3D-Printed Models Improve Surgeon Accuracy and Reliability for Recognition of Complex Elbow Fracture Patterns

Huub H. De Klerk, BS*; Jacobien Oosterhoff, MD; Bram Schoolmeesters, MD; Patrick Nieboer, MD; Denise Eygendaal, PhD; Ruurd Jaarsma, FRACS; Frank Ijpma, MD; Michel Van den Bekerom, PhD; Job N. Doornberg, MD*
Flinders Medical Centre, Adelaide, AUSTRALIA

Purpose: This study aimed to evaluate the clinical value of three-dimensional (3D)-printed models for managing patients with complex elbow fractures. Therefore, we asked the following study questions: (1) Do 3D-printed models lead to more accurate recognition of complex elbow fracture patterns? (2) Do 3D-printed models lead to more reliable recognition of complex elbow fracture patterns? (3) Do junior surgeons benefit more from 3D-printed models than senior surgeons?

Methods: 15 orthopedic trauma surgeons (7 juniors, 8 seniors) evaluated 20 complex elbow fractures for overall pattern (ie, posterior medial varus rotational injury (PMVRI), terrible triad injury, radial head fracture with posterolateral dislocation, anterior (trans)-olecranon fracture-dislocation, posterior (trans)-olecranon fracture-dislocation) and specific fracture characteristics. First, fractures were assessed based on radiographs, 2D and 3D CT; and in a subsequent round with additional 3D-printed models. Diagnostic accuracy (acc) and intersurgeon reliability (κ) were determined for each assessment.

Results: (1) Accuracy significantly improved with 3D-printed models for the total group on pattern recognition (acc2D/3D = 0.617 vs acc3Dprint = 0.690; Δacc = 0.073 [95% confidence interval (CI) 0.004-0.142]; P = 0.025). (2) A significant improvement was also seen in reliability with the additional 3D-printed models (κ2D/3D = 0.408 [moderate] vs κ3Dprint = 0.590 [moderate]; Δκ = 0.182 [95% CI 0.144-0.220]; P<0.001) for recognition of fracture patterns. Moreover, 3D-printed modeling significantly improved reliability for 6 of the 7 specific fracture characteristics. (3) Accuracy was comparable between juniors and seniors with the 3D-printed model (accjunior = 0.700 vs accsenior = 0.681; Δacc= –0.019 [95% CI –0.172 to –0.134]; P =0.904). Reliability was also comparable between juniors and seniors without the 3D-printed model (κjunior = 0.399 [fair] vs κsenior = 0.433 [moderate]; Δκ = 0.034 [95% CI –0.033 to –0.101]; P = 0.318); however, junior surgeons showed greater improvement regarding reliability than seniors with 3D-printed models (κjunior = 0.648 [substantial] vs κsenior = 0.536 [moderate]; Δκ= 0.112 [95% CI 0.041-0.183]; P = 0.002).

Conclusion: 3D-printed models significantly improve accuracy and reliability in recognizing complex elbow fracture patterns compared to conventional imaging. As juniors benefit more in reliability, one could argue that in the setting of resident teaching, 3D-printed models may have a place in the discussion of complex cases.