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Original Article

Adding glue to the surgical site after surgery for lower-extremity fractures

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ABSTRACT

INTRODUCTION. Surgical site infection is a concern after lower-extremity fracture surgery, and post-operative wound oozing may increase this risk. Applying glue to the incision could reduce oozing and thereby reduce the need for adhesive patch (AP) changes. This study compared AP change rates in adults with surgically treated lower-extremity fractures with and without the addition of wound glue.

METHODS. In this prospective cohort study, lower-extremity fractures treated surgically with implants were included, while external fixation and in-hospital deaths were excluded. Patients were enrolled over four months: two as controls and two with glue added to the wound. The primary outcome was AP change on all surgical wounds; secondary outcomes were AP change by fracture location, wound closure method and incision length (small: screw/nail; large: arthroplasty/plate). Follow-up continued throughout admission.

RESULTS. Among 339 patients, 162 received no glue and 177 received glue. The median age was 76 years, 55% were female and femoral fractures predominated. Groups were comparable at baseline. AP change occurred in 44% without glue and 35% with glue ($p = 0.097$). For large incisions, AP change was 42% without glue versus 27% with glue ($p = 0.040$). No differences were found by fracture location, surgery type or closure method.

CONCLUSIONS. Adding glue showed no significant overall reduction in AP changes. However, in large incisions, glue reduced AP changes by 15 percentage points, suggesting a benefit in this subgroup.

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Wound closure after fracture surgery is an important surgical skill that should produce a closed environment [1]. However, oozing from the wound remains a common problem, creating a wet environment around the wound, thus increasing the risk of infection [2]. Therefore, it is important to improve treatment to reduce oozing.

One option is to add glue to the surgical wound. When glue comes into contact with the skin, it forms an artificial barrier that holds the wound together [3]. In recent years, four RCTs have been published on the addition of glue to the wound in elective arthroplasty surgery [3, 4]. These RCTs show reduced post-operative oozing from the surgical wound. Although the studies are on the lower extremities, none investigated fracture patients. In fracture surgery, only three studies have been published [5-7]. An RCT on acetabulum fracture showed that wounds treated with glue remain dry for an average of 4.2 days compared with 5.9 days without glue ($p < 0.032$) [5]. The two remaining studies were on hip fractures; both showed less wound oozing in the group where glue was added [6, 7]. Adding glue to the wound appears to offer a general benefit; however, this has not been

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assessed in general fracture surgery.

This study aimed, first, to compare the rate of adhesive patch (AP) change in surgically treated lower-extremity fractures in adults with and without the addition of glue to the surgical wound. Second, it aimed to assess subgroups with respect to oozing.

Methods

Study design

This was a prospective cohort study on adult patients with lower-extremity fractures. A design to minimise intervention bias was chosen, with the control and intervention periods first reversed (control-intervention), then reversed again (intervention-control). When switching back to control, this study served as a quality-control study and therefore did not require informed consent or ethical approval; only approval from the hospital board (approved 07/07/2022). This study reports in accordance with the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines [8].

Setting and participants

The study was conducted at a level 1 university hospital, and the inclusion criteria were all adult patients with surgically treated lower-extremity fractures who underwent implantation of an internal device. The exclusion criteria were no surgery, external fixation and death during admission.

On 1 February 2022, a new treatment protocol was introduced regarding the requirements for AP change. All APs used for surgery after lower-extremity fractures in adults were labelled with the number 1 and were to be changed during admission only if more than 50% of the AP was filled or if it leaked (**Figure 1**). If the AP was changed, the consecutive number was written on the AP. All AP used were from the department's standard assortment. However, the size of the AP depended on wound size.

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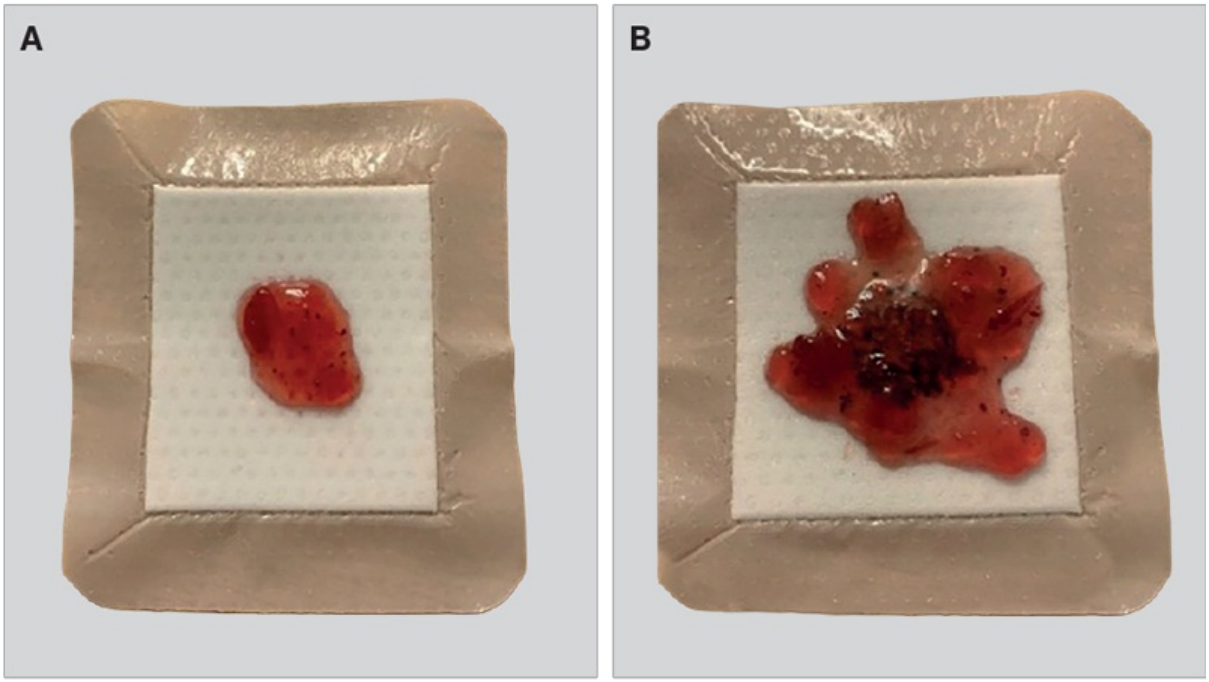
FIGURE 1 Demonstration of adhesive patch filling.
A. Less than 50% filled. **B**. More than 50% filled.



The follow-up period was the length of admission, and the number on each AP was recorded at discharge.

On 1 March 2022, glue was introduced as an intervention for all surgical fracture wounds, to be used in addition to conventional closure ar the surgeon's discretion. The intervention lasted two months (March and April). Thereafter, participants returned to the control group using no glue for one month (May). The glue used was LiquiBand Flow Control and Derma+Flex. All surgical procedures were performed by a specialist or supervised by a specialist.

Variables

All data were collected via patient records, including X-rays, and stored in an electronic database. Demographic data comprised age, sex (male, female), American Society of Anesthesiologists (ASA) score (1-5), smoking (no, former, yes), alcohol above the recommended level (no, former, yes), BMI (< 18.5, 18.5-24.9, 25-29, ≥ 30 kg/m^2) and admission length in days. Fracture classification was categorised into three groups (Arbeitsgemeinschaft für Osteosynthesefragen (AO) types A, B or C), and the surgery was grouped by anatomical region (femur, tibia and ankle/foot) and type of surgery (arthroplasty, plate, nail and screws).

The primary outcome data on AP change were retained as a binary event (yes, no) for all surgeries. The secondary outcome was AP change by location, type of surgery, wound closure method (suture or staples) and amount of AP change. During the inclusion period, another secondary outcome was planned on the length of incision using a binary category for small incisions (screw, nail) and large incisions (arthroplasty, plate) on the assumption that a larger incision would potentially ooze more than a small incision. This was based on observations made by the author team and was therefore added.

Study size

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The sample size was calculated based on a 12-percentage-point reduction in AP use [9]; with alpha set to 0.05 and power to 0.80, and allowing for a 5% dropout rate. The minimum number of patients needed was 145 in each group. Data were retrieved on the department's monthly lower-extremity fracture treatment, and a four-month inclusion period was considered sufficient. Any excess of patients would be small and would be accepted to ensure better protocol adherence.

Statistics

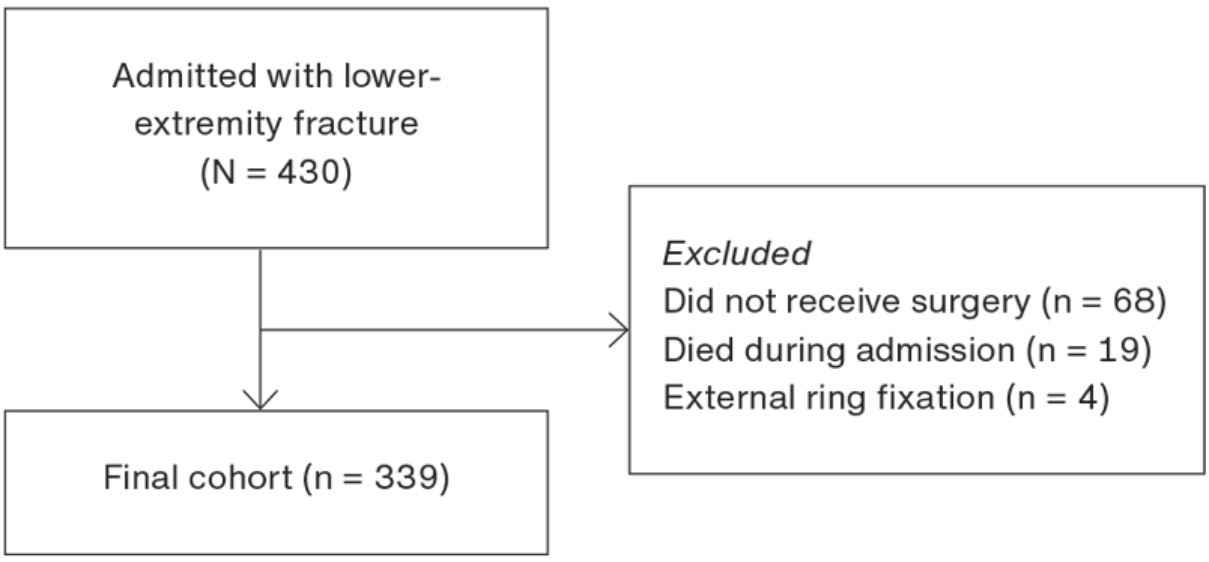
STATA 17 was used for statistical analyses. Descriptive analyses were performed. A group comparison of continuous data was conducted using the Wilcoxon rank-sum test due to non-normality. For categorical data, the χ^2-test was used. 95% CIs were calculated for proportions.

Trial registration: not relevant.

Results

A total of 430 patients were admitted with a primary lower-extremity fracture in the four-month inclusion period. However, 68 did not receive surgery, four were treated with external ring fixation and 19 died during hospitalisation (**Figure 2**).

FIGURE 2 Inclusion of patients during the four study months.



A total of 339 patients were included in the final cohort; 162 were treated without glue and 177 had glue added (**Table 1**). The median age was 76 (range: 16-100) years; 55% were females. The predominant fracture was of the femur. No statistical differences were found between the glue or non-glue group regarding age, sex, comorbidity, smoking, alcohol, BMI, fracture classification, ASA score or length of admission.

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TABLE 1 Demographic overview of the study population, divided into those who had glue added to the wound and those who did not.

	Study population	Non-glue group	Glue group	p value
Included patients, N (%)	339 (100)	162 (48)	177 (52)	
Age, median (IQR), yrs	76 (21-99)	76 (22-95)	76 (22-99)	0.731
Sex, n (%)				0.937
Male	152 (45)	73 (45)	79 (45)	
Female	187 (55)	89 (55)	98 (55)	
ASA score, n (%)				0.796
1	35 (10)	14 (9)	21 (12)	
2	140 (41)	67 (42)	73 (41)	
3	150 (44)	74 (46)	76 (43)	
4	14 (4)	7 (4)	7 (4)	
Smoking, n (%)				0.447
No	169 (50)	76 (47)	93 (53)	
Former	40 (12)	17 (10)	23 (13)	
Yes	71 (21)	39 (24)	32 (18)	
Missing	59 (17)	30 (19)	29 (16)	
Alcohol, n (%)				0.684
No	228 (67)	106 (65)	122 (69)	
Former	6 (2)	2 (1)	4 (2)	
Yes	46 (14)	25 (15)	21 (12)	
Missing	59 (17)	29 (18)	30 (17)	
BMI group, n (%)				0.296
< 18.5 kg/m²	27 (8)	11 (7)	16 (9)	
18.5-24.9 kg/m²	142 (42)	62 (38)	80 (45)	
25-29 kg/m²	81 (24)	45 (28)	36 (20)	
≥ 30 kg/m²	46 (14)	20 (15)	26 (15)	
Missing	43 (13)	24 (15)	19 (11)	
Fracture type, n (%)				0.376
AO type A	154 (45)	69 (43)	85 (48)	
AO type B	165 (49)	85 (52)	80 (45)	
AO type C	20 (6)	8 (5)	12 (7)	
Admission, median (IQR), days	5 (0-18)	5 (1-15)	5 (1-14)	0.866

AO = Arbeitsgemeinschaft für Osteosynthesefragen; ASA = American Society of Anesthesiologists.

The AP change was 44% (95% CI: 36-52%) in the non-glue group compared with 35% (95% CI: 28-43%) in the glue group (p = 0.097; **Table 2**). For the sub-analyses, the AP change in the non-glue group was 43% (95% CI: 34-52%) compared with 33% (95% CI: 25-42%) in the glue group (p = 0.132) in femur fracture surgery. Additionally, no statistical differences were found for arthroplasty, nail or plate surgery. For large incisions, the AP change was 42% (95% CI: 31-53%) in the non-glue group compared with 27% (95% CI: 18-38%) in the glue group (p = 0.049). No statistical differences were found between the groups based on staples, sutures or amount of AP change.

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TABLE 2 Data on the adhesive patch (AP) change, incl. subgroups.

	Study population	Non-glue group	Glue group	p value
All, n (% AP change [95% CI])	339 (39)	162 (44 [36-52])	177 (35 [28-43])	0.097
Femur:	248 (38)	122 (43 [34-52])	126 (33 [25-42])	0.132
Arthroplasty	96 (31)	51 (37 [24-52])	45 (24 [13-40])	0.177
Nail	105 (54)	46 (57 [41-71])	59 (49 [36-63])	0.453
Plate	22 (36)	13 (46 [19-75])	9 (22 [3-60])	0.251
Tibia	34 (26)	8 (13 [0-53])	26 (31 [14-52])	0.306
Ankle/foot	52 (54)	29 (59 [39-76])	23 (48 [27-69])	0.438
Incision:				
Small	182 (43)	83 (46 [35-57])	99 (41 [32-52])	0.554
Large	157 (34)	79 (42 [31-53])	78 (27 [18-38])	0.049
Wound closure, n (% AP change [95% CI])				
Staples	281 (37)	130 (40 [32-49])	151 (34 [27-43])	0.336
Suture	58 (50)	32 (59 [41-76])	26 (38 [20-59])	0.113
Amount of AP changes if changed, median (IQR)	1 (1-17)	1 (1-17)	1 (1-16)	0.134

Discussion

In this prospective cohort study on adult patients with lower-extremity fractures from a level 1 university hospital, we found that using glue in addition to conventional closure yielded an overall non-significant 9-percentage-point reduction in AP change. However, a statistically significant 15-percentage-point reduction in AP change was observed for large-incision surgery (plates and arthroplasty) with glue.

Our results are consistent with those reported in the current literature. Three studies have been published on fracture surgery, all focusing on lower-extremity fractures [5-7]. Mudd et al. [5] conducted an RCT including 103 acetabulum fractures, randomising wound closure between intracutaneous sutures and metallic staples. They found no statistically significant difference in their primary endpoint of wound infection, but wounds closed with intracutaneous sutures and glue were dry for an average of 4.2 days compared with 5.9 days for wounds without glue added to metallic staples ($p < 0.032$). Badres et al. [7] conducted a prospective cohort study on 468 consecutive inpatients receiving surgery for proximal femoral fractures. They had three cohorts categorised according to wound closure technique: skin staples, intracutaneous sutures and intracutaneous sutures with the addition of glue. They measured wound drainage on the third post-operative day and found a prolonged wound drainage of 21.1% in the staples group, 8.5% in the suture group and 4.4% in the suture with glue group ($p < 0.001$). Length of stay was also significantly increased in the staples cohort (5.83 days versus 4.78 days versus 5.5 days, $p = 0.005$) but not compared with the glue group. The length of stay was also assessed by Zhao et al. [6] in a retrospective study on hip fracture patients aged over 60 years at a single institution during a three-year period. They compared skin closure techniques using intracutaneous sutures and skin glue in 175 patients with staples in 211 patients. They reported that patients with sutures and glue as wound closures had, on average, a two-day shorter post-operative length of stay (five vs. seven days), with fewer interventions for wound-related complications (0% vs. 8%) than staples. These three studies demonstrate prolonged oozing from the wound

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when glue is not used in addition to sutures or staples. In our opinion, this is directly transferable to our study; however, we used AP changes as our primary outcome. In particular, we report percentage-point reductions in AP change very similar to those reported by Badres et al. [7] on their third post-operative day.

The level of evidence on the addition of glue to wound closure is higher for elective hip and knee arthroplasty surgery. In recent years, four RCTs on the addition of glue in elective arthroplasty surgery have been published [3, 4, 9, 10]. These RCTs all show reduced post-operative oozing from the surgical wound, even when using different closure techniques. Among the four studies, Gromov et al. [4] had the same primary outcome as we did but included only primary bilateral total knee arthroplasties. They included 30 patients, and knees with glue addition underwent fewer dressing changes ($p = 0.001$). Among the knees with glue, 59% did not undergo AP changes before discharge compared with 24% of the knees without glue. Therefore, we find that the evidence from the elective surgery is similar to that in our study.

A British National Health Service study on skin closure in hip and knee arthroplasty found a notable reduction in prolonged wound drainage and inpatient stay for wound exudate with the use of barbed sutures and glue compared with staples or monofilament sutures [11]. Furthermore, the study conducted a cost-benefit analysis demonstrating overall cost savings with the use of barbed sutures and glue, despite the sutures being more expensive than staples. The additional cost of using barbed sutures was outweighed by their benefit in reducing the cost of prolonged inpatient hospitalisation for wound observation.

A study comparing suture closures with staples in hip arthroplasty found that, on average, using suture closures added only five minutes to surgical time [12]. Notable cost savings can be inferred when comparing the cost of materials and surgical time for barbed suture and skin glue closure with the costs of increased length of stay, negative pressure wound therapy, and revision surgery in the staple closure group.

Our study has limitations. Although we made recommendations for when to perform an AP change, we cannot be sure that they were followed. The small-versus-large-incision analyses were not planned before the inclusion of patients. However, we recorded a difference during the study and therefore planned the analyses afterwards. We included various fractures and surgery techniques to understand the advantages and disadvantages of adding glue at different anatomical locations and adopting different surgical techniques. We find great strength in this trial, as it is highly pragmatic and demonstrates what to expect when introducing glue in a large clinic with a very large staff.

The results in our institution have led to changes in wound treatment. All larger wounds after lower-extremity fracture surgery are now closed with staples and glue. During the study, we found that sutures and glue posed a problem as the glue occasionally made removal very difficult. If glue is added to the suture, then this should probably be performed intracutaneously. Additionally, we learned that when switching to applying glue to the wound, healthcare personnel removing the staples or sutures should be informed, as we received many questions at the beginning of the glue period. The questions mainly concerned what the “white substance” was and whether there was anything they should be aware of.

Conclusions

We found no statistically significant effect on AP change when adding glue to surgical wounds. However, reported trends indicate a probable power issue, and we found a 15-percentage-point reduction when adding glue to large incision wounds after lower fracture surgery.

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