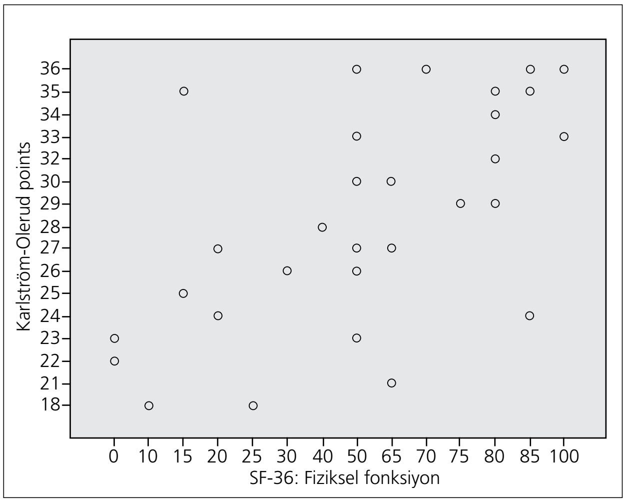

Fig. 10. Comparison of Karlström-Olerud scores with SF-36 physical function scores.

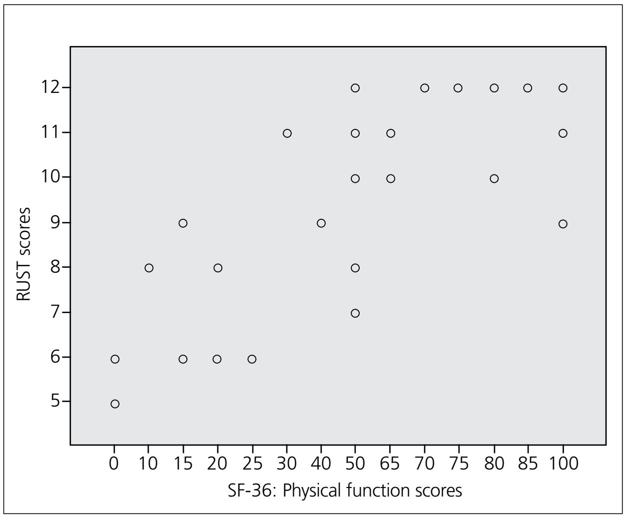

Fig. 8. Comparison of RUST scores with SF-36 physical function scores.

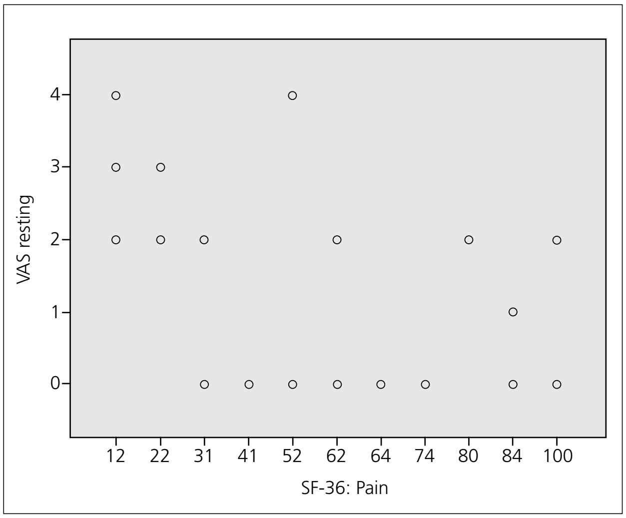

Fig. 11. Comparison of VAS resting pain scores with SF-36 pain scores.

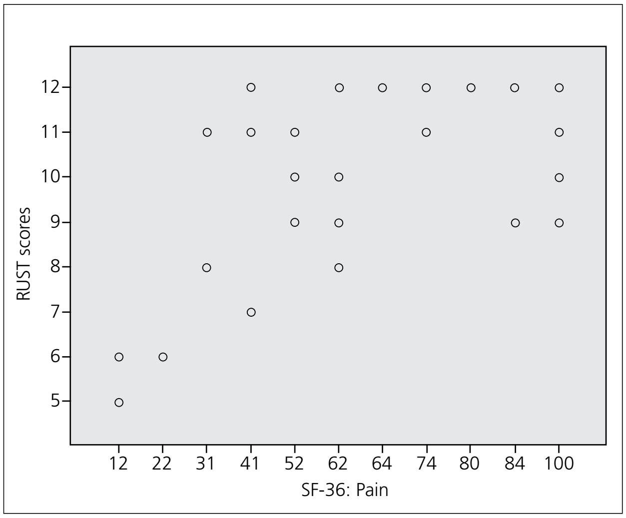

Fig. 9. Comparison of RUST scores with SF-36 pain scores.

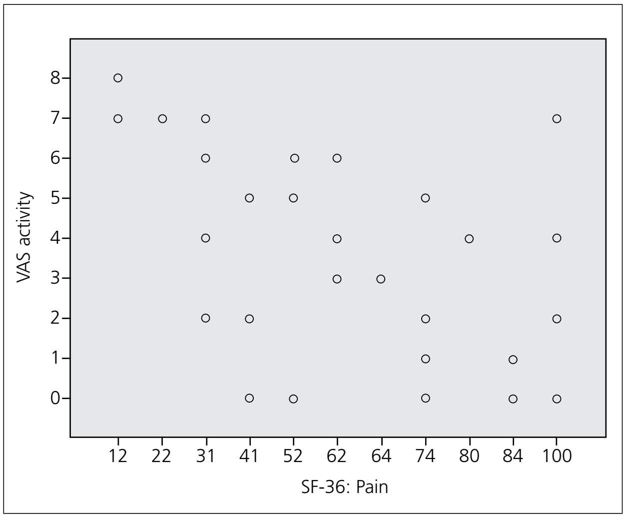

Fig. 12. Comparison of VAS activity pain scores with SF-36 pain scores.

Table 3. Cross-analysis results of all parameters.

	RUST score	Karlström-Olerud score	VAS resting score	VAS activity score	KF-36 physical function score	KF-36 pain score
RUST score						
Correlation coefficient	1.00	0.637	-0.463	-0.541	0.710	0.702
p value	0.000	0.000	0.002	0.000	0.000	0.000
Karlström-Olerud score						
Correlation coefficient	0.637	1.000	-0.534	- 0.837	0.767	0.728
p value	0.000	0.000	0.002	0.000	0.000	0.000
VAS resting score						
Correlation coefficient	-0.463	-0.534	1.000	0.629	-0.523	-0.578
p value	0.002	0.000	0.000	0.000	0.000	0.000
VAS activity score						
Correlation coefficient	-0.541	-0.837	0.629	1.000	-0.671	-0.692
p value	0.000	0.000	0.000	0.000	0.000	0.000
SF-36 physical function score						
Correlation coefficient	0.710	0.767	-0.523	-0.671	1.000	0.861
p value	0.000	0.000	0.000	0.000	0.000	0.000
SF-36 pain score						
Correlation coefficient	0.702	0.728	-0.578	-0.692	0.861	1.000
p value	0.000	0.000	0.000	0.000	0.000	0.000

Corrales et al. reported that only 62% of studies investigated both clinical and radiological fracture union.[15] The most frequently utilized radiological criteria was the visualization of bridging callus at the fracture site. This was followed by demonstration of bridging in 3 cortices and cortical persistency.[9,16]

Sarmiento et al. suggested that successful union may be possible in the presence of 3 criteria; no pain in the fracture region during weight-bearing, no movement on the fracture line, and visible callus formation on the fracture line in radiography.[17]

Plain radiographs, radionuclide imaging, computed tomography, ultrasonography and resonance frequency analysis have yielded good results in defining fracture consolidation. However, their utilization in routine practice is both expensive and troublesome.[18-22]

Many authors have advocated the visualization of callus bridging in at least two different radiographs as criteria of "fracture healing".[20,23,24] The most commonly used criteria for radiological investigation of the consolidation of long bone fractures in different studies were callus bridging (bone or trabecula), 3-dimensional bridging of the fracture line and disappearance of the fracture line.[25] However, consideration of bridging in three instead of four cortices of the bone for evaluation has yielded unacceptable faulty outcomes.[15,26] It has been reported by various studies that cortical persistency is a strong indicator of torsional resistance of the fracture, whereas development of callus area is a weaker indicator.[2,27]

Conversely, some authors advocated the necessity of fresh bone formation, disappearance of the fracture line and visualization of remodeling for determination of adequate fracture healing.[2,28,29]

The reliability of radiological evaluation in fracture healing is controversial due to the absence of a gold standard method for the radiographic assessment of bone healing.[30-33] Therefore, the aim of this study was to conduct a patient-based retrospective investigation about the reliability of the RUST scoring system in patients with tibial fractures by using both the clinical properties of the patients and the clinical evaluation scales mentioned above.

We observed that RUST scores were directly matched to the patients' clinical conditions. It was observed that callus bridging in two or three cortices and/or fracture line disappearance were not visualized on radiological images of the patients with high pain scores. We determined that the RUST scoring system was accurate enough to reveal both radiological and clinical union problems in the tibial bone. Utilization of this system starting from the preoperative period and collecting data until consolidation of the fracture will provide much more accurate results.

As the RUST scoring system is based on the visualization of the cortical zone of the bone, it can certainly be used for other long bones as well. The scoring system uses the same criteria for the femur, forearm and humerus but these bones have different dynamics during fracture union. For this reason, more studies regarding different bones should be conducted for standardization of results.

This scoring system may also be used with other fixation techniques, such as plate-screw fixation and external fixation. However, the conditions observed during fracture union such as callus tissue formation, endosteal bone formation rate and the disappearance of the fracture line may differ according to the type of the technique used in procedure.

It is unknown whether any different scores may be obtained if these surveys are performed at different periods during fracture healing. Patients may experience pain around the tibial entry point or incision scars for a long time after the procedure and also interlocking tibial nailing can cause persistent pain even if the fracture consolidates. Therefore, one-time application of these surveys may be considered as a limitation of the study. An additional limitation was that the same observer was used throughout the study. More realistic results may be obtained with evaluation of the patients by different observers.

In conclusion, the RUST scoring system may be promising in the future. However, it is a very recent classification system and is not expected to be used solely in daily practice by orthopedic surgeons in the near future. On the other hand, the standardization of a new and easy to use scoring system of bone healing will provide an important contribution to scientific development. Studies with larger sample sizes and different patient profiles should be conducted to develop this new scoring system. This scoring system can be instructive for the development of other new systems that are applicable to different bones and are more practical to use.

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Conflicts of Interest: No conflicts declared.

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