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ORIGINAL ARTICLE

Retrospective Study

Accuracy of the rotator cuff reparability score

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Abstract

BACKGROUND

The reparability of large or massive rotator cuff tears is difficult to determine pre-operatively. We previously identified age ≥ 65 years, acromiohumeral interval ≤ 6 mm, and anteroposterior tear size ≥ 22 mm as risk factors for rotator cuff repair failure. We therefore developed a rotator cuff reparability score where each of the above risk factors is assigned a score of one point.

AIM

To determine the accuracy of a rotator cuff reparability score.

METHODS

This was a retrospective cohort study of recruited patients with large or massive rotator cuff tears treated at our institution between January 2013 and December 2019. Exclusion criteria were revision surgery and patients with contraindications for surgery. All patients underwent arthroscopic rotator cuff repair and were categorized into either complete or partial rotator cuff repair. Rotator cuff reparability scores were calculated for each patient. The sensitivity, specificity, positive and negative predictive value, and positive and negative likelihood ratio were assessed. A receiver operating characteristic curve was plotted to determine the optimal cut-off rotator cuff reparability score.

RESULTS

Eighty patients (mean age, 61 years; range, 25–84 years; 41 females and 39 males) were recruited. Intra- and inter-observer reliabilities were good to excellent. The

number of patients with 0, 1, 2, and 3 risk factors for rotator cuff repair failure were 24, 33, 17, and 6, respectively. Complete repair was performed in all patients without risk factors. Two of the 33 patients with one risk factor and seven of the 17 patients with two risk factors underwent partial repair. One of the six patients with three risk factors underwent complete repair. The area under the curve was 0.894. The optimal cut-off score was two points with a sensitivity of 85.71% and a specificity of 83.33%.

CONCLUSION
A rotator cuff reparability score of two was determined to be the optimal cut-off score for predicting the reparability of large or massive rotator cuff tears.

Key Words: Rotator cuff tear; Reparability; Prognostic factors; Rotator cuff reparability score

Core Tip: This is retrospective study to evaluate the accuracy of a novel rotator cuff reparability score. In large or massive rotator cuff tears, arthroscopic rotator cuff repair is not always feasible. The reparability of large or massive rotator cuff tears can be more accurately determined after intra-operative arthroscopy. The identification of pre-operative risk factors for rotator cuff tear repair failure may facilitate improvements in management and provide patients with more accurate treatment information. Accordingly, we developed a novel scoring system to predict the likelihood of rotator cuff repair failure.

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INTRODUCTION

The recommended treatment option for rotator cuff tears is arthroscopic surgery. Complete rotator cuff repair yields superior functional outcomes with a lower rate of recurrent tears compared to partial rotator cuff repair or arthroscopic debridement[1,2]. Partial rotator cuff repair may initially improve functional outcomes; however, half of patients are reportedly dissatisfied with the results of partial rotator cuff repair at long-term follow-up[3]. Prior to arthroscopic rotator cuff surgery, a variety of salvage operations, such as superior capsular reconstruction, tendon transfer, subacromial balloon spacer, and reverse total shoulder arthroplasty, should be planned. Furthermore, arthroscopic repair of large or massive rotator cuff tears may not always be feasible. The reparability of large or massive rotator cuff tears can be more accurately determined during intra-operative arthroscopy. Pre-operative risk factors for rotator cuff repair failure may improve management planning and provide patients with more reliable treatment information.

Age, tendon retraction, rotator cuff tendon tear size, fatty infiltration, muscle atrophy, and superior humeral head migration are reported predictors of the reparability of large rotator cuff tears[4-7]. Our previous study identified age, acromiohumeral interval (AHI), anteroposterior (AP) tear size, and AHI as pre-operative clinical and radiographic parameters associated with the reparability of rotator cuff tears[5]. Pre-operative evaluations have been shown to facilitate better treatment outcomes and lower re-tear rates after complete rotator cuff repair[1,2]. In cases where complete repair is not feasible, alternative salvage techniques with superior results to partial rotator cuff repair should be considered [8].

Accordingly, we developed a novel scoring system for predicting the reparability of large or massive rotator cuff tears. The objective of the present study was to determine the accuracy of our novel pre-operative scoring system in predicting the probability of the reparability of large or massive rotator cuff tears. We hypothesized that higher rotator cuff reparability scores predict rotator cuff repair failure.

MATERIALS AND METHODS

The present retrospective cohort study collected data from January 1, 2013 to December 31, 2019 after the Queen Savang Vadhana Memorial Hospital's Research Ethics Committee gave its approval to the study protocol. All patients with large or massive rotator cuff injuries identified by magnetic resonance

imaging (MRI) prior to surgery and verified during surgery by arthroscopy were included in the current study. Rotator cuff tears were classified using the Snyder classification and modified Millstein[9,10].

The term "complete supraspinatus tendon tears" was used to describe large rotator cuff tears. At least two tendons must be involved for a rotator cuff injury to be considered massive. The current study excluded patients with recurrent rotator cuff injuries or surgical contraindications.

Our rotator cuff reparability scoring system consisted of three factors: age ≥ 65 years, AHI ≤ 6 mm, and AP tear size ≥ 22 mm[2]. AHI was used to assess superior humeral head migration and was measured as the distance between the inferior border of the acromion and the superior aspect of the humeral head on AP plain radiography[11] (Figure 1). AP tear size was determined using T2-weighted MRI in the sagittal oblique view as the largest straight distance from anterior to posterior tendon edge [12]. No measurements were performed for frayed tissues at the tendon edge (Figure 2). Two independent observers measured both imaging parameters twice.

Arthroscopic repair was performed by three fellowship-trained sports medicine surgeons. General anesthesia was used to sedate the patients, who were then placed in a beach chair position. If an acromial spur was identified, acromioplasty was performed. Arthroscopic capsular release and manipulation under anesthesia were performed in cases of adhesive capsulitis. After confirming the size of the tear using an arthroscopic probe, tendon adhesions were released and mobilized to cover as much of the native footprint as feasible. The interval sliding technique was used where necessary. Where feasible, double-row rotator cuff repair or trans-osseous equivalent repair could improve tendon healing, lower the risk of re-rupture, and improve functional outcomes compared to single-row repair[13-15]. Single-row or partial repair was performed in cases where double-row repair was not possible.

Partial repair was defined as having less than 50% of the anatomical footprint covered by tendon. Complete repair was defined as 50% tendon coverage or greater[7,11] (Figure 3A and B). On the first post-operative day, passive range-of-motion exercises were permitted for all patients. Patients were provided an arm sling for 6 wk post-operatively. In the third or fourth post-operative week, progressive active-assisted passive motion exercises were initiated for muscle strengthening.

Statistical analyses were performed using SPSS version 26. Each risk factor score's sensitivity, specificity, positive and negative predictive value, and positive and negative probability ratio were assessed. The optimal cut-off score and values of area under the curve (AUC) were determined using receiver operating characteristics (ROC) curves. Intra-observer and inter-observer reliabilities were calculated using Kappa analysis and the intra-class correlation coefficient for categorical and continuous data, respectively.

RESULTS

Eighty patients (mean age, 61 years; range, 25–84 years; 41 females and 39 males) met the study inclusion criteria. A total of 64 massive rotator cuff tears (82.5%) and 14 Large rotator cuff tears (17.5%) were identified by MRI and confirmed by arthroscopic examination.

AP distance and AHI had intra-observer reliability values of 83.8 and 84.6 %, respectively. The inter-observer reliability values for AP distance and AHI were 81.2 and 81.6 %, respectively. Both outcomes were rated as good to excellent. Sixty-six patients underwent complete arthroscopic rotator cuff repair. Partial arthroscopic rotator cuff repairs were performed in 14 patients. All 24 patients who had no risk factors for rotator cuff surgery failure had complete arthroscopic repair of their rotator cuffs. Only two of the 33 patients with one risk factor underwent partial repair. Seven patients with two risk factors underwent partial repair, while ten patients with two risk factors underwent complete repair. One of the six patients with all three risk factors underwent complete repair. The numbers of patients undergoing complete or partial repair according to number of risk factors for rotator cuff repair failure are shown in Table 1.

For each rotator cuff reparability score, sensitivity, specificity, positive and negative predictive value, as well as positive and negative likelihood ratios, were investigated (Table 2). The AUC of ROC curve was 0.894 (Figure 4). Two was the optimal cut-off score for rotator cuff reparability, with a sensitivity of 85.71% and a specificity of 83.33%.

DISCUSSION

Arthroscopic rotator cuff repair is currently the standard treatment for rotator cuff tears. However, arthroscopic surgery is technically challenging in cases of large or massive rotator cuff tears. Previous studies have demonstrated that complete rotator cuff repair leads to superior functional results compared to partial rotator cuff repair[1,2,16,17]. Shon *et al*[3] suggested that arthroscopic partial repair may result in initial clinical improvements at two-year follow-up; however, over half of the study participants were dissatisfied with surgical outcomes which had worsened over time[3]. Heuberer *et al*[1] conducted a 45-mo follow-up study and demonstrated that partial rotator cuff repair was associated with higher re-rupture rates compared to complete rotator cuff repair.

Table 1 Number of patients undergoing complete or partial repair according to number of risk factors

No. of risk factors	Partial repair	Complete repair	Total
3	5	1	6
2	7	10	17
1	2	31	33
0	0	24	24
Total	14	66	80

Table 2 Diagnostic values of rotator cuff repair score in patients undergoing complete or partial rotator cuff repair

Rotator cuff reparability score	Sensitivity	Specificity	PPV	NPV	Positive likelihood ratio	Negative likelihood ratio
1	100%	36.36%	25%	NA	1.57	0
2	85.71%	83.33%	52.17%	96.49%	5.14	0.17
3	35.71%	98.47%	83.33%	87.84%	23.57	0.65

PPV: Positive predictive value; NPV: Negative predictive value; NA: Not available.

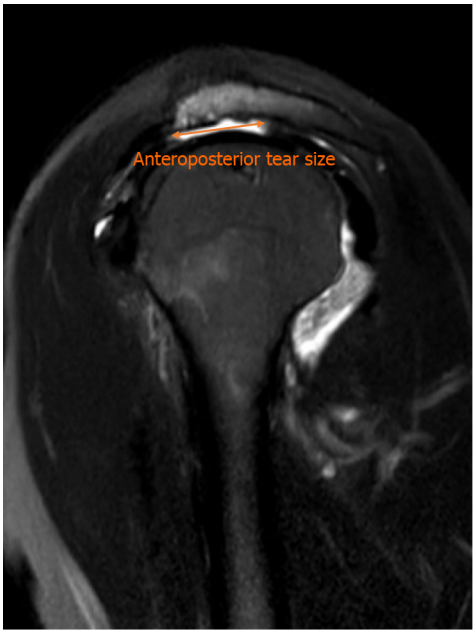

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Figure 1 Anteroposterior tear size was measured as the greatest distance between the anterior tendon edge and the posterior tendon edge in sagittal oblique magnetic resonance imaging slices.

Many salvage procedures have recently been developed for irreparable rotator cuff tears. However, there is a lack of studies comparing partial rotator cuff repair with other salvage procedures. A recent prospective cohort study comparing a latissimus dorsi muscle transfer with a partial rotator cuff repair in irreparable posterosuperior rotator cuff tears showed higher the University of California-Los Angeles (UCLA) shoulder scale, forward flexion, and shoulder strength in the muscle transfer group[8]. A cost-effective study by Makhni *et al*[18] revealed that arthroscopic rotator cuff repair may be a more cost-effective initial treatment for massive rotator cuff tears compared with primary reverse total shoulder arthroplasty. However, reverse total shoulder arthroplasty had superior outcomes in cases of rotator cuff repair failure or re-tear. The results of the study by Makhni *et al*[18] demonstrate the importance of comprehensive evaluation of the reparability of rotator cuff tears. Salvage procedures including superior capsular reconstruction, subacromial spacer, tendon transfer, and reverse total shoulder arthroplasty, are recommended in cases of irreparable rotator cuff tears after their utility in significantly improving functional outcomes was confirmed[19,20]. To our knowledge, no comparative studies of

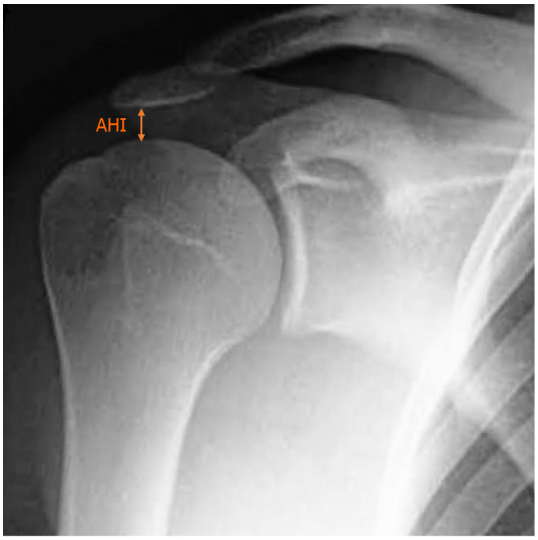

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Figure 2 The acromiohumeral interval was measured as the distance between the inferior border of acromion and the superior aspect of the humeral head on true anteroposterior plain radiography. AHI: Acromiohumeral interval.

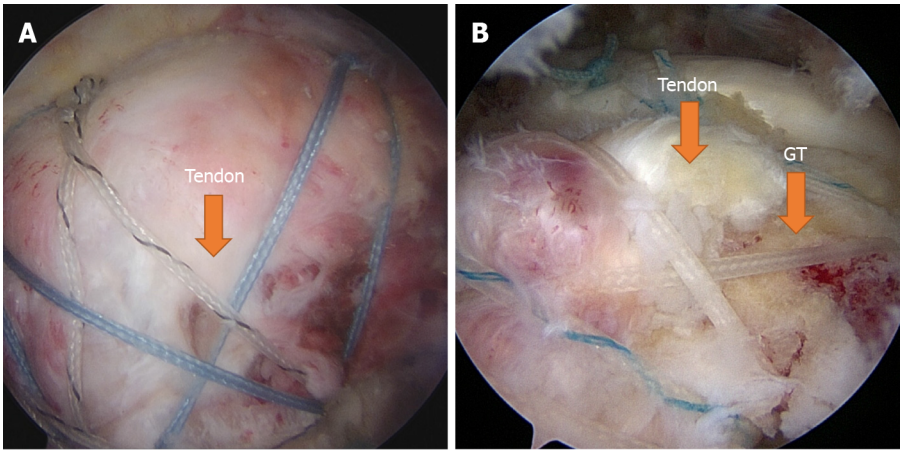

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Figure 3 Arthroscopic view of rotator cuff repair. A: After arthroscopic rotator cuff repair, the tendon is seen to over more than 50% of the anatomical footprint following complete repair. B: In partial repair, the tendon covers less than 50% of the anatomical footprint. GT: Greater tuberosity.

partial rotator cuff repair and salvage procedures have been reported to date. Accordingly, the assessment of rotator cuff reparability is clinically challenging, particularly in cases of large or massive rotator cuff tears. However, many factors have been reported to be associated with rotator cuff tear reparability and have utility in predicting treatment outcomes pre-operatively[1-3,17].

Rotator cuff injuries are a phenomenon of natural aging[21]. The majority of rotator cuff injuries are asymptomatic. However, 30% – 40% of patients with asymptomatic tears developed symptoms in the subsequent 2 to 5 years[22-23]. Larger rotator cuff tears are typically associated with degeneration and fatty infiltration[21,24]. Moreover, increasing age, particularly ≥ 65 years, has been shown to significantly correlate with rotator cuff tear irreparability[5-6].

Rotator cuff tears cause an imbalance between the forces acting on the glenohumeral joint, which can result in the humeral head superior migration, [25] which is one of the earliest signs of rotator cuff tear arthropathy[26]. The humeral head superior migration, as measured by the AHI or inferior glenohumeral distance, is an important factor in predicting the reparability and clinical outcomes of rotator cuff tears[4-7,27]. Previous studies have reported that an AHI ≤ 6 mm is associated with rotator cuff tear irreparability[4-5].

Tear size is another significant factor, which many studies reported as a main predicting factor of reparability[4-7,11,21]. Previous studies have determined rotator cuff tear size using different imaging modalities and in coronal and sagittal oblique views. Our previous study reported that both mediolateral tear size ≥ 36 mm and AP tear size ≥ 22 were associated with rotator cuff tear irreparability. This result corroborates a previous study by Di Benedetto *et al*[4]; however, their multiple logistic

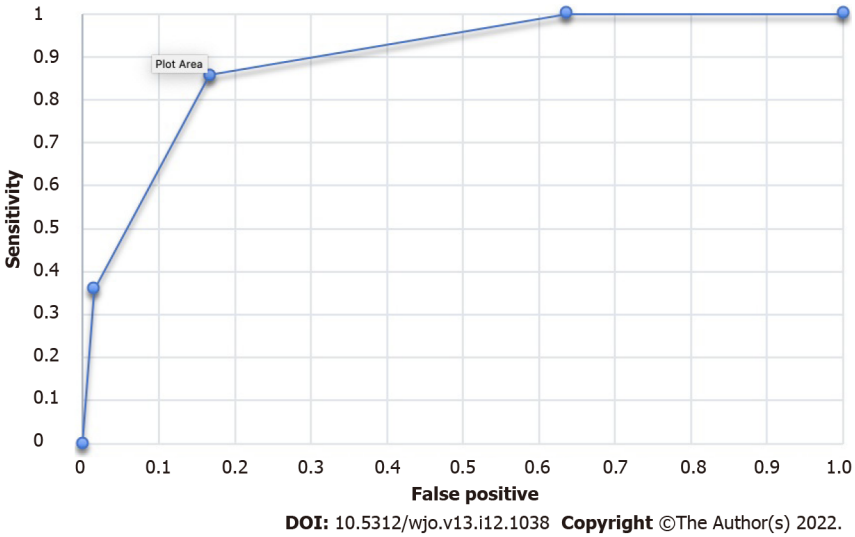

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Figure 4 Receiver operating characteristics curve of the rotator cuff reparability score.

regression model demonstrated that only AP tear size was significantly correlated with rotator cuff tear irreparability.

A previous retrospective study reported the development of a quantitative scoring system for large-to-massive rotator cuff tears[6]. Their scoring system, which included AP tear size, mediolateral tear size, muscle atrophy, and fatty infiltration, had a sensitivity of 73.5% and a specificity of 96.2%. However, this study included only pre-operative MRI factors and not clinical and radiographic factors.

Our previous study analyzed all pre-operative clinical and radiographic factors to estimate the reparability of large and massive rotator cuff tears[5], demonstrating that age, AHI, and AP tear size were correlated with rotator cuff reparability. As all three factors had similar odd ratios, we weighted them equally to develop the present three-point scoring system.

In this study, the AUC for our rotator cuff reparability score was 0.894, indicating good accuracy. A score of two, which had a sensitivity of 85.71% and a specificity of 83.33%, was found to be the optimal cut-off rotator cuff reparability score. Accordingly, rotator cuff tears are most likely to be irreparable in patients with a score rotator cuff reparability of two or three. We recommend pre-operative consideration of backup procedures in such cases.

This study had several limitations. First, the retrospective nature of the present study may have introduced selection or information into the study analysis. Second, there was a wide range of participant ages which may have affected tissue quality and the likelihood of traumatic rotator cuff tears. Third, the small sample size and small number of patients in the partial repair group may have influenced the study results. Finally, clinical outcomes and follow-up were not assessed in the present study. Further studies are required to validate the clinical utility of our rotator cuff reparability score in improving clinical outcomes and provided satisfactory results after long-term follow-up.

CONCLUSION

A score of two is the optimal rotator cuff reparability score for predicting the reparability of large or massive rotator cuff tears. Patients with a pre-operative rotator cuff reparability score of two or greater are likely to have irreparable rotator cuff tears.

ARTICLE HIGHLIGHTS

Research background

It is challenging to predict the reparability of a large and massive rotator cuff injury before surgery. Age, tendon retraction, tendon tear size, fatty infiltration, muscle atrophy, and superior humeral head migration are factors that influence whether or not large or massive rotator cuff tears can be repaired.

Research motivation

The better result and lower recurrent rate of complete rotator cuff repair, make the pre-operative evaluation much more important. If a complete repair is not possible, alternative salvage techniques

with better results than partial rotator cuff repair should be considered.

Research objectives
The aim of the current study was to determine the accuracy of the rotator cuff reparability score.

Research methods
This was a retrospective cohort diagnostic study including all patients with large and massive rotator cuff tears between January 2013 and December 2019. All patients underwent an arthroscopic rotator cuff repair and were classified as having either complete or partial rotator cuff repair. The sensitivity, specificity, positive and negative predictive value, and positive and negative likelihood ratio were assessed. The receiver operating characteristic curve was analyzed to define the optimal cut-off level for the reparability of the rotator cuff tear.

Research results
Eighty patients were recruited for this study. The intra- and inter-observer reliabilities were good to excellent. The number of patients with 0, 1, 2, and 3 positive factors were 24, 33, 17, and 6 respectively. The complete repair was done in all patients without any positive factors. Two of 32 patients with one positive factor and seven of 17 patients with two positive factors were partially repaired. Only one of six patients with three positive factors was completely repaired. The area under the curve was 0.894. The optimal cut-off point was two with the sensitivity of 85.71% and the specificity of 83.33%.

Research conclusions
The optimal cut-off point for predicting the reparability of a large or massive rotator cuff tear is a rotator cuff reparability score of two. If the pre-operative score is two or more, the rotator cuff tear is likely to be irreparable.

Research perspectives
Further studies are required to validate the clinical utility of our rotator cuff reparability score in improving clinical outcomes and provide satisfactory results after long-term follow-up.

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FOOTNOTES
Author contributions: Prasathaporn N designed and performed the research and supervised the report; Kuptniratsaikul V designed the study and contributed to the analysis; Thamrongskulsiri N wrote the manuscript; Itthipanichpong T contributed to the analysis and wrote the manuscript and supervised the study; All authors have read and approved the final manuscript.

Institutional review board statement: This study was reviewed and approved by the Research and Ethics Committee Queen Savang Vadhana Memorial Hospital, Chonburi, Thailand (Approval No. IRB026/2561).

Informed consent statement: Patients were not required to give informed consent to the study as the study analysis used anonymous clinical data obtained after each patient had agreed to treatment by written consent.

Conflict-of-interest statement: All the authors report having no relevant conflicts of interest for this article.

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ORIGINAL ARTICLE

Retrospective Study

Taper-wedge stem suitable for anterior approach total hip arthroplasty: Adequate biomechanical reconstruction parameters and excellent clinical outcome at mid-term follow-up

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Abstract

BACKGROUND

The direct anterior approach (DAA) for total hip arthroplasty (THA) is a less invasive and muscle-sparing approach that seems to improve early function and patient satisfaction. Several studies, however, have reported high complication and revision rates due to the technical difficulties related to the femoral preparation.

AIM

To evaluate the usefulness and safety of a new stem equipped with a morphometric design and a size-specific medial curvature in DAA for THA.

METHODS

This retrospective study was based on 130 patients that underwent mini-invasive DAA procedures for THA using the Accolade II stem. A total of 144 procedures were included in the assessment, which was based on postoperative complications, survival rates, functional parameters, and patient related outcomes.

RESULTS

Overall complications were recorded in 6 procedures (4.2%). There were no complications related to the stem implantation and no intraoperative fractures. Only one patient was revised for deep infection. On radiographs, biomechanical hip reconstruction was satisfactory and no stem showed any subsidence greater

than 2 mm. Full osseointegration based on Engh scores was seen in all of the implanted stems. Median Harris hip score at final follow-up was 99 points (range 44-100 points), which resulted excellent in 91.3% of patients. The median values of the osteaorthritis outcome score ranged from 87.5 to 95.

CONCLUSION
The mid-term positive outcomes and low complication rate in our consecutive series of patients support the safety and suitability of this new stem design in DAA for THA.

Key Words: Total hip arthroplasty; Orthopedics; Direct anterior approach; Orthopedic surgery; Stem implantation; Accolade II stem

Core Tip: The direct anterior approach can provide a less invasive and muscle-sparing technique for total hip arthroplasty. New stems used in the direct anterior approach have been designed to reduce complication rates, and enhance postoperative morphologic and functional outcomes. The Accolade II stem is equipped with a morphometric design and a size-specific medial curvature, which can be advantageous for this type of surgery.

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INTRODUCTION

Total hip arthroplasty (THA) is one of the surgical procedures with the highest levels of safety, efficacy, and clinical satisfaction[1]. In the last decade, there have been numerous improvements in techniques and technologies, which have given rise to better clinical outcomes and less need for early surgical THA revisions[2,3]. New technology, methods and implants, however, need to be carefully tested and assessed in long term studies on large cohorts to determine the clinical usefulness and safety before widespread use.

The direct anterior approach (DAA) for THA has been a debatable issue in current literature. Several studies supporting this surgical technique have reported that this less invasive and muscle-sparing approach can improve early functional and patient-reported outcomes. Others studies, however, have reported the limitations of using this approach, which include high complication and revision rates, usually dependent on long and difficult surgeon learning curves[4,5]. The technical difficulties in the DAA have been reported to be linked with the implantation of undersized stems[6] and early femoral failure[7].

The design of the femoral stem used in surgery can be an additional contributing factor in postoperative early aseptic loosening. Lindgren *et al*[8] found that stems with an "anatomic" design were more likely to loosen when implanted through an anterolateral approach. Janssen *et al*[9] reported that cementless femoral stems with a proximal shoulder tend to be associated with early aseptic loosening when inserted through an anterior or anterolateral approach, while an anatomically shaped stem may be preferred with these approaches.

The choice of a suitable stem to be used in an anterior approach should preferably consider a reduction in possible complications rates related to the difficulties of femoral exposure. A new second-generation cementless stem (Accolade II) with its short length and smooth tapered tip could be considered a good candidate when using the DAA for THA. This new stem was created to better adapt to the anatomy of the femoral canal thanks to a more anthropomorphic dimension ratio between its proximal and distal portions and to the variation, size to size, of the radius of curvature of its medial side[10].

The aim of our study was to evaluate the feasibility, utility and safety of this second-generation cementless stem (Accolade II) for the DAA. The assessment in our study was based on data regarding complications, survival of the implanted prostheses, biomechanical hip reconstructions, radiographic evolutions, functional results, and patient-related outcomes.

MATERIALS AND METHODS

Study design

This retrospective observational study analyzed consecutive patients that underwent THA with DAA using the Accolade II stem (Stryker Orthopedics) in the Department of Traumatology and Orthopedics at a public Italian hospital located in Seriate, Bergamo between November 2013 and March 2019. The analysis was based on data obtained from outpatient reports, medical records, and radiographs. The investigation was performed in accordance with the tenets of the Declaration of Helsinki and informed consent was obtained from all participants before surgery. The study was in compliance with Institutional Review Boards and the Health Insurance Portability and Accountability Act requirements of the hospital. The study was approved by the Ethics Committee of Bergamo (n. 144/19, August 5, 2019).

Hip-fractured patients and patients with a final follow-up of less than 12 mo were excluded. All the surgical procedures were performed *via* a mini-invasive DAA without a traction table. A preoperative radiological 2D plan, using TraumaCad® software, and intraoperative fluoroscopy evaluation of trials for stem positioning were performed for each patient. The stems were used in combination with an uncemented Trident HA-coated cup (Stryker orthopedics). In all cases, a highly cross-linked polyethylene on Biolox Delta femoral head bearing was used.

One hundred forty-eight subjects (161 hips) were treated in the time interval considered. Seventeen patients were lost to follow-up. At the last outpatient follow-up visit, these patients were stable from a clinical and radiographic point of view. Four patients died for reasons unrelated to their hip surgery. Thirteen patients, contacted by phone, refused to come to the follow-up visit for logistical or work reasons. They all reported that no other surgical revisions were performed on the operated hip.

Data collection

Body mass index (BMI), American Society of Anesthesiologists (ASA) Score, Charlson Comorbidity Index (CCI)[11], and Charnley classification were calculated for each patient[12]. The postoperative outcome assessments included data based on complications, implant survival, and clinical and radiological outcomes. Complications and adverse events were coded according to the Hip Society THA Complications workgroup[13]. Clinical outcomes were obtained at the last follow-up visit. Functional results were evaluated by the Harris Hip Score (HHS)[14]. Patient-related outcomes were assessed by the Hip disability and Osteoarthritis Outcome Score Italian version LK 2.0 (HOOS)[15].

Standardized pre- and post-operative anteroposterior radiographs of the pelvis and the lateral view of the operated hip were used for the radiological assessment. Occurrence of radiolucent lines, osteolytic changes, or cortical hypertrophy were recorded using Gruen's zones for the stem and the DeLee Charnley zones for the cup[16,17]. Stem subsidence was calculated using the method reported by Grant *et al*[18]. Femoral component fixation and stability were assessed by the Engh score[19]. Adequate radiographs to measure the biomechanical parameters for hip reconstruction as described by Asayama *et al*[20] and Schmidutz *et al*[21] were available in 104 hips. Acetabular cup positioning was evaluated by referring to the safe zones defined by Lewinnek *et al*[22].

Statistical analysis

Data regarding quantitative variables included mean, standard deviation, range and/or median, and qualitative variables as a percentage. The student *t*-test for independent samples was used to compare continuous variables in normally distributed data among groups. The Wilcoxon rank-sum test was used for data not normally distributed. The implant survival probabilities were computed using Kaplan–Meier analysis (revision of any component for any reason as the terminating event or at the end of the follow-up period). The statistical analysis was performed using the STATA11 software package (Statistic Data Analysis, StataCorp, College Station, TX). *P* values lower than 0.05 were considered significant.

RESULTS

One hundred and thirty patients were included in the study. Surgery was carried out bilaterally in 14 cases for a total of 144 hips that underwent DAA for THA. One hundred and twenty cases were performed by a senior experienced surgeon; twenty-four cases by two other surgeons in their learning curve.

The demographic and clinical data of the patients are shown in Table 1.

Complications

Complications were recorded in 6 procedures (4.2%). Analytical data are reported in Table 2.

No significant differences in terms of complications were observed between the senior surgeon and the training surgeons (5 complications out of 120 procedures *vs* 1 complication in 24 procedures – not significant, Fisher exact test).

Table 1 Demographic and clinical data of the 144 hips included in the study

Demographic and clinical data	*n* = 144
Male/female, *n* (%)	70 (49)/74 (51)
Right hip/left hip, *n* (%)	83 (58)/61 (42)
Age avg. (range)	68.6 (43-88)
BMI avg. (range)	26.3 (17.5-39.8)
Diagnosis primary OA, *n* (%)	135 (94)
AVN, *n* (%)	7 (5)
Post-traumatic OA, *n* (%)	2 (1)
ASA, *n* (%)	
1	9 (6)
2	89 (62)
3	44 (30)
4	2 (1)
CCI, *n* (%)	
0	6 (4)
1-2	39 (27)
≥ 3	99 (69)
Charnley classification, *n* (%)	
A	79 (54.9)
B	33 (22.9)
BB	28 (19.4)
C	4 (2.8)

BMI: Body mass index; AVN: Avascular necrosis; ASA: American Society of Anesthesiologists; OA: Osteoarthritis; CCI: Charlson comorbidity index.

Table 2 Data of the six patients with complications

Patient, *n* (age)	Gender	Charnely	Complications	Grade[13]	HHS	HOOS	Remarks
12 (50)	F	A	2-wound complication	2	93	89	
53 (77)	M	B2	9-PJI	3	85	52	Two stage procedure with resolution
55 (63)	M	A	1-bleeding	3	100	96	Hematoma that required surgical drainage
115 (55)	M	B1	10-heterotopic calcification	3	93	84	
139 (69)	F	B1	2-wound complication	3	79	78	Surgical debridement, no patogens, healed in 3 wk
141 (44)	F	B1	2-wound complication	2	100	96	

HHS: Harris Hip Score; HOOS: Hip disability and Osteoarthritis Outcome Score; F: Female; M: Male.

No intra-operative complications and no dislocations were reported.

Survivorship

At 69 mo, the cumulative survival of the stem and cup (that did not require surgical revisions) was 98.6% (95%CI: 90.7-99.8). Only one implant was revised due to deep infection (0.7%). No failures were observed for aseptic loosening.

Component positioning

Stem alignment averaged -0.3° ± 1.9°; 97 out of 104 stems (93.3%) were within 3° of varus/valgus. The mean cup inclination was 38° ± 5.7° and the mean anteversion was 15° ± 5.2°. Eighty-eight out of 104

cups (84.6%) were within the Lewinnek safe zone.

No significant differences were seen between the senior surgeon and the training surgeons regarding stem alignment and cup position.

Hip center of rotation, femoral offset and abduction lever arm reconstruction and leg length

When compared to the contralateral side, hip center of rotation (CoR) was postoperatively elevated by 3.7 mm ± 4.3 mm and medialized by 3.4 mm ± 4.5 mm on average. Femoral offset (FO), abduction lever arm (ALA), and leg length (LL) after surgery are shown in Figure 1. FO increased in 83 out of 104 cases (79.8%); when compared to the contralateral side, only 8 out of 104 cases (7.7%) showed a decrease of FO greater than 15%. Compared to the contralateral side, the leg length of the operated hip was longer by 2 mm ± 6.1 mm on average. In 56.7% of cases, leg length discrepancy was within ± 5 mm.

Radiographic outcomes

No lines of radiolucency or lysis were observed around any of the implanted acetabular components. One stem showed an area of lysis in Gruen zone 1 and radiolucencies in zones 3, 4, and 5 at 24 mo. This patient was asymptomatic with an Engh score of 15.

No stem showed any subsidence greater than 2 mm. The Engh score provided results between 15 and 26 suggesting osseointegration of all implanted stems. Distal femoral cortical hypertrophy (DFCH) was observed around 32 femoral stems (22.2%) (Figure 2). Gruen zone 3 was the most affected (28 cases), followed by zones 2 and 5 (respectively 13 and 11 cases). None of the patients involved were symptomatic nor showed any functional impairment. HHS and HOOS total scores were not significantly different between those with DFCH and those without it (respectively 95.8 ± 9.6 *vs* 97.4 ± 2.9 and 86.9 ± 16.6 *vs* 89.5 ± 9.9, Wilcoxon rank-sum test).

Functional outcomes and patient-related outcome

The HHS median at final follow-up was 96.2 points (range 44-100 points). The score was excellent in 119 patients (91.5%), good in 5 (3.8%), fair in 3 (2.3%) and poor in 3 (2.3%).

The patients with poor HHS included 3 Charnley class C females with disabling chronic low back pain. HOOS results at final follow-up for all patients are presented in Figure 3. Median values range from 87.5 to 95.

Two multivariate analysis was performed to identify potential risk factors for a poor outcome using HHS and total HOOS at final follow-up as independent variable and age, gender, BMI, ASA, CCI and Engh Score as dependent variables. Regarding HHS, male gender was a significant positive factor whilst age, ASA and CCI were significantly inversely correlated with the score. Age and ASA were also significantly inversely correlated with final HOOS total score.

DISCUSSION

The results of our study showed that the Accolade stem is suitable, safe, and efficient when used in the DAA for THA. The overall complication rate was low even for surgeons during the learning curve. None of the complications were related to the difficulties of exposure of the femur during the surgical procedure, intraoperative fractures or stem subsidence. Failures due to infection was very rare, with only one of the 144 cases that showed failure for periprosthetic infection at a mean follow-up of 35 mo.

Femoral exposure and preparation through the DAA is a complex part of the operation. Meneghini *et al*[7] found that the revisions due to early femoral failure were more common in patients who had undergone the DAA. In this regard, the design of the stem can play an important role during surgery, and data from the literature suggests that the shape of the stem can induce specific problems. Janssen *et al*[9] found that there was a stem-approach interaction, in which shoulder stems showed a greater likelihood of early aseptic loosening when the anterolateral or the anterior approach was used.

Studies have reported that longer stems or those with particular designs were associated with more perioperative complications, especially periprosthetic fractures. Dietrich *et al*[23] found an odds ratio of 1.98 for intraoperative fractures when a Quadra-H stem was used compared to the Fitmore and AMIStem. Tamaki *et al*[24] and Greco *et al*[25] reported an increase in femur complication rate using the Taperloc Microplasty short stem with full profile taper concerning the standard length Taperloc. Rivera *et al*[6] reported that the Fitmore stem was associated with a higher probability of undersizing when implanted by DAA.

New stem designs may reveal new problems with other surgical approaches as well, as suggested by the data from Tootsi *et al*[26], which reported a 5% incidence of intraoperative femoral fracture in 222 THA performed using the novel SP-CL® implant. With regards to the Accolade II, the morphometric design with a size-specific medial curvature and optimized length potentially renders this stem suitable for DAA. Our radiographic results on the reconstruction of the biomechanics of the operated hip also seem to promote the design of this stem. Stem positioning and the reconstruction of FA, ALA, and LL resulted comparable to those reported by Schmidutz *et al*[21] This study compared a short-stem hip with a conventional stem implanted with a minimally invasive anterolateral Hardinge approach in the

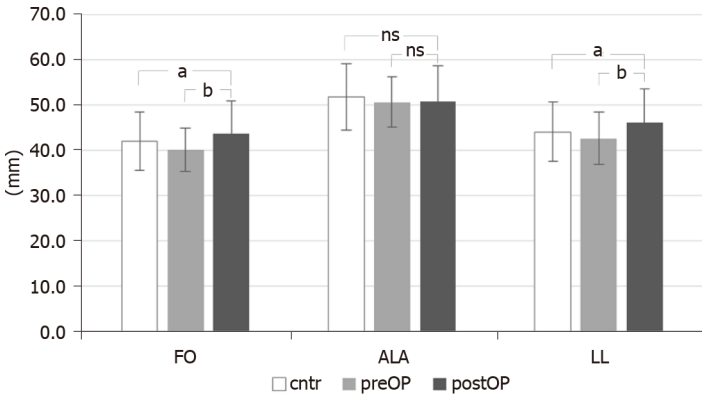

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Figure 1 Comparison of postoperative femoral offset, abductors lever arm and leg length with preoperative and contralateral parameters. [a]*P* < 0.05, [b]*P* < 0.01; ns: Not significant. postOP: Postoperative; FO: Femoral offset; ALA: Abductors lever arm; LL: Leg length; preOP: Preoperative; cntr: Contralateral.

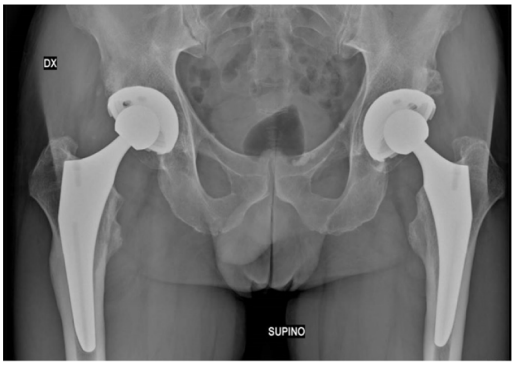

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Figure 2 Patient with bilateral prosthesis. Right hip at 36 mo since surgery with distal femoral cortical hypertrophy in Gruen zones 2 and 3; left hip at 18 mo postoperative without cortical hypertrophy.

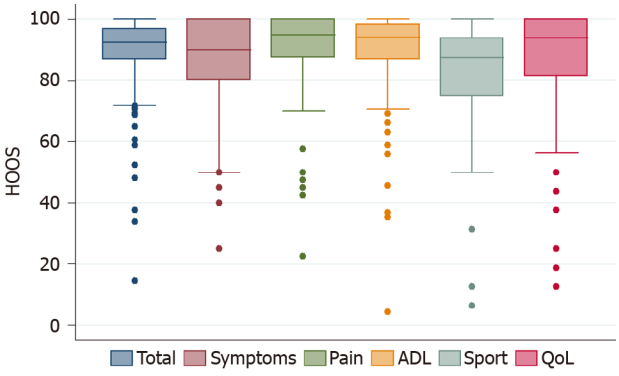

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Figure 3 Box plot for Hip disability and Osteoarthritis Outcome scores at final follow-up (median, 25th and 75th percentile, max and min values, outliers). HOOS: Hip disability and Osteoarthritis Outcome Score; ADL: Activities of daily living; QoL: Quality of life.

supine position. The achieved degree of precision of the joint reconstruction was such as not affecting patient-related outcomes[27].

The performance of the Accolade II stem has also been described in other studies. Pierce *et al*[28] reported the results of 68 hips implanted at a high-volume institution using an anterolateral approach. No stem complications were shown, with an all-cause survivorship of 99.2% at a mean follow-up of 3.5 years. Kolisek *et al*[29] examined 202 Accolade II femoral stems implanted in 4 different hospitals with a 2-year follow-up. They reported two surgical complications related to stem implantation, which included a posterior trochanteric avulsion and a periprosthetic fracture. Aseptic and all-cause survival

rates of 100% and 99.5% were reported. Berndt *et al*[30] reviewed 151 THA procedures with the Accolade II/Trident implant system using DAA. With regards to complications, this study reported one intraoperative stem perforation and one aseptic stem loosening at 45 mo with a total implant survival of 96.9% at 5 years.

Our study showed that all patients had favorable radiographic outcomes. The Engh scores suggested that all stems were well integrated and showed a low incidence of radiolucency lines (reported in 1 of the 115 hips). These results are indicative of a satisfactory fit and fill of the femoral canal and adequate adhesion of the circumferential porous coating to the surrounding bone[31].

A better "fit and fill" of the Accolade II stems when compared to the previous models has been reported in a preclinical study by Faizan *et al*[32], which showed a more uniform proximal-distal grip in a large sample of femoral sizes. Studies by Issa *et al*[10] reported a significant improvement in both proximal and distal fixation in the current version. Numerous evidences affirms that excellent "fit and fill" correlate with better clinical-functional results[33-35]. Our data confirm the excellent results in HHS and HOOS in addition to the absence of radiological subsidence in the stems.

We detected DFCH in 22% of our stems, but this did not appear to influence the implant survival and functional and subjective outcomes. Previous studies have shown that DFCH prevalence ranges from 6% to 56% in different cementless stem designs without determining any functional impairment[36,37].

Our study has several limitations. The data is based on a retrospective study in which the lack of complication related to the stem may be due to the relatively limited number in the cohort. Similar types of study in literature, however, have reported incidence rates of perioperative fractures ranging from 1 to 7 cases[23,25], which was not seen in our cohort. Moreover, our study was based on a rather short follow-up (3.5 years), thus does not provide information regarding the long-term success rates of this stem.

CONCLUSION

The design of the stem can have an effect on the risk of adverse events in DAA for THA. Studies are needed to confirm the safety and success rates when new models are proposed for implantable stems for THA are desirable. Our preliminary data shows that the Accolade II stem tends to provide a low complication rate and satisfactory biomechanical reconstruction. The mid-term positive outcomes concerning survivorship, functional scores, and activity levels in our consecutive series of patients support the safety and suitability for DAA of this new stem design, which can be a long-term predictor of success. Further multicenter studies with longer follow-up are needed to confirm these preliminary positive results.

ARTICLE HIGHLIGHTS

Research background

The direct anterior approach for total hip arthroplasty is a less invasive and muscle-sparing approach that seems to improve early function and patient satisfaction.

Research motivation

To study the results of this surgery in a cohort of patients.

Research objectives

To report outcomes, advantages and indications for this surgery.

Research methods

Analysis of outcomes after surgery.

Research results

Result outcomes were good. Complication rates were relatively low.

Research conclusions

The mid-term positive outcomes and low complication rate in our consecutive series of patients support the safety and suitability of this new surgery.

Research perspectives

New models to enhance surgery can improve outcomes.

FOOTNOTES

Author contributions: Trevisan C designed the research study, performed data acquisition, and wrote the manuscript; Lombardo AS, Gallinari G, and Klumpp R designed the research study and performed data acquisition; Trevisan C, Lombardo AS, Gallinari G, Zeppieri M and Klumpp R contributed towards conception of the study and final editing; All authors revised the article critically for important intellectual content, and provided final approval for the paper to be published.

Institutional review board statement: The study was reviewed and approved by the Ethics Committee of Bergamo, Italy (No. 144/19, August 5, 2019).

Informed consent statement: Patients were not required to give informed consent to the study because the data was collected retrospectively and anonymized. Clinical data were obtained after each patient agreed to treatment by written consent.

Conflict-of-interest statement: All authors report no relevant conflict of interest for this article.

Data sharing statement: No additional data are available.

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ORIGINAL ARTICLE

Observational Study

Occupational injuries and burn out among orthopedic oncology surgeons

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Abstract

BACKGROUND

Orthopedic oncology surgeons commonly engage in prolonged and complex surgical procedures. These types of surgeries increase the risk of physical and psychological stressors, which may in turn make these physicians prone to work-related occupational injuries.

AIM

The aim of this study was to explore in orthopedic oncologists, the prevalence of work-related physical injuries and psychological disturbances.

METHODS

A modified version of the physical discomfort survey was developed to assess occupational injuries among orthopedic oncology surgeon members of the Musculoskeletal Tumor Society, the Canadian Orthopedic Oncology Society and European Musculoskeletal Oncology Societies. The survey was sent by email, and it explored musculoskeletal complaints, psychological disturbances, treatment required for these complaints and the requirement of time off work.

RESULTS

A total of 67 surgeon responses were collected. A high number of orthopedic

oncologists (84%) reported an occupational injury. Low back pain (39%) was the most prevalent musculoskeletal condition, followed by lumbar disk herniation (16%), shoulder tendinitis (15%) and lateral epicondylitis (13%). Of the cohort, 46% required surgery and 31% required time off work due to their injury. Thirty-three respondents reported a psychological disorder. Burnout (27%), anxiety (20%) and insomnia (20%) were the most commonly reported. Time required off work due to injury was associated with old age and years in practice.

CONCLUSION

Orthopedic oncology surgeons report a high prevalence of work-related disorders. Lower back related injury and burnout were the most reported disorders. Improving operative room ergonomics and prevention of stress related to the work environment should be areas to explore in upcoming research.

Key Words: Orthopedic oncology; Surgeons; Occupational; Musculoskeletal; Injuries.

Core Tip: Orthopedic oncologists reported a high prevalence of occupational injury and work-related stress. Futures studies should be directed towards exploring areas to improve the operative environment and methods to decrease conditions associated with stress at work.

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INTRODUCTION

Alarming rates of occupational injuries have been previously reported in different surgical fields including orthopedic surgery[1-5]. It has been an area of interest and investigation due to the implications of these injuries on surgeons, health care system and the quality of provided care[6-9]. Occupational injuries are either work-related injuries or illnesses caused by incidents at a workplace or previous illnesses aggravated by work-related injuries, that could negatively impact the well-being of the affected workers or the quality of provided care[10-12]. Orthopedic surgeons are more vulnerable to a variety of work-related injuries and hazards associated with the nature of their profession such as blood born infections, sharp injuries, noise-induced hearing impairment, exposure to radiation and chemicals, heavy physical workload, emotional and psychological disturbances[13-16].

Several studies have suggested that orthopedic surgeons are at increased rates of occupational injuries[17-20]. When compared to general surgeons, orthopedic surgeons were found to have higher rates of subjective physical injuries. The most reported injuries were back pain, neck pain and upper extremity related complaints[15,21,22]. Furthermore, the psychological disturbances including burnout rates, were found to be higher among orthopedic surgeons as compared to other medical professions and the general population, which in turn may negatively impact the quality of patient care due to increased medical errors and depersonalization[10,23].

Orthopedic oncology is a subspecialty of orthopedics that is physically and psychologically challenging as it involves prolonged and complex surgical procedures, as well as higher rates of serious surgical complications and limited survivorship and functional outcome relating to the oncology patient population. Consequently, such physical and psychological stressors may subject orthopedic oncology surgeons to higher rates of work-related "occupational" injuries that can impact their quality of life, wellness and the quality of delivered patient care. These occupational stressors can lead to preventable musculoskeletal injuries, time off work, increased burnout rates, emotional and psychological disturbances. Investigating this aspect among orthopedic oncology surgeons can help institutions and occupational health agencies to develop preventive strategies to minimize the negative implications of these injuries on the quality of provided care and promote surgeons' personal well-being.

To our knowledge, there are no studies to date investigating the occupational injuries among orthopedic oncology surgeons. The aim of this survey is to explore occupational injuries in orthopedic oncologists, including their prevalence and characteristics.

MATERIALS AND METHODS

An anonymous online, web-based, modified version of the Physical Discomfort Survey (originally developed by the Workplace Safety and Health Division of Manitoba, Canada)[24] and modified version of Maslach Burnout Inventory-Human services survey for medical personnel[25] was emailed to all surgeon members of Musculoskeletal Tumor Society (MSTS), Canadian Orthopedic Oncology Society (CANOOS), and European Musculoskeletal Oncology Society (EMSOS). Only practicing orthopedic oncology surgeon members of the above-mentioned societies were eligible to participate in our study. The first invitation email was sent out in November 2016 and a reminder email was sent out in January 2017. The survey was closed by mid-February 2017. To minimize the magnitude of potential selection and response biases, we sent our survey to all surgeon members of three large orthopedic oncology societies in North America and Europe. Furthermore, we attempted to reduce the potential response bias by sending a subsequent reminder email.

The survey was divided into 3 parts, the first part included questions about participant's demographic data (age, gender, hand dominance), practice setting (academic, community or private), practice duration in years and the average operative caseload *per* year. The second part of the survey was about the musculoskeletal complaints by region (neck, lower back, upper extremity and lower extremity). For each question, participants were asked about the diagnosis, medical or surgical treatments (if any) and if they ever required work stoppage consequently. The third part of the survey involved questions concerning psychological disturbances (anxiety, depression, insomnia, suicidal thoughts and burnout symptoms) and symptoms of "burnout" (emotional exhaustion, depersonalization, low job satisfaction), treatments required (if any) and any time off work needed as a result.

Descriptive statistics were used to report participants' demographics. The prevalence of occupational injury was estimated as the number of injuries *per* total number of respondents. To determine significant associations between patient demographics and occupational hazards, we performed classical tests of hypothesis as well as logistic regression analysis. Statistical significance was set at an alpha of 0.05 and analysis was carried out using Stata v12.1 (Statacrop).

RESULTS

Sixty-seven orthopedic oncology surgeons (58 male and 9 female surgeons) completed the survey (22% response rate). Of the respondent, 40.3%, 43.3% and 6% of respondents were from MSTS, EMSOS and CANOOS, respectively. Most of the participant surgeons are practicing in academic setting (83.3%). The oncologic yearly caseload was seventy-five cases or more in 38.8% of the surgeons.

Eighty four percent of surveyed orthopedic oncology surgeons reported an occupational injury. Musculoskeletal injuries were reported by 76% of participating surgeons, psychological injuries by 50% and both by 43%. The most common musculoskeletal injuries were low back pain (39%), shoulder symptoms (27%), neck pain (24%), lumbar disc herniation (16%), shoulder tendinitis (15%), lateral epicondylitis (13%), hip or knee osteoarthritis and varicose veins (10 % each) (Figure 1). Consequently, time off work was reported by 33.3% surgeons and 27% required treatment including either medical or surgical treatment. Exacerbation of musculoskeletal injuries was experienced by 18% of respondents (Table 1).

Thirty-three surgeons reported a psychological disturbance (50%). The most prevalent were burnout (27%), anxiety and insomnia (20% each) and depression (11%). More seriously, suicidal thought was reported by one participant (Figure 2). Medical and/or psychiatric treatment was required by 18% of respondents and the time off work was required by 3% (Table 2). Young age (35-45 years) was the only significant factor associated with developing symptoms of burnout ($P < 0.015$).

Eighteen surgeons (26.9%) required time off work due to occupational injuries (17 musculoskeletal injuries and 1 psychological disturbance). Factors significantly associated with time off work were age and years of practice of the surgeon ($P < 0.011$) in the logistic regression analysis models performed.

DISCUSSION

Our study revealed a concerning prevalence of occupational injuries among orthopedic oncology surgeons (84%), which is much higher than the previously reported rates in other orthopedic subspecialties[11,17-20]. This could lead to consequences not only on the surgeon's career, but also on the quality and cost of provided health care. One third (33.3%) of participating surgeons reported periods of work stoppage due to work-related injuries and 27% required either medical or surgical treatments. Fifty percent of respondents reported symptoms of occupational psychological disturbances, with burnout being the most reported (27%) followed by insomnia and anxiety (20% each). Orthopedic surgeons in general have higher work-related subjective musculoskeletal symptoms when compared to general surgeons[15]. However, orthopedic oncology is a unique field in orthopedics which deals with complex osseous and soft tissue tumors and therefore, orthopedic oncologists are involved in prolonged

Table 1 Proportion of orthopaedic oncologists' surgeons with diagnosed musculoskeletal disorders per region requiring treatment and time off work

Region	Proportion of injured respondents (%)	Proportion of injured respondents requiring treatment (%)	Proportion of injured respondents requiring surgery (%)	Proportion of treated respondents requiring time off work (%)
Neck	24	56	6	13
Shoulder	27	72	22	22
Elbow	13	67	0	0
Forearm, wrist and hand	39	62	23	23
Hip and thigh	7	80	20	17
Knee and lower leg	13	56	56	40
Ankle/foot	7	100	20	40
Lower back	55	51	8	24

Table 2 Proportion of orthopaedic oncologists' surgeons with diagnosed psychological disorders requiring treatment and time off work

Disorder	Number of respondents with disorders	Number of treated respondents requiring treatment	Proportion of treated respondents requiring medical treatment	Proportion of treated respondents requiring time-off
Anxiety	20	5	2	1
Depression	11	5	3	1
Insomnia	20	2	1	0
Suicidal thoughts	2	1	1	0
Burnout	27	5	2	1
Other	6	1	1	0
Total	33	19	10	3

meticulous surgical procedures with relatively higher complication rates than any other orthopedic specialties. Furthermore, Orthopedic oncologists face psychological stressors as they are involved in psychological and emotional aspects associated with the management of oncology patients. Hence, it is not surprising that this surgeon population have higher rates of occupational injuries including musculoskeletal and psychological disturbances as shown in the results of this study.

Several factors have been shown in the literature as contributing factors to the high rates of occupational injuries among surgeons[4-8]. The nature of their work involves poor ergonomics such as lengthy non-neutral postures while operating, repetitive intra-operative physically demanding tasks, the height of operating table and the non-ergonomically designed surgical instruments[5-8]. New ergonomic innovations have been suggested to improve the operating room environment and minimize the risks of occupational injuries; however, the utilization of these devices is not yet popularized. These factors are applicable even more to orthopedic oncologists due to the complexity and nature of their profession. However, if such work-related injuries are not addressed early, it may progress to more sever morbidity and adversely influence the surgeon's wellbeing and career lifespan.

In addition, psychological disturbances were also found to be high in surgeons, especially in surgical oncologists in the current literature[26]. This is consistent with our results showing high psychological morbidity rates among orthopedic oncologists. Nevertheless, many surgeons may neglect their occupational health issues and thus not pursue the appropriate help when needed, likely due to lack of mindfulness about the potential occupational health injuries and the heavy workload nature of their professions[8].

The limitations of our survey study are similar to most survey studies in the literature. One of the limitations is the subjective nature of self-reported occupational musculoskeletal and psychological complaints. However, our participants are practicing surgeons and most likely they are accurately reporting their health issues. Additionally, the primary focus of our study is to assess the magnitude of occupational injuries among orthopedic oncologist and the characteristics of these injuries. Most work-

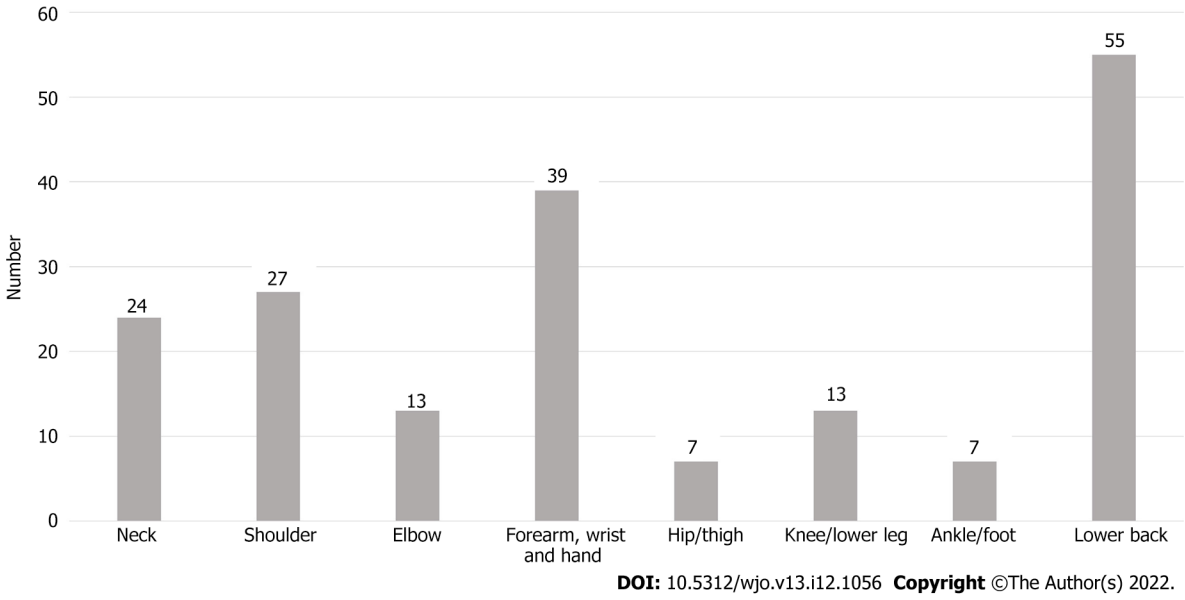

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Figure 1 Percentages of reported musculoskeletal disorders and complaints among survey participants.

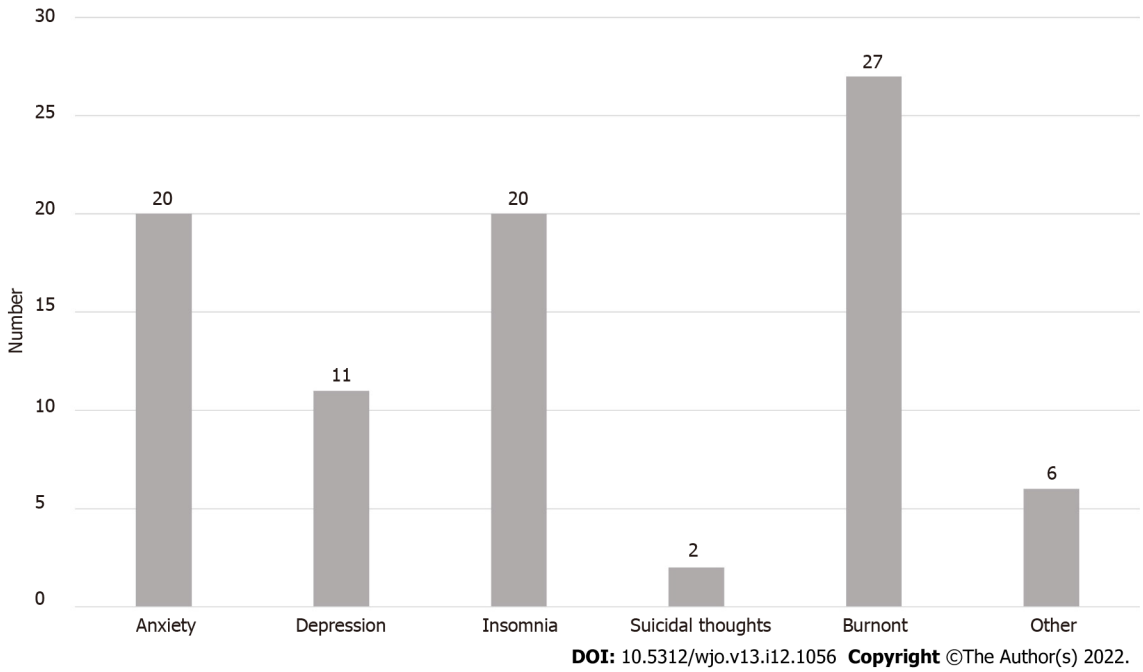

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Figure 2 Percentages of reported psychological disorders among survey participants.

related symptoms are subjective complaints and may not be associated with objective clinical findings. Therefore, it is widely accepted to evaluate the prevalence of occupational injuries by self-administered surveys. Another possible argument is the significantly higher prevalence rate of occupational injuries reported in our study. This possibly inflated prevalence could be related to that some participants in such surveys are currently or have previously been affected by occupational injuries, thus probably leading to possible response or selection bias. Although we believe this is certainly a valid concern, we still anticipate a high rate of occupational injuries among orthopedic oncologists if we assume the non-respondents are not affected with occupational injuries. The surveys used in our current study included modified self-reported outcomes, which could be an area of limitation. Future research should be directed at studying the reliability, validity, and area of weaknesses of these surveys. One of the strengths of our study is that the study sample, although relatively small, is representative of the orthopedic oncology surgeons' population in North America and Europe, which is considered not a large population.

CONCLUSION

The purpose of this survey was to increases the mindfulness of work-related health issues and its possible consequences on surgeons' wellness, patient care delivery and institutional health quality measures. Our data should help health institutions and occupational health services develop early educational programs directed to surgeons and provide preventive and supportive ergonomic measures in order to improve the surgeons' wellness and minimize the undesirable consequences of occupational injuries on the health care system.

ARTICLE HIGHLIGHTS

Research background

Orthopedic oncology surgeons commonly perform complex and prolonged surgical. This places the surgeon at increased risk of not only physical but also psychological stressors.

Research motivation

The effect of these physical and mental burdens on both the surgeon and healthcare system has not been adequately studied.

Research objectives

We aimed to explore occupational injuries among orthopedic oncology surgeons, especially prevalence, characteristics and their effect on practice.

Research methods

A modified version of the physical discomfort web-based survey was used to determine prevalence and patterns of occupational injuries among orthopedic oncology and this survey was sent to multiple orthopedic oncology societies.

Research results

The overall prevalence of occupational injury among our surgeon cohort was 84% (musculoskeletal 76%; psychological 50%; and both 43%). Low back pain was the most prevalent musculoskeletal conditions and burnout was the most prevalent psychological disorder. Old age and years in practice were associated with requirement of time off work.

Research conclusions

We found a high prevalence of occupational injuries in orthopedic oncologists, with a large proportion of them requiring time off due to these injuries.

Research perspectives

Future research should be directed towards exploring strategies directed at decreasing the prevalence of these injuries through improved ergonomics and optimized working environments to minimize stress associated with the workplace.

FOOTNOTES

Author contributions: Alaseem AM, Turcotte RE, Alzahrani MM, Al-Qahtani SM, Goulding KA contribute to study design; Alaseem AM, Turcotte RE, Ste-Marie N, Alzahrani MM, Al-Qahtani SM, Goulding KA contribute to manuscript preparation; Turcotte RE, Alzahrani MM, Al-Qahtani SM, Goulding KA contribute to methodology; Ste-Marie N contribute tostatistical analysis.

Institutional review board statement: This was a survey study and institutional review board was not required for this study.

Informed consent statement: This study is a survey and informed consent was not required.

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CASE REPORT

Wooden foreign body impalement through the right shoulder region – an unusual penetrating injury: A case report

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Abstract

BACKGROUND

Impalement of the body is a rare injury and comes with varied presentation. There is no set classification or defined protocols for managing this injury. This case report aims to create awareness among trauma surgeons about unusual presentation and management of such case.

CASE SUMMARY

A 45-year-old man presented to the emergency department with a sharp penetrating wooden plank at right clavicular region between the neck and shoulder following a road traffic accident. The vehicle had crashed into a roadside wooden hut, thus causing an impalement injury. He was meticulously worked up and taken to emergency theatre. The wooden plank was removed and the wound healed uneventfully. Postoperatively, he had fairly good shoulder function and was able to return back to work successfully.

CONCLUSION

Each impalement injury brings in challenges in management as no two cases are the same. The varied presentation and risks involved should be known to medical professionals handling the emergency. Coordinated multidisciplinary team approach is needed for successful outcome.

Key Words: Impaling; Wooden; Foreign body; Sharp object; Trunk; Case report

Core Tip: Penetration of the body, cavity, or region by an elongated object which remains *in situ* is called impalement injury. It can result from both penetrating and blunt trauma, with the severity of injury being factored by mechanism and velocity of trauma. Associated crushing, penetration, tissue loss, wound contamination, major fractures, and massive blood loss bring great challenges to surgeons besides posing difficulty in administering anesthesia.

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INTRODUCTION

Impalement injuries have been defined as penetration of a body cavity or region by an elongated object which remains *in situ* following the injury[1]. It can result from both penetrating and blunt trauma, with the severity of injury being factored by mechanism and velocity of trauma[2]. Associated crushing, penetration, tissue loss, wound contamination, major fractures, and massive blood loss bring great challenges to surgeons besides posing difficulty in administering anesthesia[3].

CASE PRESENTATION

Chief complaints

A 45-year-old male driver who lost control of a four-wheeler and hit against a roadside wooden hut, presented to the emergency department with a sharp penetrating wooden plank at right clavicular region between the neck and shoulder following the accident.

History of present illness

The vehicle had crashed into a roadside wooden hut, thus causing an impalement injury (Figure 1A).

History of past illness

Not significant.

Personal and family history

Not significant.

Physical examination

An initial assessment in the emergency room (ER) revealed a conscious patient with stable vitals and no respiratory distress. There was a large piece of wood passing through-and-through the right trapezius muscle just above the clavicle and midway between the neck and shoulder (Figure 1A). He had no evidence of any neurological deficit and the peripheral pulses were comparable in both upper limbs. He was administered Inj Tetanus Diphtheria, started on intravenous antibiotic, and immediately mobilized for radiological assessment.

Laboratory examinations

All laboratory parameters were within normal limits. However, the case was further confronted by a positive coronavirus disease 2019 (COVID-19) test report.

Imaging examinations

A rectangular cast with a slightly crooked radio-opaque shadow was seen jutting cranio-caudally, on the radiograph (Figure 1B). No other bony injury was observed.

FINAL DIAGNOSIS

Wooden foreign body (FB) impalement of right shoulder region without any neurovascular deficits following a road traffic accident.

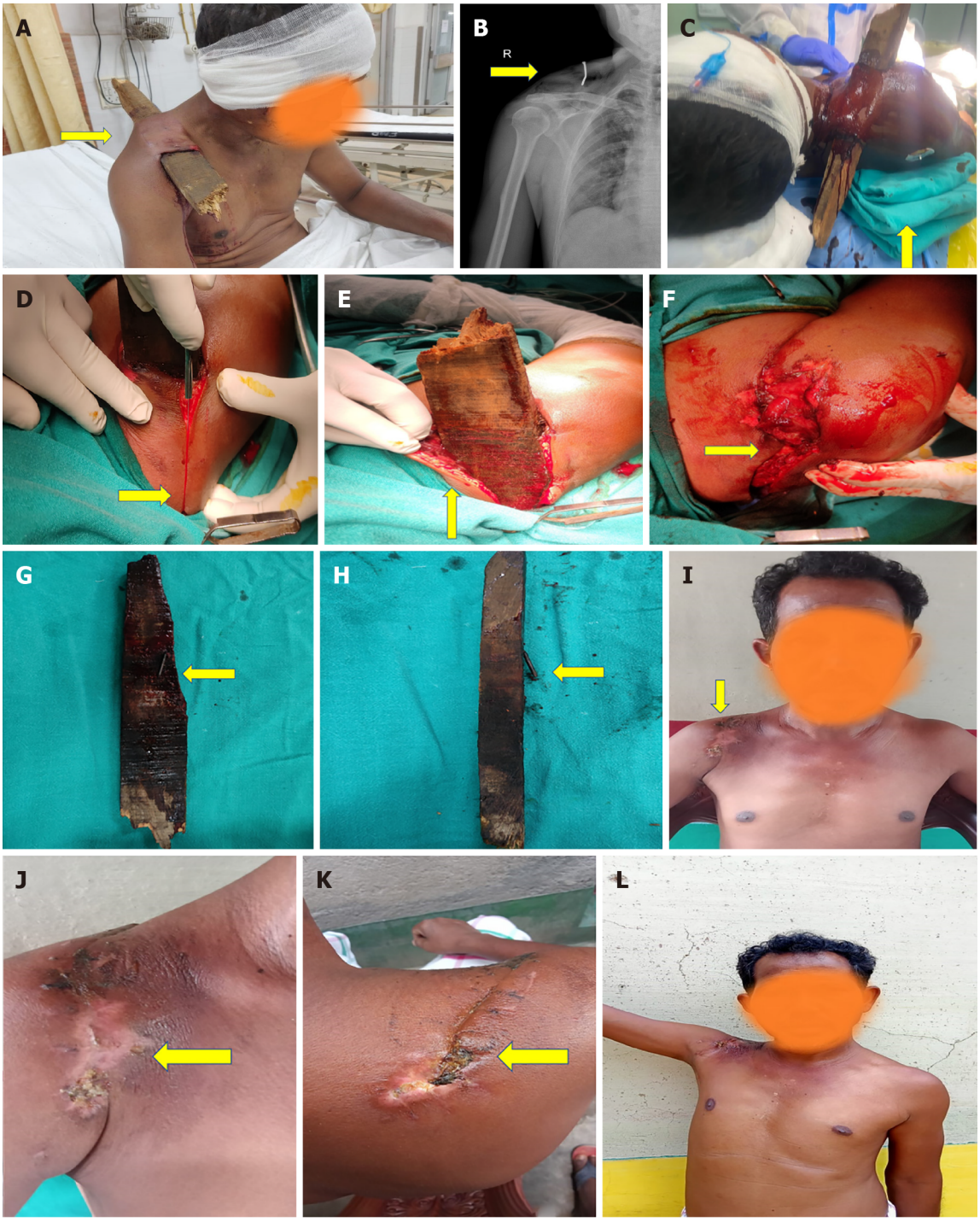

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Figure 1 Chronological figures showing impaled foreign body with its outcome. A: Emergency presentation of the injured right side with the wooden foreign body *in situ*; B: X-ray showing a rectangular cast with a metallic shadow (iron nail) embedded within the FB and tissues; C: Post intubation, folded sheets were kept underneath the scapula for better access and vision; D: After proper positioning and draping, lateral entry and exit points were connected; E: A medial based flap was raised to expose the FB. The iron nail was directed inferiorly, which was carefully dissected out; F: Condition of wound post FB removal showing crushing of edges with minimal skin loss; G and H: 30 cm × 5 cm × 1.5 cm dimension wooden FB with jagged edges at both ends and an embedded bent nail within itself; I-K: Healed flap without any evidence of secondary infection or necrosis; L: Near normal shoulder function seen 2 mo after surgery.

TREATMENT

The patient was scheduled for immediate surgery for the removal of the said FB, debridement, and repair in consultation with the general surgeon and anesthesiologist.

Upon arrival, at the operation theatre and after attaching all requisite monitoring, the patient was gently placed in the supine position with the help of multiple pillows supporting the back and head of the patient, leaving a gap in between for the posterior half of the FB protruding out through his back. General anesthesia was administered, airway secured, and the patient was repositioned with pillows

under the right shoulder for better surgical access (Figure 1C).

A vertical incision was made connecting the lateral points of entry and exit wounds (Figure 1D). A medial based flap was raised to expose the FB (Figure 1E). It was found that it had grazed over the superior surface of the clavicle at the entry point and pierced the trapezius muscle at the exit point. The FB also had a bent nail stuck within the muscle-fibres close to the exit point. It was carefully dissected out, with care being taken not to cause any injury to the adjoining tissues. The wooden FB retrieved measured 30 cm × 5 cm × 1.5 cm in dimension with the bent nail embedded within its body (Figure 1G and H). The wound was given a thorough lavage and damaged structures were looked for. Fortunately, none was noticed, and hence the wound was closed in layers (Figure 1F). The patient was reversed from anesthesia with stable hemodynamic and respiratory parameters. Subsequently, he was shifted to high dependency unit for further monitoring. The postoperative course was uneventful, and the patient was discharged after 2 d.

OUTCOME AND FOLLOW-UP

The patient on discharge was put on an arm pouch sling and intermittent shoulder mobilization was started as the glenohumeral joint escaped injury. The flaps healed well without any secondary infection and necrosis (Figure 1I-K). Passive and active range of motion exercises were initiated post suture removal. At the end of 2 mo, he had good recovery with near normal function of his right upper limb. Partial overhead abduction was present due to scarring and contracture which ensued after healing (Figure 1L).

DISCUSSION

Penetration of the body, cavity or region by an elongated object which remains *in situ* is called impalement injury[1]. Eachempati *et al*[4] classified it under two broad categories. Type 1 injuries occur when the human body strikes an immobile object. Usually, it is seen in industrial and car accidents when persons involved are ejected from their automobiles. Type 2 injuries occur due to penetration of a moving object into an immobile human body.

In prehospital management of penetrating injuries, it is of paramount importance that impaled object should not be removed, so that possible vascular lesions can remain buffered by the object, avoiding major bleeding and cataclysmic hemorrhage. High grade thoracic impalement injuries are rare and complex. It holds a high mortality rate due to associated thoracic wall and lung injuries[5]. Impalement injuries traversing the abdomen and injuring multiple organs too have high rates of morbidity and mortality[6,7].

In our case, the site of the injury was peculiar as the wooden FB grazed superiorly over the right clavicle, between the neck and shoulder presenting a horrific picture, a type 1 injury. Understanding the complexity of the injury, the general surgeon was kept on standby. The presence of the bent nail directed caudally into the tissues ameliorated any chances of removing the FB without proper dissection and assessment. The entry and exit points of the FB were not far apart unlike many reported cases. The lateral corners of both the points were connected, and a flap was raised to expose the FB. Being unusually on the right side, above the clavicle and cranial trajectory, the neurovascular bundle escaped unhurt. The above reason also minimized the chances of lung parenchymal injury. Post FB removal, the flap was approximated without any tension, which healed uneventfully.

The patient also presented with difficult anesthesia as the nature of FB orientation precluded a normal supine position[8]. Additional innovative measures had to be taken to place the patient supine by using multiple pillows behind the back and head. This made it difficult to attain the usual position for laryngoscopy and intubation, especially compounded by the presence of a COVID-19 infection.

Despite the difficulties in the management of the surgical removal of this unusual FB, a multi-disciplinary team with proper coordination and comprehension along with innovative ideas to circumvent the problems unique to this case, made it possible for us to achieve a favorable surgical outcome.

CONCLUSION

Impalement injuries are indeed challenging cases which require early mobilization to hospital and multidisciplinary team approach. As our case demonstrated, right sided supraclavicular anteroposterior impalement usually has a good functional outcome without any sequelae.

FOOTNOTES

Author contributions: Kerketta AH and Kumar R contributed equally to this work; Kerketta AH and Sahu S designed the case study; Kumar R, Laik JK, and Rajak MK performed the research; Kerketta AH and Sahu S wrote the manuscript and analyzed the data; all authors have read and approved the final manuscript.

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