

WHAT'S NEW IN ORTHOPAEDIC TRAUMA

and 74 to nonoperative treatment with a sling⁴. Patients in the nonoperative group had significantly higher rates of nonunion (23% compared with 2%; $p < 0.0001$) and revision surgical procedures to treat a nonunion (13% compared with 1%; $p = 0.006$). The rate of a secondary surgical procedure was 27% in the operatively treated group (17% for elective plate removal) and 17% in the nonoperatively treated group ($p = 0.18$). There was no difference between the groups with respect to the Constant and DASH scores at any time points. Nineteen percent of the patients in the operative group had persistent loss of sensation around the scar. The authors concluded that although the rate of nonunion was lower with surgical fixation, the procedure did not improve shoulder function or general symptoms and did not decrease limitations compared with nonoperative treatment.

A meta-analysis was performed to compare the outcomes of anteroinferior and superior plate placement for fixation of midshaft clavicular fractures⁵. Eight studies were included with anteroinferior plating ($n = 390$) and 27 studies were included with superior plating ($n = 1,104$). There were no significant differences between the 2 groups with respect to nonunion, malunion, implant failure, and DASH or Constant scores. Compared with the anteroinferior plating group, patients in the superior plating group had a significantly higher probability of a symptomatic implant (odds ratio [OR], 2.51; $p = 0.005$) and a significantly higher rate of a surgical procedure for implant removal (OR, 2.36; $p = 0.008$). Superior and anteroinferior plating of the clavicle leads to similar outcomes with respect to nonunion, malunion, implant failure, and function. However, plates applied superiorly are associated with higher rates of a symptomatic implant and implant removal (arguably a very subjective decision) in retrospective studies.

In an RCT comparing plate fixation with intramedullary nail fixation of displaced midshaft clavicular fractures, 123 patients were randomized: 63 to superior clavicular plate fixation, and 60 to fixation with a 2.0 to 3.5-mm titanium elastic intramedullary nail⁶. Five patients randomized to nail fixation were found to have a small medullary diameter: 2 were treated with plate fixation, 1 sustained bending of the nail during insertion and healed in that position, and 2 had fixation with a smaller-diameter nail that went on to failure and required revision open reduction and internal fixation with a plate. Plate fixation provided a faster functional recovery in the first 6 months (higher DASH and Constant scores), but there was no difference after 1 year. The duration of the surgical procedure was shorter for the elastic intramedullary nail group at 53 minutes compared with 70 minutes for the plate fixation group ($p < 0.001$). However, nails were associated with a significantly higher rate ($p < 0.001$) of implant removal at 63% compared with 8% for the plate fixation group. Nails also were associated with a significantly slower recovery ($p < 0.05$) with comminution involving ≥ 3 fragments. Plate fixation is associated with a faster recovery in comminuted fractures and is the

superior method of fixation for these fractures in general. An elastic intramedullary nail is associated with a high rate of implant removal, but it may be used in midshaft fractures with no comminution and a wide medullary canal.

A retrospective study of clavicular fractures examined the effects of ipsilateral rib fractures on clavicular fracture stability. This review of 243 midshaft clavicular fractures at a level-I trauma center identified 149 patients with ipsilateral rib fractures and 94 patients without ipsilateral rib fractures⁷. Patients in the ipsilateral rib fracture group were more likely to have $>100\%$ displacement of the clavicular fracture (78% compared with 54%; $p = 0.0047$) and a high rate of the clavicular fracture progressing from $<100\%$ to $>100\%$ displacement (72% compared with 54%; $p < 0.05$). In addition, fractures involving ribs 1 to 4 significantly increased the rate of the clavicular fracture being $>100\%$ displaced (OR, 4.08; $p < 0.0002$), whereas this was not noted in fractures of the lower ribs. The presence of ipsilateral rib fractures increases the risk of initial clavicular fracture displacement, especially if it involves ribs 1 to 4.

Ribs

A meta-analysis was conducted to assess the cost-effectiveness of surgical fixation of flail chest injuries⁸. Twenty studies were included, for a total of 1,633 patients. Compared with nonoperative treatment, operative treatment resulted in decreased mortality (risk ratio, 0.44), pneumonia (risk ratio, 0.59), tracheotomy (risk ratio, 0.52), length of time in the intensive care unit (3.3 days), and total length of stay (4.8 days). Operative fixation was associated with increased costs (\$23,682 compared with \$8,629 per case) as well as improved outcomes (32.60 quality-adjusted life-years [QALYs] compared with 30.84 QALYs), giving it an incremental cost-effectiveness ratio of \$8,577 per QALY. This is well below the generally accepted threshold of \$50,000 per QALY. Surgical fixation of rib fractures sustained from flail chest injuries resulted in improved outcomes and was a cost-effective intervention.

Humerus

The authors of a number of recent studies have commented on a higher nonunion rate with functional bracing of humeral shaft fractures, in contrast to prior reports. A retrospective cohort study of 84 patients with humeral shaft fractures treated nonoperatively showed fracture union in 87% by a mean time of 18 weeks⁹. The study determined that if there was motion at the fracture site on a physical examination at 6 weeks after the injury, progression to fracture union was unlikely. Of the 11 patients who had motion at 6 weeks, only 1 went on to fracture union and 8 chose to undergo surgical fixation at a mean time of 8 months. Clinical examination of fracture motion at 6 weeks should be performed to determine which patients are at a higher risk of nonunion. This information can be used for patient counseling and shared decision-making with regard to appropriateness of transitioning to surgical fixation.

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Elbow

An RCT was conducted comparing tension-band wiring with plate fixation (with a precontoured, nonlocking dorsal proximal ulnar plate) of displaced olecranon fractures¹⁰. Sixty-seven patients between 16 and <75 years of age were randomized. The groups had similar outcomes in terms of range of motion, the Mayo Elbow Performance Score, or the DASH score at all assessment points during the 1-year follow-up. However, complication rates were significantly higher ($p = 0.042$) in the tension-band wiring group (63%) compared with the plate group (38%), predominantly because of a higher rate of implant removal in symptomatic patients (50% in the tension-band wiring group compared with 22% in the plate group; $p = 0.021$). Loss of reduction was twice as common in the tension-band wiring group (27%) compared with the plate group (13%), although this difference was not significant ($p = 0.206$). Although more expensive, the use of a precontoured plate may have some advantages in this setting by decreasing reintervention rates.

Pelvis

A retrospective study at a level-I trauma center assessed whether advanced imaging is necessary in the evaluation of pelvic fractures caused by low-energy trauma in elderly patients (age ≥ 60 years)¹¹. All geriatric patients with low-energy pelvic fractures were treated nonoperatively with weight-bearing as tolerated with an assistive device. Eighty-seven patients were assessed, of whom 42 had radiographs and advanced imaging (32 had computed tomography [CT] and 10 had magnetic resonance imaging [MRI]) to evaluate the posterior pelvic ring, and the remaining only had radiographic assessment. In the group with radiographs and advanced imaging, more posterior pelvic ring injuries were identified with advanced imaging (62%) compared with radiographs alone (5%) ($p < 0.001$). However, displacement of >1 cm at presentation and 6-week follow-up was unaffected by the presence of a posterior injury diagnosed on advanced imaging, and there was no difference in the length of hospital stay and readmissions. The authors concluded that, given the lack of effect on displacement and length of stay despite identification of posterior ring injuries on advanced imaging, the use of advanced imaging in elderly patients with low-energy traumatic pelvic ring fractures may not be necessary.

Hip

A multicenter database study was conducted to assess the prevalence of surgical delay in geriatric patients with hip fracture, as well as the risk factors and complications associated with such delay¹². A total of 4,215 patients were identified, of whom 78% experienced a surgical delay of ≥ 1 day, 31% experienced a surgical delay of ≥ 2 days, and 11% experienced a surgical delay of ≥ 3 days. There was a significant difference in complications if patients experienced a surgical delay of ≥ 2 days ($p < 0.01$). Using multivariate analyses, risk factors associated

with a delay of ≥ 2 days were identified as congestive heart failure (OR, 3.09) and body mass index of ≥ 40 kg/m² (OR, 2.31). Subgroup analysis revealed that patients undergoing total hip arthroplasty were not at risk for complications with a surgical delay of ≥ 2 days. A surgical delay of ≥ 2 days in hip fracture surgical procedures is common and is associated with an increased risk of complications in those undergoing procedures other than total hip arthroplasty. Intervention prior to 48 hours from hospital admission is recommended when possible.

A health-care database study from Ontario, Canada, reviewed outcomes of hip fracture surgical procedures performed after hours (weekdays 5 P.M. to 12 A.M. or weekends 7 A.M. to 12 A.M.) compared with those performed during normal working hours (weekdays 7 A.M. to 5 P.M.); no procedures were performed overnight (12 A.M. to 7 A.M.)¹³. In total, 87,647 patients with an age of ≥ 60 years who had sustained a hip fracture were identified. An after-hours surgical procedure was performed in 68% of patients. Adverse outcomes were similar whether the surgical procedure occurred during normal hours or after hours. After-hours fixation of hip fractures is standard in this health-care system, but it does not appear to increase adverse outcomes. This information can be used when addressing a hip fracture prioritization strategy.

A study from the Netherlands showed 12-year outcomes of an RCT comparing hemiarthroplasty with a cemented implant ($n = 137$) and total hip arthroplasty with a cemented implant ($n = 115$) in active elderly patients (≥ 70 years of age) with a displaced femoral-neck fracture¹⁴. In total, 252 patients were included, with a mean age of 81 years, and 81% of patients were female. Patients were excluded if they had advanced radiographic osteoarthritis, rheumatoid arthritis, or senile dementia or if they were bedridden or were unable to move from the bed to the chair. Only 50 patients (20%) were alive and completed the 12-year follow-up. At 12 years postoperatively, there were no significant differences in the mean modified Harris hip score, mortality, complications, or rate of a revision surgical procedure between the 2 groups. At 12 years after the injury, patients with hip fracture had a mortality rate of 80% and similar outcomes and complications if treated with hemiarthroplasty or total hip arthroplasty.

Femur

A small, multicenter RCT investigated the use of the Reamer-Irrigator-Aspirator (RIA) (Synthes) on the volume of embolic load and respiratory function during intramedullary reaming of femoral-shaft fractures¹⁵. Twenty-two patients were enrolled: 11 randomized to femoral-shaft intramedullary nailing with standard reamers (the standard reamer group), and 11 patients randomized to RIA. A continuous transesophageal echocardiogram was performed throughout the surgical procedure to assess the volume of reamings in the right atrium (preoperatively, during fracture reduction, guidewire passage, reaming, and nail insertion, and postoperatively). Using a standardized scoring

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system, there was a modest reduction in the total emboli score in the RIA group during reaming and nail insertion. However, these findings were not correlated with any change in physiologic parameters (arterial pressure, end-tidal carbon dioxide, oxygen saturation, pH, partial pressure of oxygen, and partial pressure of carbon dioxide). Use of the RIA device for femoral nailing provided a modest reduction of embolic debris during the reaming and nail insertion stages; however, this did not correlate with any change in physiologic parameters.

Tibia

The results of a prior RCT assessing the effect of low-intensity pulsed ultrasound (LIPUS) on tibial-shaft fractures treated with intramedullary nailing were used for an economic evaluation¹⁶. The study included 501 patients: 250 randomized to LIPUS and 251 randomized to a placebo device. Costs and QALYs were compared between LIPUS and placebo. The cost per device was \$3,995 in Canadian dollars. Compared with the placebo group, the mean cost was significantly higher for patients treated with LIPUS from a payer perspective (mean increase, \$3,647 in Canadian dollars; $p < 0.001$) and a societal perspective (mean increase, \$3,425 in Canadian dollars; $p < 0.001$). LIPUS also did not provide a substantial benefit in terms of QALYs gained. At the current price and effectiveness, LIPUS was not cost-effective for routine use in acute tibial fractures treated with intramedullary nailing.

Ankle

An RCT was conducted comparing the outcomes of patients with syndesmotic injuries undergoing syndesmosis fixation with a suture button (TightRope; Arthrex) ($n = 48$) and 1 quadricortical syndesmotic screw ($n = 49$)¹⁷. CT scans of both ankles were obtained at 2 weeks and 1 and 2 years after the surgical procedure. At 2 years, patients in the suture button group, when compared with the syndesmotic screw group, had higher American Orthopaedic Foot & Ankle Society (AOFAS) ankle scores (96 compared with 86 points; $p = 0.001$) and Olerud-Molander ankle scores (100 compared with 90 points; $p < 0.001$), and a lower rate of tibiofibular widening of ≥ 2 mm (20% compared with 50%; $p = 0.009$). Seven patients in the syndesmotic screw group had symptomatic recurrent syndesmotic diastasis (5 after screw removal and 2 with broken screws), compared with none in the suture button group ($p = 0.005$). Suture-button fixation resulted in improved functional outcomes scores and radiographic outcomes compared with single-screw fixation.

Another similar multicenter RCT was conducted on syndesmotic injuries: 103 patients were randomized to suture button fixation with TightRope or screw fixation with two 3.5-mm cortical screws¹⁸. Results revealed that the rate of malreduction was higher in the screw group compared with the TightRope group (39% compared with 15%; $p = 0.028$). The TightRope group had greater syndesmosis diastasis compared with the control limb (4.1 compared with 3.3 mm; $p = 0.005$)

and less fibular medialization compared with the screw group (1.04 compared with 0.3 mm; $p = 0.05$). Functional outcome measures demonstrated significant improvements over time, with no difference between the groups. Unplanned reoperations were higher in the screw group compared with the TightRope group (19% compared with 2%; $p = 0.009$), primarily because of implant removal. Although there were no differences in functional outcomes, TightRope fixation achieved a lower rate of malreduction and implant removal compared with screw fixation.

Venous Thromboembolism and Tranexamic Acid

Isolated fractures below the knee are associated with low to intermediate risk of venous thromboembolism, and there is a controversy with regard to the need for postoperative anticoagulation for these fractures. A meta-analysis of Level-I evidence was conducted to evaluate the role of chemoprophylaxis for these injuries¹⁹. Five RCTs were included, with a total of 1,181 patients. The risk of venous thromboembolism was significantly reduced with use of chemoprophylaxis with a low-molecular-weight heparin compared with placebo or no intervention (relative risk, 0.696; $p = 0.043$); however, there was no difference in the rate of clinically important venous thromboembolism (relative risk, 0.865; $p = 0.790$). There were no major bleeding events reported. Calculation of the number needed to treat revealed that treatment of 31 patients with low-molecular-weight heparin would prevent 1 venous thromboembolism and treatment of 584 patients would prevent 1 clinically important venous thromboembolism. Routine postoperative anticoagulation after surgical management of an isolated fracture below the knee in patients without risk factors for venous thromboembolism is unlikely to provide a clinical benefit.

Tranexamic acid is an antifibrinolytic drug, which has been shown to be effective in reducing blood loss and the need for transfusions after several orthopaedic surgical procedures (such as elective hip and knee arthroplasty). Two meta-analyses were performed to assess the effectiveness and safety of tranexamic acid in reducing blood loss and transfusion rates for patients undergoing fracture fixation.

One meta-analysis included studies published prior to 2016, yielding 7 studies with 559 patients²⁰. Results revealed that compared with placebo, the use of tranexamic acid significantly reduced total blood loss by 330 mL ($p = 0.009$), reduced the transfusion rate (relative risk, 0.54; $p < 0.001$), and decreased the drop of hemoglobin by 0.76 g/dL ($p < 0.001$). There was no difference between the number of venous thromboembolic events in the 2 groups.

Another meta-analysis included studies from 2014 to 2016, for a total of 12 studies (11 RCTs and 1 cohort study) involving 1,333 patients²¹. Nine studies involved patients with hip fractures, and the other studies involved femoral shaft, calcaneal, and acetabular fractures. The results of the meta-analysis revealed that, compared with the control group, the tranexamic acid group had a significantly lower risk of

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blood transfusion (OR, 0.407; $p \leq 0.001$) and less blood loss (mean difference, 304 mL; $p < 0.001$), with no significant difference in risk of symptomatic venous thromboembolic events between the 2 groups.

Tranexamic acid may be used in an orthopaedic fracture surgical procedure to reduce blood loss and transfusion rates, without increasing the risk of venous thromboembolism.

A double-blind RCT comparing tranexamic acid with placebo was conducted on patients undergoing open reduction and internal fixation to treat an acetabular fracture²². Eighty-eight patients were randomized: 42 to the tranexamic acid group and 46 to the placebo group. There were no significant differences between the 2 groups with regard to estimated blood loss, transfusion incidence, number of units transfused, or incidence of venous thromboembolism. Blood transfusion was significantly more likely to occur in patients with low preoperative hemoglobin levels, higher rates of intraoperative blood loss, or longer surgical time. The authors concluded that any potential benefit of tranexamic acid seemed to be overwhelmed by other factors, specifically preoperative anemia and surgical time. Their findings did not support the routine use of tranexamic acid in this setting.

Another RCT of tranexamic acid compared with placebo was conducted in patients with femoral-neck fractures undergoing arthroplasty²³. In this study, 138 patients with low-energy femoral-neck fractures were randomized to receive tranexamic acid (69 patients) or placebo (69 patients). The results revealed no significant difference ($p = 0.22$) in transfusion rates between the tranexamic acid group (17%) and placebo (26%). However, tranexamic acid reduced the amount transfused by 305 mL ($p = 0.0005$). Tranexamic acid was also safe, with no differences in adverse events at 30 and 90 days. Tranexamic acid administration reduced blood loss for patients undergoing hip arthroplasty for acute femoral-neck fractures.

Opioid Use

Given the recent trend in the abuse of prescription of opioids, a study examined identifying patterns of postoperative opioid misuse among patients with orthopaedic trauma²⁴. The results of the survey completed by 182 patients revealed that 19.2% of patients felt undermedicated, 12.6% admitted to using pain medications at a higher dose than prescribed, and 9.3% admitted to using external opioids. Unemployed and lower-income patients were significantly more likely to believe that their surgeon was not prescribing them enough pain medication and to use prescribed opioid medications at a higher-than-recommended

dose. Patients who were unemployed were also significantly more likely to use supplementary opioids in addition to those prescribed by their treating surgeon. An awareness of a patient's socioeconomic situation and associated risk of opioid misuse is crucial to prescribe the safest, most effective pain regimen.

Orthopaedic Trauma Association (OTA) Annual Meeting, Courses, and Web Site

The 2018 OTA Annual Meeting will take place in Orlando, Florida, from October 17 to 20, 2018. The 2019 OTA Annual Meeting will take place in Denver, Colorado, from September 25 to 28, 2019. The OTA Annual Meeting has a diverse program, and is of interest for a variety of practitioners, including orthopaedic traumatologists, general orthopaedic surgeons, residents, fellows, nurse practitioners, physician assistants, researchers, and basic scientists. The Basic Science Forum and OTA Resident Comprehensive Fracture Course will take place concurrently during the annual meeting. Further information is available at www.ota.org.

Evidence-Based Orthopaedics

The editorial staff of *The Journal* reviewed a large number of recently published research studies related to the musculoskeletal system that received a higher Level of Evidence grade. In addition to articles cited already in the Update, 8 other articles with a higher Level of Evidence grade were identified that were relevant to trauma. A list of those titles is appended to this review after the standard bibliography. We have provided a brief commentary about each of the articles to help guide your further reading, in an evidence-based fashion, in this subspecialty area.

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Buckley R, Kwek EBK, Duffy P, Korley R, Moller E, Buckley A, Schneider P. Single screw fixation compared with double screw fixation for treatment of medial malleolar fractures: a prospective randomized trial. Read at the Orthopaedic Trauma Association 33rd Annual Meeting; 2017 Oct 11-14; Vancouver, British Columbia, Canada.

In this study, 140 patients were randomized to receive either 1 or 2 screws to repair a medial malleolar fracture. Fourteen patients crossed over from the double-screw group to the single-screw group because of a small fragment noted intraoperatively. There was no difference between the 2 groups with regard to operative time or Short Form-36 (SF-36) scores, implant pain, or implant removal. Single-screw fixation resulted in no failures in fixation, malunion, or rotation.

Costa M. UK Wound management of Open Lower Limb Fractures (UK WOLFF): a randomized controlled trial of standard wound management versus negative pressure wound therapy in the treatment of adult patients with an open wound fracture of the lower limb. Read at the Orthopaedic Trauma Association 33rd Annual Meeting; 2017 Oct 11-14; Vancouver, British Columbia, Canada.

A multicenter RCT involved 460 patients with a severe, open lower-limb fracture. Patients were randomized to standard wound dressing or negative pressure wound therapy after the first surgical debridement of the open fracture. There was no difference in the Disability Rating Index, the health-related quality of life, the number of surgical-site infections, or other complications at any point in the 12 months after the surgical procedure. Negative-pressure wound therapy did not reduce the cost of treatment.

Costa ML, Achten J, Griffin J, Petrou S, Pallister I, Lamb SE, Parsons NR, FixDT Trial Investigators. Effect of locking plate fixation vs intramedullary nail fixation on 6-month disability among adults with displaced fracture of the distal tibia: the UK FixDT randomized clinical trial. *JAMA.* 2017 Nov 14; 318(18):1767-76.

A multicenter RCT in patients with acute, displaced, extra-articular fractures of the distal part of the tibia compared intramedullary nail fixation (n = 161) with open reduction and internal fixation with a locking plate (n = 160). There were improved outcomes involving the Disability Rating Index and functional outcomes at 3 months in the intramedullary nail group; however, there were no differences noted at 12 months. There were no significant differences in complications.

Davidovitch R, Goch A, Driesman A, Konda S, Pean C, Egol K. The use of liposomal bupivacaine administered with standard bupivacaine in ankle fractures requiring open reduction internal fixation: a single-blinded randomized controlled trial. *J Orthop Trauma.* 2017 Aug;31(8):434-9.

Seventy-six patients undergoing ankle fracture fixation were randomly assigned to the control group, local intraoperative sterile saline solution injection under general anesthesia, or the intervention group, local intraoperative liposomal bupivacaine and bupivacaine injection under general anesthesia. Intervention with liposomal bupivacaine improved pain relief in the immediate postoperative period and resulted in a reduction of Percocet (oxycodone with acetaminophen) ingestion.

Duckworth A, Tuck C, Rodriguez A, Murray G, Ralston S. The FaB (fractures and bisphosphonates) trial: a multicenter, double-blind, randomized controlled trial on the effect of alendronic acid on healing and clinical outcomes of

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wrist fractures. Read at the Orthopaedic Trauma Association 33rd Annual Meeting; 2017 Oct 11-14; Vancouver, British Columbia, Canada.

A double-blind, randomized, placebo-controlled trial was performed to determine if there was any difference between alendronic acid and placebo with respect to the union rate at 4 weeks after treatment in patients who were ≥ 50 years of age who had sustained a fracture of the distal part of the radius. In this study, 421 patients were randomized. There were no differences between the 2 groups with regard to rates of union at 4 weeks, 6 weeks, or 2 months. There was also no difference at any time point with regard to DASH scores, pain, grip strength, malunion rates, or the prevalence of complex regional pain syndrome.

Jansen H, Jordan M, Frey S, Hölischer-Doht S, Meffert R, Heintel T. Active controlled motion in early rehabilitation improves outcome after ankle fractures: a randomized controlled trial. *Clin Rehabil.* 2018 Mar;32(3):312-8.

In an RCT of 50 patients with unstable ankle fractures requiring postoperative partial weight-bearing for 6 weeks, patients were randomized into 2 groups: physiotherapy alone or physiotherapy with an additional active controlled motion device. The use of active controlled motion resulted in better clinical and functional results and an earlier return to work.

Matsunaga FT, Tamaoki MJ, Matsumoto MH, Netto NA, Faloppa F, Belloti JC. Minimally invasive osteosynthesis with a bridge plate versus a functional brace for humeral shaft fractures: a randomized controlled trial. *J Bone Joint Surg Am.* 2017 Apr 5;99(7):583-92.

In an RCT, 110 patients with humeral-shaft fractures were randomized to a surgical procedure with a bridge plate or nonoperative treatment with a functional brace. Bridge plating resulted in lower rate of nonunion (0% compared with 15%; $p < 0.05$). No difference was noted with regard to the SF-36 score, pain level, and Constant-Murley score.

Wu J, Faux SG, Estell J, Wilson S, Harris I, Poulos CJ, Klein L. Early rehabilitation after hospital admission for road trauma using an in-reach multidisciplinary team: a randomized controlled trial. *Clin Rehabil.* 2017 Sep;31(9):1189-200.

An RCT compared usual care with early involvement of an in-reach rehabilitation team. Telephone follow-up was conducted by a blinded assessor at 3 months for those with minor or moderate injuries and 6 months for serious or severe injuries. The intervention group received more physiotherapy and occupational therapy sessions. However, there was no difference between the 2 groups with regard to acute length of stay or secondary outcomes at hospital discharge and follow-up.