

Is There an International Consensus as to How to Assess Fracture Healing Based on Clinical and Radiological Findings?

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Purpose: The lack of consensus and variability among orthopaedic surgeons in the assessment of fracture healing was reported in the literature. The aim of the study was to survey orthopaedic surgeons as to how they do this in clinical practice.

Methods: Orthopaedic surgeons / fracture researchers personally involved in fracture treatment were surveyed over the Internet. Personal e-mails containing an individual invitation to respond on the Internet-based survey were sent to 350 corresponding authors of articles published on fracture treatment. Additionally, an invitation was shared over orthopaedic trauma groups on social network portals. Eighty orthopaedic surgeons / researchers responded to the survey. We created an International Survey on Fracture Healing Assessment Methods through the survey portal (mini-ankiety.pl). The link to the survey was sent in every e-mail (<http://www.mini-ankiety.pl/Survey/Take/30>).

Results: The survey respondents came from 23 countries (Australia, Austria, Belarus, Canada, China, Colombia, France, Germany, Greece, India, Italy, Japan, Kazakhstan, Malaysia, Nigeria, Poland, Russia, Serbia, Sweden, Switzerland, Ukraine, USA, and Uzbekistan). Forty of them were Board-certified and forty during their residencies. The average age of respondents was 42.09 years (standard deviation 12.21). 83.75% consistently or ordinarily use specific clinical criteria to define a fracture union. Physical examination criteria are regularly or usually observed as follows: the absence of pain or tenderness on palpation, 87.50%; the absence of pain/tenderness when bearing weight, 95%; no pain/tenderness on examination, the ability to bear weight, 90%; and the ability to walk/perform activities of daily living with no pain, 82.50%. Any kind of fracture stiffness mechanical measurement is performed regularly or usually in 27%. Ultrasound propagation measurement, vibration analysis, impulse response analysis, or resonant frequency analysis are not performed in 67.5% to 85%. Radiographic modalities are constantly used by 92.5% of surveyed professionals. Surgeons rarely declared the regular use of advanced imaging technologies (CT - 7.5%, ultrasound - 6.25%, MRI - 5%, and scintigraphy - 3.75%). Interestingly, only 31.25% of international respondents always use AO/OTA fracture classification, 17.5% usually, 20% often, 18.75% sometimes, and hardly ever 12.5%. Semiquantitative scoring is seldom performed (7.5% - 8.75%). Bone densitometry (DEXA or QCT) is rarely used (11.25% and 16.25%, respectively).

Conclusion: Except for some recent approaches, fracture healing assessment studies remain semiquantitative and subjective due to the lack of consensus described in the orthopaedic literature and absent internationally proven quantitative methods. It is still not standardized in clinical practice as seen in this study. Further international incentives are mandatory to

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achieve a more standardized approach for valid and reliable clinical or radiological measures of the union, at least for the interpretation of fracture care trials. We have launched Spanish, Chinese, and Japanese versions of the survey already.

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Any Cortical Bridging Predicts Healing of Tibial Shaft Fractures

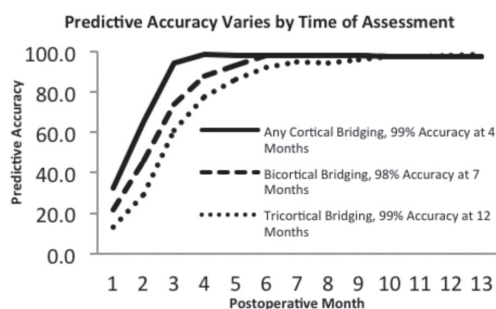
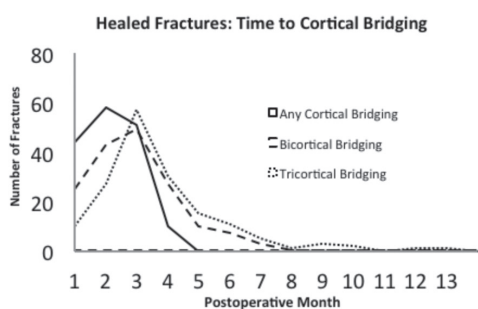
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Background/Purpose: There is no consensus regarding the optimal radiographic criteria for predicting the final healing of fractures or when these criteria should be employed. Given that healing occurs over time, the accuracy of radiographic criteria for predicting union is time-dependent. The purpose of this study was to determine the accuracy of unicortical, bicortical, and tricortical bridging in predicting the final healing of tibial shaft fractures treated with intramedullary nailing and to determine when these assessments are most accurate during the postoperative period.

Methods: A retrospective review at a Level I trauma center identified 176 tibia fractures (OTA 42-A,B,C) treated with intramedullary nailing over a 3-year period. All postoperative digital radiographs were assessed for the presence of varying degrees of cortical bridging. Receiver operating curve (ROC) and χ^2 analyses determined the accuracy of predicting union by assessing for the degree of radiographic cortical bridging at various postoperative time points.

Results: The nonunion rate was 7.4% (13 of 176 fractures). Any cortical bridging by 4 months postoperatively was an excellent predictor of final healing (accurate in 174 of 176 fractures, ROC curve area 0.995, $P < 0.0001$) and was the most reliable criterion (kappa 0.90). All fractures bridging a single cortex within the first 4 months eventually bridge three cortices with observation alone. Bridging of additional cortices did not improve the predictive accuracy (ROC curve area 0.975 and 0.990 for bridging of two and three cortices, respectively, $P < 0.0001$ for both). Additionally, these more stringent criteria were not accurate until 7 months for two cortices and 12 months for three cortices and were less reliable (kappa 0.74 for two cortices and 0.78 for three cortices).

PAPER ABSTRACTS



Conclusion: Assessment for any cortical bridging by 4 months postoperatively accurately predicts final healing of tibial shaft fractures and has a high reliability. This relatively early radiographic finding discriminates between fractures achieving late union with observation alone and those destined to nonunion. Requiring additional cortices to be bridged does not

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add predictive value and risks overestimation of the nonunion rate. Assessment for any cortical bridging at 4months may guide early intervention in appropriate patients while avoiding unnecessary surgery in others.

Ultrasonographic Monitoring of Fracture Healing: Is This the End of Radiography in Fracture Follow-ups?

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Purpose: This study was conducted with the aim to compare the efficiency of ultrasonography and radiography in monitoring fracture healing process and to further define the role of ultrasonography in following-up fracture cases. The hypothesis was that fracture healing, being a soft-tissue process in the earlier stages with bone formation occurring only in the later stages, should be better monitored by a modality evaluating soft tissues like ultrasonography, unlike radiography, which basically evaluates hard structures like bones.

Methods: A prospective follow-up study was conducted at the department of orthopaedics of a tertiary care center from October 2011 to October 2012. The study included 48 (male = 32, female = 16) cases of acute closed fracture of tibial diaphysis located in the mid-third. All the cases were treated by closed reduction and internal fixation with reamed static locked tibial interlocking nail, as soon as possible. All the patients were followed up for an average period of 24 weeks (range, 14-52 weeks). For every case, fortnightly evaluation was done using both ultrasonography and radiography. Ultrasonographic criterion for fracture healing was set as progressive appearance of periosteal callus with complete disappearance of nail at union. Radiographic criterion for fracture union was set as appearance of bridging callus at all the four cortices.

Results: Most of the cases were in the age group of 22 to 33 years and 80% of the total cases were result of road traffic accidents. 40% of the cases were classified as OTA 42-A2 fractures. Categories OTA 42-A1, A3, B1, and B2 constituted 17%, 23%, 10.5%, and 10.5% of the cases, respectively. Out of 48 cases, 38 achieved union, 4 went into non-union, and 6 developed delayed union. It was observed that using the above criteria, fracture union can be diagnosed at an average of 2 weeks earlier on ultrasonography as compared to radiography. Four out of six cases of delayed union and all nonunion cases also declared themselves much earlier on ultrasonography than radiography.

Conclusion: Use of ultrasonography for monitoring of fracture healing process has a clear advantage over radiography. It provides valuable early information about union and also accurately predicted delayed unions and nonunions at a very early time. Thus it can be presumed that using ultrasonography instead of radiography in follow-up of fracture cases can help in early diagnosis and intervention for unfavorable fracture healing outcomes.

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