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## Comment on “A comparative study of 6-week and 12-week Radiographic Union Scores for HUmeral fractures (RUSHU) as a predictor of humeral shaft non-union”

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Dear Editor,

We read with interest the recent paper by Guevel et al.<sup>1</sup> and thank the authors for this important external validation of the Radiographic Union Score for HUmeral fractures (RUSHU).<sup>2</sup> The authors should be commended for their study, which along with recent data from another centre<sup>3</sup> endorses the RUSHU as a credible predictor of nonunion in patients with non-operatively managed humeral shaft fractures.

The authors reported good to excellent reliability for the RUSHU when measured at six (interobserver ICC 0.81, intraobserver ICC 0.69) and 12 weeks post-injury (interobserver ICC 0.88, intraobserver ICC 0.84),<sup>1</sup> comparable with our original findings (interobserver ICC 0.79, intraobserver ICC 0.91).<sup>2</sup> Although the RUSHU was specifically developed for use at six weeks post-injury,<sup>2</sup> the secondary aim of the present study was to ‘test whether a RUSHU at 12 weeks would be a better predictor of non-union’.<sup>1</sup> Perhaps unsurprisingly, the authors found that the 12-week RUSHU was indeed more accurate in predicting subsequent nonunion (false positive rate 22% at 12 weeks *cf.* 39% at six weeks),<sup>1</sup> however we note that both of these values exceed the 20% false positive rate at six weeks observed in our original study.<sup>2</sup>

In the present study there was a non-significant trend between the six-week RUSHU and development of non-union on regression modelling ( $p = 0.062$ ). However, the study cohort may not have been large enough to undertake such modelling, with only nine nonunions upon which to base the analysis. Furthermore, to include both the six- and 12-week RUSHU scores in the same model may have resulted in covariance (as they are measuring the same variable), potentially leading to the non-significant effect observed.

The authors found that progression of callus formation between the six- and 12-week timepoints was the strongest predictor of subsequent nonunion.<sup>1</sup> In Table 5, they provide some interesting data regarding the probability of nonunion on the basis RUSHU progression, in the context of a range

of six-week RUSHU scores. However, we would like to suggest to the authors and other readers that the maximum possible RUSHU is 12 (indicating bridging callus at all four fracture cortices). Therefore, with a six-week RUSHU of 8 the maximum possible score progression would be 4, with a RUSHU of 10 the maximum progression would be 2, and with a RUSHU of 12 there can be no further progression (as the maximum score has already been achieved). However, Table 5 suggests that a score progression between 0 and 5 is possible regardless of the six-week RUSHU score. Furthermore, Figure 4 suggests that all patients with a RUSHU progression of  $\geq 3$  from six to 12 weeks went on to unite, which is inconsistent with the probabilities provided in Table 5. We would welcome any clarification from the authors regarding how these results should be interpreted.

More broadly, we would invite the authors to comment upon whether a RUSHU at 12 weeks post-injury should be regarded as a ‘predictor’ of nonunion. The authors defined nonunion as ‘a lack of clinical or radiographic union at the fracture site after a period of six months’,<sup>1</sup> although many modern trauma centres (including our own) consider inadequate radiographic callus formation at 12 weeks to be essentially ‘diagnostic’ of nonunion,<sup>4–6</sup> particularly when accompanied by persistent pain and mobility at the fracture site. We agree that ‘there is an imperative to

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develop a robust system that can reliably predict humeral shaft non-unions at an earlier stage and thus guide intervention'.<sup>1</sup> However, improving the diagnostic certainty of systems such as the RUSHU – by deferring decisions about nonunion surgery until 12 weeks post-injury – should be weighed against continued pain and functional limitation for patients living with a nonunion during this extended period. There is increasing evidence in the literature suggesting that humeral shaft nonunion surgery performed beyond 12 weeks post-injury may result in inferior long-term patient-reported outcomes compared with patients who unite after initial management.<sup>7,8</sup> While we also agree that 'exposing someone to the risks of humeral shaft fracture surgery... unnecessarily is difficult to justify and something one would want to avoid',<sup>1</sup> we recommend discussion with patients regarding the potential longer-term implications of nonunion at an early stage in their non-operative treatment.

Finally, we agree with the authors that a large, prospective multicentre study would be useful in confirming the predictive value of the RUSHU.

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