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Original Article

Outcomes of surgical management of ankle fractures in patients with diabetes

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الملخص

أهداف البحث: تعتبر العمليات الجراحية لكسور الكاحل بين مرضى السكري شائعة ويمكن أن يكون لها عواقب وخيمة ونتائج سلبية خطيرة. تم اقتراح مستوى السكر التراكمي مستهدف <8٪ في جميع العمليات الجراحية الاختيارية لمرضى السكري لتقليل النتائج السيئة. نحن نهدف إلى دراسة نتائج ومضاعفات ما بعد الجراحة بين المرضى الذين خضعوا لعملية جراحية لكسر الكاحل باستخدام مستوى السكر التراكمي كقيمة تنبؤية.

طريقة البحث: كانت هذه دراسة أترابية بأثر رجعي أجريت في مدينة الملك عبد العزيز الطبية بين يناير 2016 وديسمبر 2022 على جميع مرضى السكري الذين خضعوا للرد المفتوح والتثبيت الداخلي والذين لديهم مستوى موثق لنسبة مستوى السكر التراكمي. وقد لوحظت النتائج والمضاعفات الإشعاعية جنبا إلى جنب مع مستويات مستوى السكر التراكمي وتم تحليلها إحصائيا.

النتائج: تم تضمين أربعة وأربعين مريضا في الدراسة، 29 امرأة (65.9٪) و 15 (34.1٪) رجلا. كان نوع كسر الكاحل الأكثر شيوعا هو كسر الكاحل ثنائي الجانب (54.5٪). كان نسبة مستوى السكر التراكمي مرتفعة (54.5٪) من المرضى. كانت هناك نسبة أعلى بكثير من المرضى الذين لديهم مستوى مستوى السكر التراكمي أقل من 8% لديهم اتحاد إشعاعي مقارنة بالمرضى الذين لديهم مستوى مستوى السكر التراكمي ≥ 8%. لوحظ أن المرضى الذين لديهم مستوى مرتفع من مستوى السكر التراكمي لديهم مضاعفات أكثر على الرغم من أنها لم تصل إلى دلالة إحصائية. أظهر تحليل الانحدار متعدد المتغيرات أن العمر ومستوى السكر التراكمي كانا من العوامل المهمة لإجراء جراحة الكاحل غير المعقدة والناجحة.

الاستنتاجات: تعد النتائج والمضاعفات السيئة بعد العملية الجراحية أكثر شيوعا بين المرضى الذين يعانون من ارتفاع نسبة مستوى السكر التراكمي. يشير هذا إلى أن ارتفاع مستوى السكر التراكمي يرتبط بنتيجة علاج سيئة. قد يؤدي تحديد مستويات مستوى السكر التراكمي إلى التنبؤ بالمشاكل المحتملة بعد جراحة كسر الكاحل وتحسين نتائج الإدارة.

الكلمات المفتاحية: كسر في الكاحل؛ مرض السكري؛ مستوى السكر التراكمي؛ النتائج؛ المضاعفات

Abstract

Objective: Ankle fracture surgeries among diabetic are common and can have fatal consequences and serious adverse outcomes. A target hemoglobin A1c (HbA1c) level <8% in all elective surgeries for patients with diabetes is suggested to minimize poor outcomes. We investigated the postoperative outcomes and complications among patients who underwent ankle fracture surgery using HbA1c level as a predictor value.

Methods: This retrospective cohort study was conducted at King Abdulaziz Medical City between January 2016 and December 2022 on all patients with diabetes who underwent open reduction and internal fixation and who had a documented HbA1c level. Radiological outcomes

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and complications were noted along with the levels of HbA1c and analyzed statistically.

Results: A total of 44 patients were included in the study: 29 women (65.9%) and 15 (34.1%) men. The most frequent ankle fracture type was bimalleolar (54.5%). HbA1c was elevated (54.5%) in patients. A significantly higher proportion of patients who had <8% HbA1c level had radiological union compared to patients who had ≥8% HbA1c level ($p = 0.036$). Patients who had elevated HbA1c level had more complications although it did not reach statistical significance ($p > 0.05$). Multivariate regression analysis showed that age and HbA1c level were the significant factors for an uncomplicated and successful ankle surgery.

Conclusion: Poor postoperative outcomes and complications are more common among patients with elevated HbA1c. This suggests that an elevated HbA1c level is associated with a poor treatment outcome. Determination of HbA1c levels may predict potential problems post ankle fracture surgery and improve management outcomes.

Keywords: Ankle fracture; Complications; Diabetes mellitus; HgbA1c; Outcomes

Introduction

Ankle fractures are common orthopedic emergencies, particularly among patients with diabetes who need special attention because of their associated adverse events such as infections and disability.[1,2] Dealing with fractures remains a challenge for the health care system, treating facilities, and the patient due to cost, burden of injury, and disability.[1,3] A nationwide study in the United States had an ankle fracture incidence rate of 4.22/10,000 person-years with a higher in women than men.[4] Falls, sports, and exercise accounted for the top three mechanisms of injury in ankle fractures.[4–6]

For complete care, an assessment and treatment strategy for ankle fractures are required through evaluation of anatomical structures and type of injury, and use of a categorization system must be considered.[5,7] The presence of comorbidities such as diabetes mellitus (DM) make management more difficult and can have fatal consequences and serious adverse outcomes.[1,5] It has been demonstrated that osteoblast activity and the cellular molecular environment of the bone are altered in the presence of type 2 DM.[8,9] The severity of diabetes is significantly proportional to bone turnover and resorption and vasculature, and plays an important role in bone healing.[10,11] Regarding ankle fractures, 30% of patients with DM do not have restored function after surgery compared to patients without diabetes.[9] Amputation rate in patients with diabetes who have ankle fractures was found to be increased fivefold after surgery and was even worse if it was an open ankle fracture, increasing the percentage of amputation to 42%.[9,12] Furthermore, DM was more likely to increase the likelihood of complications in orthopedic fractures such as deep wound infection, delayed union, non-union, and surgical site infection.[9] The American Diabetes Association published a guideline that recommended a target hemoglobin A1c (HbA1c) level <8% in all elective surgeries for patients with diabetes.[13] The effect of HbA1c levels on the surgical management of ankle fracture showed a poor correlation with bone healing and higher rates of postoperative infection when the HbA1c level was >7.3%.[14,15]

This study investigated the postoperative outcomes and complications among patients who were surgically managed using HbA1c level as a predictor. The goal of this study is to bring value and expand the information and knowledge in the literature on the influence of HbA1c level in ankle surgery outcomes among patients with diabetes.

Materials and Methods

We conducted a retrospective cohort study at King Abdulaziz Medical City (KAMC), a tertiary center in Riyadh, KSA between January 2016 and December 2022. We included all patients with diabetes with ankle fracture who underwent open reduction and internal fixation and those who had a documented hemoglobin A1c (HbA1C) ≥ 6.5% within a 3-month period of the surgery. Excluded patients were non-diabetics, diabetics without a documented HbA1c level, and diabetics who were non-operatively managed for ankle fractures.

We collected the data through the BESTCare system of KAMC using a data collection sheet that contained the patients' demographic profile (age, sex), HgA1c level, type of fracture, surgical site infection, delayed wound healing, readmission within 90 days, revision surgery, radiological outcome, and complications. Regarding the follow-up period implemented for all patients were 2 weeks, 6 weeks, 3 months, and 6 months.

Data were encoded in Microsoft Excel 2019 (Microsoft, Redmond, WA, USA). Data were checked for any missing information, and new variables were recorded and computed based on the data extracted. Statistical analysis was performed using the Statistical Package for Social Sciences version 25.0 (IBM-SPSS; Armonk, NY, USA). Frequencies and percentages were used to detail categorical variables, whereas continuous variables were examined by the mean and standard deviation. The Fisher's exact test and chi-square test for association between categorical variables were used to determine the significant difference in the proportion of patients with radiological outcomes and complications. $P < 0.05$ was considered statistically significant.

Consent was not required for this retrospective cohort study, and all data were kept safe. No identification data were asked for, and privacy and confidentiality were assured. Access to research data was only given to the study group members.

Results

After inclusion and review of collected data, 44 patients were included in the study: 29 women (65.9%) and 15 (34.1%) men. Mean age was 27.1 ± 15.0 years old (15–79

Table 1: Demographic and clinical characteristics.

Characteristics	n (%)
Sex	
Male	15 (34.1%)
Female	29 (65.9%)
Fracture type	
Bimalleolar	24 (54.6%)
Lateral malleolus	9 (20.5%)
Trimalleolar	8 (18.2%)
Medial malleolus	2 (4.6%)
Posterior malleolus	1 (2.3%)
HbA1c levels	
<8%	20 (45.5%)
≥8%	24 (54.6%)

years old). Mean HbA1c was 9.0 ± 1.9% (6.5%−13.4%). Bimalleolar ankle fracture type was the most encountered (n = 24, 54.5%) followed by lateral malleolar fracture (n = 9, 20.5%). HgA1c level was ≥8% in 24 (54.5%) patients. Table 1 shows the detailed demographics of the patients.

Delayed wound healing was documented in 25 (56.8%) patients, whereas deep infection at the surgical site, readmission within 90 days after surgery, and revision surgery were each noted in 5 patients (11.4%) (Figure 1). Union was achieved in the majority of patients (n = 33, 75.0%) (Figure 2).

Table 2 shows the relationship between radiological outcome and complications with HbA1c level. A significantly higher proportion of patients who had <8% HbA1c level had radiological union compared with

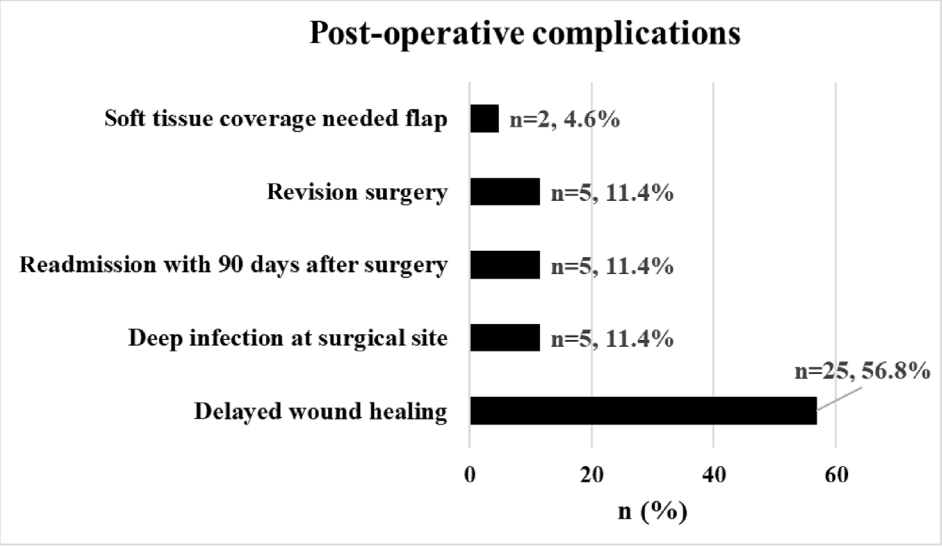

Figure 1: Post-operative ankle surgery complications.

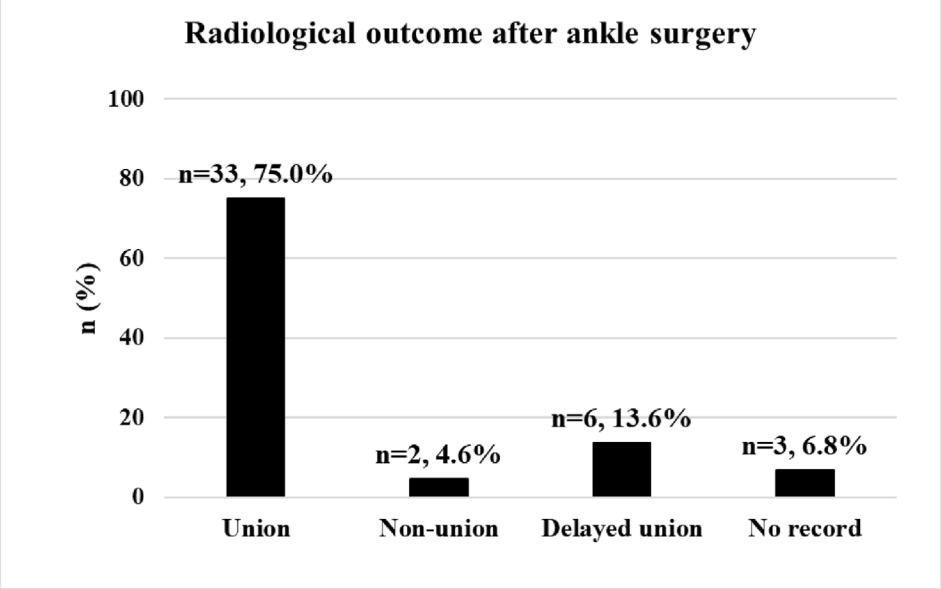

Figure 2: Radiological outcome after ankle surgery.

Table 2: Comparison of mean age and proportion of sex, radiological outcome, and complications according to HbA1c levels.

Outcome and complications	HbA1c level		p values
	<8% n = 20	≥8% n = 24	
Age in years, mean ± SD	53.7 ± 13.6	59.9 ± 15.8	0.177
Sex			
Male	8 (40.0%)	7 (29.2%)	0.331
Female	12 (60.0%)	17 (70.8%)	
Radiological outcomes			
Union	18 (90.0%)	15 (62.5%)	0.036
Non-union	0	2 (8.3%)	0.187
Delayed	2 (10.0%)	4 (16.7%)	0.522
Complications			
Deep infection (surgical site)	1 (5.0%)	4 (16.7%)	0.226
Delayed wound healing	9 (45.0%)	16 (66.7%)	0.149
Readmission within 90 days	2 (10.0%)	3 (12.5%)	0.795
Revision surgery	2 (10.0%)	3 (12.5%)	0.795
Soft tissue coverage need flap	0	2 (8.3%)	0.187
Ankle fusion	0	1 (4.2%)	0.358
Fixation failure	1 (5.0%)	0	0.267

patients who had ≥8% HbA1c level ($p = 0.036$). There were more patients who had elevated HbA1c level ≥8% had non-union and delayed union ($p = 0.187$ and $p = 0.522$, respectively), although it did not reach statistical significance. Furthermore, patients who had elevated HbA1c level had more complications observed although it did not reach statistical significance ($p > 0.05$). There was no significant difference in the mean age between patients who had elevated HbA1c and those who had <8% HbA1c level ($p = 0.177$), and no significant correlation was found between age and HbA1c level ($r = 0.194$, $p = 0.208$).

The 33 patients who reached union were significantly younger than those who had complications (54.2 ± 16.1 vs. 65.7 ± 5.4 years; $p = 0.025$). A significantly higher proportion of patients with HbA1c < 8% reached union compared to those who had elevated HbA1c ($p = 0.036$). Multivariate linear regression analysis showed that age and HbA1c level were the significant factors for reaching union and having a successful ankle surgery (odds ratio [OR]: 0.915, 95% confidence interval [CI]: 0.842–0.994, $p = 0.035$ and OR: 0.185, 95% CI: 0.035–0.992, $p = 0.049$), whereas sex (OR: 2.925, 95% CI: 0.543–15.754; $p = 0.212$) and fracture type (OR: 0.625, 95% CI: 0.329–1.192; $p = 0.153$) were not significant.

Discussion

The investigation of postoperative outcomes and complications among patients who were surgically managed using HbA1c level as a predictor value in this study revealed several findings that are worth discussing. In this study, bimalleolar ankle fracture type was the most encountered (54.5%). Bimalleolar fracture of the ankle among diabetics was reported in 17 patients with complicated DM after a failed open reduction and internal fixation.[5] When the lateral and medial malleoli at the distal extremities of the tibia and fibula are fractured, it results in a bimalleolar ankle fracture. When diabetes is undetected and people develop diabetic neuropathy, bimalleolar ankle fractures commonly occur.[16] Ischemic lesions of the toes may develop in patients with bimalleolar ankle fractures and may lead to below-the-knee amputation or even death when these patients also have infection, osteomyelitis, or other co-existing medical problems.[16–18] Elderly patients who have undiagnosed or poorly controlled diabetes and osteoporosis have higher risks to sustain bimalleolar, lateral, or medial malleoli ankle fractures.[19–21]

In this study, we found that more than half of the patients had elevated HbA1c levels ≥8%, resulting in a greater proportion of delayed wound healing and deep infection at the surgical site, leading to readmission within 90 days after surgery. Impaired wound healing among diabetics is caused by impaired circulation and uncontrolled and excessive inflammation, making it more difficult for oxygen delivery to the tissues as well as affecting the delivery of nutrients to the wounds, apart from diabetic nephropathy, which also affect wound healing.[22] Furthermore, the role of cytokines and chemokines in the wound healing process among diabetics are also defective and thought to play a major role in the wound healing process.[23]

Radiological union of fractures usually takes place by 6–12 weeks on average.[24] However, fracture healing and union depend on intact circulation, internal fixation/immobilization, and absence of infection.[24] When fracture healing takes longer, it is delayed or may even result in a non-union or permanent damage, which is common among the elderly, as well as individuals with poor nutritional status and metabolic disease such as diabetes.[24,25] Therefore, it is essential that blood glucose be monitored and controlled in order for proper fracture wound healing to occur, particularly in patients with diabetes.[26]

Poor outcomes (higher incidence of non-union and greater complication rates) were observed among patients with high HbA1c, suggesting that there is a relationship between HbA1c and treatment outcome. This study convincingly demonstrated

a relationship between HbA1c level and treatment outcome.[27] It suggests that people with elevated HbA1c level are significantly more likely to have poor treatment outcomes. To explain these findings, we hypothesized that individuals with increased HbA1c are more likely to have experienced pathological alterations in the extremities as a result of prolonged glycemic control failure. The existence of a statistically significant correlation between high HbA1c levels and unsuccessful treatment outcomes further supports this argument. Our findings also suggest that by using blood HbA1c levels as a predictive marker in the follow-up of patients who have undergone ankle fracture surgery, patients with diabetes who are more likely to experience treatment problems may be better recognized. On the other hand, doctors treating diabetes patients should be aware of the potential for problems and a subpar recovery following ankle fracture surgery, including delayed union in 10% of our cases and delayed wound healing in 45% of our cases with a HbA1c level of 8%.

Regarding the limitations we faced, it is challenging to draw firm conclusions about the level of influence that HbA1c level has on ankle fracture healing in diabetics due to the retrospective character of this study and the small sample size used. In addition, we were unable to account for additional predictors besides HbA1c that might affect the results and side effects of ankle fracture surgery.

Conclusion

Poor postoperative outcomes (radiological non-union and delayed union of fracture) and complications (infections and delayed wound healing) are more common among patients with elevated HbA1c. This suggests that an elevated HbA1c level is associated with a poor treatment outcome. Among patients with diabetes who undergo ankle fracture surgery, there is a need to be aware of unrecognized diabetes, as well as patients with diabetes with uncontrolled blood sugar levels. Determination of HbA1c levels may predict potential problems post ankle fracture surgery and improve management outcomes.

Abbreviations

DM, Diabetes mellitus; HbA1c, Hemoglobin A1C; KAMC, King Abdulaziz Medical City; KAIMRC, King Abdullah International Medical Research Center.

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Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

Ethical approval was obtained by the King Abdullah International Medical Research Center (KAIMRC) in Riyadh on March 19, 2023. The study was not conducted until KAIMRC provided the approval under approval number NRC23R/122/03.

Authors contributions

ZAJ, AAS, and HHR contributed equally to this work; KAS, HHR, ZAJ, and AAS contributed to the conception of the study; AAS, ZAJ, MMB, and AAA substantially contributed to the literature search, data extraction, quality assessment, data analyses, and manuscript preparation; AAA contributed to improving the article for language and style preparation; AAS, ZAJ, and MMB helped perform the analysis with constructive discussions; KAS, ZAJ, AAS, HHR, and AAA reviewed the manuscript and rewrote the final version. Approval of the final manuscript was obtained from all authors. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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