Soft tissue complications following extensile lateral compared with minimally invasive surgical approaches in the operative treatment of calcaneus fractures

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Background: Extensile lateral (ELA) and minimally invasive surgical (MIS) approaches are commonly used in the operative fixation of calcaneus fractures. The ELA has been the standard of care, but is associated with a high risk of wound complications. Minimally invasive surgical approaches have been developed to reduce these complications.

Methods: We completed a retrospective chart review of 201 patients with calcaneus fractures repaired by either ELA or MIS approaches between 2011 and 2018. We compared the incidence of soft tissue complications, including wound infections (requiring no surgical treatment) and deep infections (requiring surgical intervention), and performed multivariate regression analysis to determine independent risk factors associated with soft tissue complications and reoperation.

Results: The overall incidence of soft tissue complications was 8.1% in the MIS group compared with 28.8% in the ELA group ($p = 0.0004$). The incidence of patients with a deep infection requiring reoperation was 4.7% in the MIS group compared with 19.2% in the ELA group ($p = 0.003$). Risk factors of soft tissue complications included the presence of an open fracture (odds ratio [OR] 11.59, 95% confidence intervals [CI] 3.25–44.25) and use of ELA (OR 4.22, 95% CI 1.67–10.90). Risk factors for a deep infection requiring reoperation included the use of ELA (OR 4.43, 95% CI 1.51–13.64) and the presence of an open fracture (OR 4.00, 95% CI 0.91-15.3).

Conclusion: The ELA is associated with an increased incidence of soft tissue complications and reoperation when compared with the MIS approach. The ELA and open fractures were found to be independent risk factors of soft tissue complications and reoperation. Surgeons treating calcaneus fractures should consider using a MIS technique, provided they are able to achieve the goals of surgical management without the ELA.

Contexte : La voie latérale élargie (VLE) et les approches chirurgicales à effraction minimale (ACEM) sont couramment utilisées pour la fixation chirurgicale des fractures du calcanéus. Bien que la VLE constitue la norme de soins, elle est associée à un risque élevé de complications liées aux plaies. Pour réduire ces dernières, des approches chirurgicales à effraction minimale ont été élaborées.

Méthodes : Nous avons réalisé un examen rétrospectif des dossiers de 201 patients ayant subi une fracture du calcanéus dont l'intervention chirurgicale s'est déroulée soit par VLE, soit par ACEM entre 2011 et 2018. Nous avons comparé la fréquence des complications liées aux tissus mous, dont les infections de la plaie (sans traitement chirurgical) et les infections profondes (intervention chirurgicale nécessaire), et mené une analyse de régression multivariable pour déterminer les facteurs de risque indépendants associés à la réopération et aux complications liées aux tissus mous.

Résultats : La fréquence globale des complications liées aux tissus mous était de 8,1 % pour le groupe avec ACEM, comparativement à 28,8 % pour le groupe avec VLE ($p = 0{,}0004$). La fréquence des patients ayant présenté une infection profonde nécessitant une réopération était de 4,7 % pour le groupe avec ACEM, contre 19,2 % pour le groupe avec VLE ($p = 0{,}003$). Les facteurs de risque de complications liées aux tissus mous comprenaient la présence d'une fracture ouverte (rapport de cotes [RC] 11,59, intervalle de confiance [IC] de 95 % 3,25–44,25) et l'utilisation de la VAEL (RC 4,22, IC de 95 % 1,67–10,90). Les facteurs de risque d'infection

profonde nécessitant une réopération comprenaient le recours à la VLE (RC 4,22, IC de 95 % 1,51–13,64) et la présence d'une fracture ouverte (RC 4,00, IC de 95 % 0,91–15,3).

Conclusion : Comparativement aux ACEM, la VLE est associée à une fréquence accrue de complications liées aux tissus mous et de réopération. Les fractures ouvertes et la VLE seraient des facteurs de risque indépendants des complications liées aux tissus mous et de la réopération. Les chirurgiens traitant des fractures du calcanéus devraient envisager le recours à une technique chirurgicale à effraction minimale, à condition qu'ils puissent atteindre les objectifs de la prise en charge chirurgicale sans la VLE.

The incidence of calcaneus fractures is 10.5 per 100 000.[1] Associated with these fractures are frequent and serious wound complications and disability.[2,3] Management of intra-articular calcaneus fractures remains controversial. Multiple randomized controlled trials (RCTs) have compared open reduction and internal fixation with nonoperative treatment.[4–8] These studies have not shown a clear short-term benefit (i.e., in the first 2 yr) with surgical management;[4–7] however, improved long-term outcomes, including less chronic pain and subtalar arthritis, have been shown.[6] A recent meta-analysis of RCTs concluded that surgical treatment may improve long-term outcomes but places patients at a higher risk of surgical complications.[8]

A 2014 review reported soft tissue complications ranging from 5.9% to 25.3% of patients treated using the ELA.[9] Reported risk factors for wound complications can be divided into patient and surgical factors. Increased body mass index (BMI), smoking history, high American Society of Anesthesiologists classification scores and open injury have been shown to increase the risk of soft tissue complications.[9–11] Surgical factors have included the time from injury to surgery, tourniquet time, surgeon experience and surgical technique.[9–12]

Minimally invasive surgical approaches for calcaneus fractures were introduced to reduce the soft tissue complications associated with the ELA.[13,14] Studies have reported a decrease in wound complications with minimally invasive surgeries;[14–16] however, most were small series with few events. Our study, to our knowledge, is the largest comparative study of the ELA and MIS techniques to date, allowing statistical analysis by way of regression modelling to control for other risk factors noted in the literature.

Methods

We performed a retrospective review of medical records for all patients who underwent operative fixation of a calcaneus fracture at our institution between July 2011 and July 2018. Patients were aged 18 years or older and had a calcaneus fracture treated using either the ELA or MIS approaches. Patients treated with any other method were excluded from the study.

We obtained from the chart record the risk factors for soft tissue complications, which included age, gender, a Workers Compensation Board claim, a history of diabetes mellitus, a history of smoking, vascular disease or intravenous drug use. We also obtained details of the injury and surgery, including whether the injury was open or closed, time from injury to surgery and operative duration.

Surgical technique

The ELA group was treated using a standard L-shape approach, as described by Eastwood and colleagues,[17] with internal fixation using plates and screws.

The MIS group included patients treated with 1 of 3 different surgical techniques. One technique was closed reduction under fluoroscopic guidance and percutaneous screw fixation, previously described by Tomesin and colleagues.[18] The second technique was a sinus tarsi approach, as described by Hsu and colleagues,[19] which included using a limited 2–4 cm incision to expose the posterior facet and assess reduction. This reduction was subsequently fixed with percutaneous screws or Kirschner wires with an intermittent addition of a small fragment plate (2 or 2.4 mm).[19] Finally, the third technique, as described by Sivakumar and colleagues,[20] was arthroscopic-assisted reduction and internal fixation with cannulated screws.

The decision to use an ELA or a MIS approach was left to the surgeon's discretion. The surgeries were performed by 5 orthopedic surgeons trained in trauma situations; all 5 surgeons treated patients in both groups. When using an MIS technique, each surgeon used the technique they felt was adequate to obtain a good outcome. Both groups received the same postoperative follow-up care. All patients were placed in a non-weight-bearing, below-the-knee plaster splint. Patients attended follow-up visits at 2 and 6 weeks. Length of follow-up thereafter was determined by the treating surgeon. At each follow-up, incisions were assessed for any wound complications. Superficial and deep infections were identified by clinical assessment and recorded. Soft tissue complications were characterized as a wound needing nonsurgical management

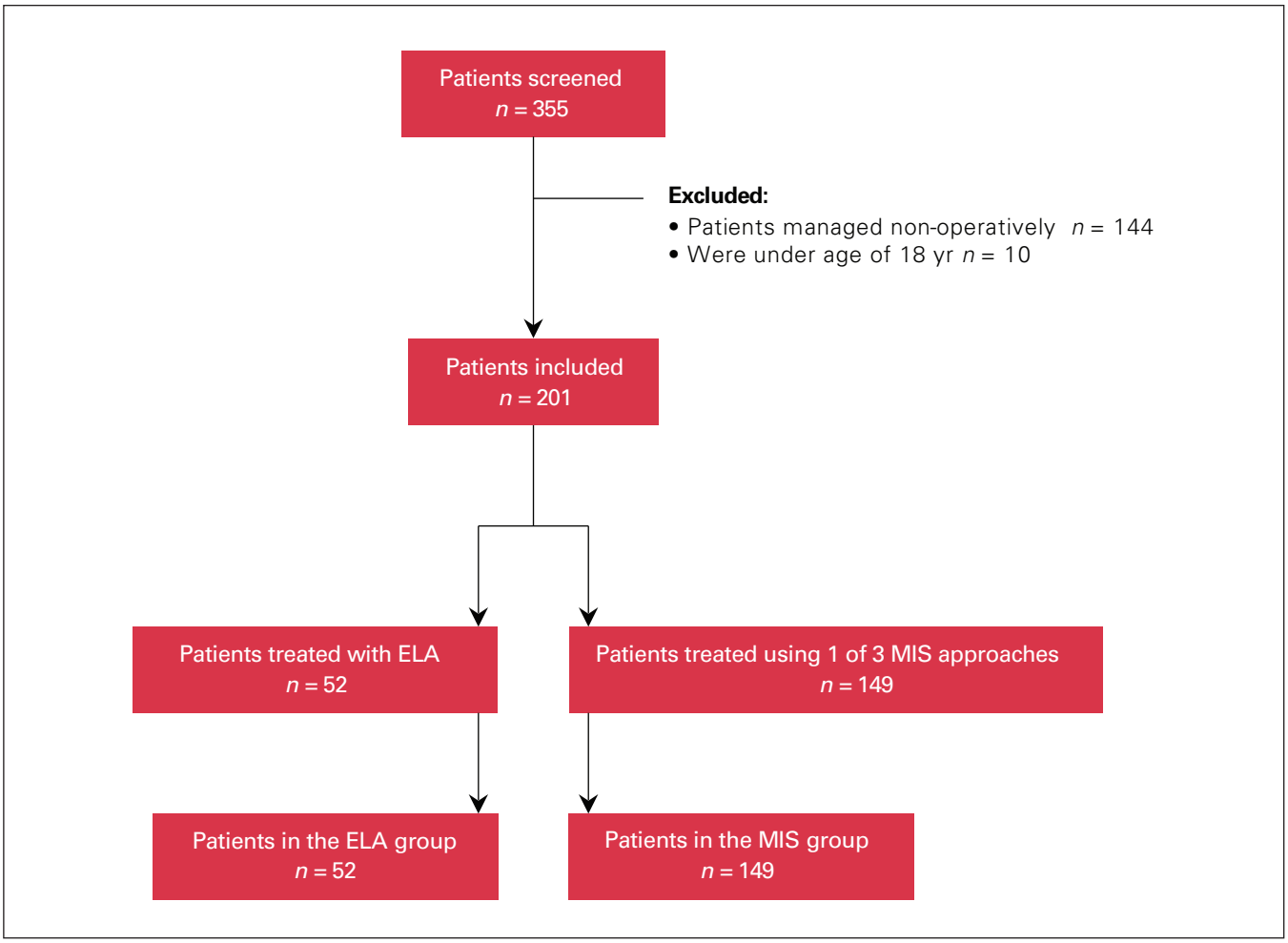

Fig. 1. Selection of study cohorts. ELA = extensile lateral, MIS = minimally invasive surgery.

(oral antibiotics and dressing changes). Deep infections were characterized by those requiring surgical debridement.[20] All patients were followed until any wound complications had resolved.

Statistical analysis

We used the χ^2 statistic to compare the incidence of soft tissue complications between groups and multivariate regression analysis to assess independent risk factors associated with increased soft tissue complications and reoperation. We generated descriptive statistics for both groups, and independent *t* tests (continuous data) or χ^2 tests (categorical data) were performed to ensure groups were comparable.

Results

We conducted an electronic search of our prospective trauma database identifying 355 consecutive patients with calcaneus fractures. We included 201 patients in the study and among those patients, 52 were treated with the ELA and 149 were treated with the MIS approach. Based on the a priori criteria, 154 patients were excluded (Figure 1). Table 1 presents the descriptive statistics for each group. Both groups had similar comorbidities, with the exception of a higher percentage of patients with peripheral vascular disease in the MIS group. Furthermore, the ELA group had more open fractures. The average follow-up was 10 months for all patients (range 1–48 mo). The average time to surgery was 136.8 hours (standard deviation [SD] 149.6) in the ELA group compared with 86.4 hours (SD 92.0) in the MIS group ($p = 0.03$). The surgical duration was longer for the ELA group at 152.3 minutes (SD 81.5) compared with 99.6 minutes (SD 39.6) for the MIS group ($p < 0.01$).

At 2 weeks, 6 patients (12%) in the ELA group had a soft tissue complication compared with 3 patients (2%) in the MIS group ($p = 0.01$) (Table 2). Among those, 2 patients (4%) of the ELA group required a second operation, whereas none were required in the MIS group ($p = 0.11$). At 6 weeks, 13 patients (25%) in the ELA group had soft tissue complications compared with

Table 1. Patient demographics and clinical characteristics

Characteristic	ELA	MIS	*p* value
Age, yr, mean ± SD	42.0 ± 14.1	43.0 ± 14.3	0.64
Sex, male/female	38/14	121/28	0.30
Last follow-up, mo, mean ± SD	10.4 ± 7.1	9.9 ± 9.1	0.72
Diabetes, *n* (%)	2 (4.0)	14 (9.0)	0.32
Peripheral vascular disease, *n* (%)	0 (0)	17 (11.0)	0.02
Smoking, *n* (%)	23 (44.0)	68 (46.0)	0.99
IVDU, *n* (%)	0 (0)	12 (8.0)	0.08
WCB, *n* (%)	7 (13.0)	25 (17.0)	0.73
Open fracture, mean ± SD	8 ± 15.0	6 ± 4.0	0.01
Time to surgery, h, mean ± SD	136.8 ± 149.6	86.4 ± 92.0	0.03
Duration of surgery, min, mean ± SD	152.3 ± 81.5	99.6 ± 39.6	< 0.01

ELA = extensile lateral, IVDU = intravenous drug users, MIS = minimally invasive surgical, SD = standard deviation, WCB = Workers Compensation Board.

Table 2. Soft tissue complications

Follow-up	ELA, *n* (%)	MIS, *n* (%)	*p* value
2 wk	6 (12)	3 (2)	0.01
2 wk Tx	2 (4)	0 (0)	0.11
6 wk	13 (24)	12 (8)	< 0.01
6 wk Tx	7 (13)	6 (4)	0.04
Total	15 (29)	12 (8)	< 0.01
Total Tx	10 (19)	7 (5)	< 0.01

ELA = extensile lateral, MIS = minimally invasive surgical, Tx = treatment.

Table 3. Secondary procedures

Procedure	ELA, *n* (%)	MIS, *n* (%)
Irrigation and debridement only	6 (12)	6 (4)
Skin graft	1 (2)	0 (0)
Free flap	2 (4)	0 (0)
Below-knee amputation	1 (2)	1 (1)
Subtalar fusion	0 (0)	3 (2)
Tendon transfer	1 (2)	0 (0)
Debridement for impingement (no infection)	1 (2)	4 (3)

ELA = extensile lateral, MIS = minimally invasive surgical.

8 patients (8%) in the MIS group (p = 0.003). Among those, 8 patients (13%) in the ELA group required a second operation compared with 6 patients (4%) in the MIS group (p = 0.04). At final follow-up, total soft tissue complications were reported in 15 patients (29%) in the ELA group compared with 12 patients (8%) in the MIS group (p = 0.0004).

The secondary procedures for soft tissue complications included 1 below-knee amputation in each group, 1 skin graft and 2 free flaps in the ELA group; the rest of the soft tissue complications required surgical debridement alone. There was no significant difference in secondary procedures unrelated to soft tissue complications (Table 3).

There was no subtalar fusion in the ELA group and 3 subtalar fusions in the MIS group (p = 0.72). The fusions were performed at a mean time of 23 months after the initial surgery.

Multivariate regression analysis showed the presence of an open fracture (odds ratio [OR] 11.59, 95% confidence interval [CI] 3.25–44.25) or the use of the ELA (OR 4.22, 95% CI 1.67–10.90) to be significant independent predictors for any soft tissue complication. Smoking history (p = 0.1), as well as diabetes mellitus (p = 0.1), were not predictive of an increased risk of soft tissue complications. When the statistical model outcome was specifically a soft tissue complication requiring reoperation, the ELA was a predictor of soft tissue complications (OR 4.43, 95% CI 1.51–13.64), and a trend was seen with the presence of an open fracture (OR 4.00, 95% CI 0.91–15.3). A history of diabetes mellitus (p = 0.23) or smoking (p = 0.68) were not statistically significant in this model.

Discussion

We compared the incidence of soft tissue complications with use of the ELA and MIS approaches in operative fixation of calcaneus fractures. The use of the ELA was predictive of an increased incidence of soft tissue complications compared with MIS. Furthermore, the ELA and open fractures were found to be independent risk factors associated with soft tissue complications and requiring reoperation.

Small retrospective series have suggested a reduction in soft tissue complications using the MIS approach.[14–16] In a recent meta-analysis, Mehta and colleagues favoured the MIS approach to decrease such complications.[15] Our results, derived from a much larger sample, are consistent with these findings.

The factors associated with soft tissue complications after calcaneus fracture were the presence of an open fracture and use of the ELA. The presence of an open fracture was associated with a more than 11-fold increased risk of a soft tissue complication compared with a closed calcaneus fracture. The use of the ELA was associated with a more than fourfold increased risk of soft tissue complication. An increased proportion of patients with an open fracture was seen in the ELA group compared with the MIS group; however, more patients with peripheral vascular disease were identified in the MIS group. After controlling for confounding variables with logistic regression, the ELA and the presence of an open fracture were found to independently predict soft tissue complications.

A previous study reported that secondary procedures (reoperation) were more likely with an ELA; however, this finding was not statistically significant.[15] This was potentially owing to a smaller sample size. We used an ELA, which was found to increase the odds of requiring a secondary procedure to treat a wound complication more than

fourfold. The presence of an open fracture was also found to increase this risk fourfold. We expected that there would be a difference in the severity of the soft tissue complications; however, both groups had similar rates of revision surgery.

We observed a significant difference in both groups in the time from injury to surgery. The ELA surgery required minimal swelling to minimize postoperative complications. Therefore, at our centre, if the surgeon decided to use the ELA, the patient would wait longer for surgery. Another difference was the shorter operative duration with the use of an MIS approach. Sampath and colleagues, as well as Badsile and colleagues reported an advantage to the MIS approach with decreased operative duration.[12] Our results were similar to those reported in the literature in this respect.

The use of MIS has been questioned by some given the concern for access to acquire anatomic reduction, as well as worse patient-reported outcomes. Basile and colleagues[21] showed that the use of MIS did not affect the outcome or the reduction. In our study, the postoperative reduction was not evaluated.

Backes and colleagues,[9] in a study on factors predicting soft tissue complication after ELA, reported that higher American Society of Anesthesiologists classification scores, longer time to discharge and the use of a postoperative drain were associated with increased soft tissue complications. They did not find diabetes mellitus, peripheral vascular disease, smoking, psychiatric history or increased BMI to be associated with soft tissue complications. Interestingly, Su and colleagues[10] and Wang and colleagues reported similar findings with diabetes mellitus not being associated with soft tissue complication in their multivariate analysis.[10,11] In the current series, a history of diabetes mellitus and smoking showed a trend toward increased risk of soft tissue complications; however, this was not statistically significant.

Limitations

A limitation of our study was its retrospective nature. In review of intraoperative or immediate postoperative imaging available to us, it was not deemed possible to consistently rate the quality of the articular reduction given the poor quality of the images and sometimes absence thereof. However, when using the outcome of a reoperation unrelated to soft tissue complication, 3 patients in the MIS group needed a subsequent subtalar fusion compared with none in the ELA group. Surgeons should be mindful of the possibility of a higher reoperation rate with MIS, although this finding was not statistically significant in our study.

As this was a retrospective study, the decision between ELA compared with MIS approaches was based on the surgeons' preference and therefore, selection bias could have been introduced between groups. However, both groups had similar comorbidities, except for peripheral vascular disease and the presence of open fractures. The presence of more open fractures in the ELA group can be interpreted as higher-energy fractures. Unfortunately, the radiographs of each patient were not available for review and fracture classification in this study. However, regression modelling was employed to control such confounding independent variables. In addition, we did not measure and report quality of reduction or functional outcomes between both techniques; however, a recent meta-analysis[22] showed no differences in the postoperative calcaneal height and Böhler or Gissane angle. Moreover, they reported an improved American Orthopaedic Foot and Ankle Society score in the MIS group.

Conclusion

The choice of an ELA or MIS approach is decided by the treating surgeon. Our study suggests that choosing the ELA compared with the MIS approach for calcaneus fracture fixation puts patients at a higher risk of wound complications and reoperation for soft tissue problems, and should be avoided whenever possible. The treating surgeon must balance this with their ability to restore the anatomy of the calcaneus successfully through a minimally invasive approach.

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