Comparative study between arthroscopic reduction and internal fixation versus open-reduction internal fixation for tibial-plateau fractures

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Received: 13 November 2021
Revised: 1 December 2021
Accepted: 14 January 2022
Published: 31 May 2022

The Egyptian Orthopaedic Journal 2022, 57:33–41

Background
Tibial-plateau fractures are challenging for orthopedic surgeons. The gold-standard treatment for most tibial-plateau fractures is open-reduction internal fixation using either screws only or plates and screws. Recently, arthroscopy has invaded the field of trauma as a useful aid in the management of intra-articular fractures. The main advantages of arthroscopic reduction and internal fixation for tibial-plateau fractures are direct visualization of intra-articular fractures, accurate fracture reduction, and diagnosis and treatment of meniscal and ligamentous injuries. This study was done to compare the results of open-reduction internal fixation versus arthroscopic reduction and internal fixation for tibial-plateau fractures.
Patients and methods
A prospective comparative study was held in EL Hadra University Hospital between January 2017 and December 2019 over 56 patients. In all patients, the fracture was fixed using two to three cannulated screws. In the first group, the fixation was done using arthroscopy, while in the second group, the fixation was done using arthrotomy. All cases were assessed using Rasmussen clinical and radiological forms, Lysholm, and International Knee Documentation Committee (IKDC) scores. The minimum follow-up was 24 months since index surgery.
Results
There was no statistically significant difference between the two groups regarding the clinical and radiological Rasmussen scores. Moreover, the results of the Lysholm and IKDC were comparable. However, the arthroscopic group had longer operative time than the arthrotomy group.
Conclusion
Arthroscopic fixation technique was not inferior to open technique for management of Schatzker I–III fracture types with excellent comparable clinical and radiological outcomes while avoiding the drawbacks of the open approach.

Keywords:
arthroscopic reduction and internal fixation, arthroscopic-assisted fixation, Schatzker classification, tibial-plateau fractures

Egypt Orthop J 57:33–41

1110-1148

Introduction

Tibial-plateau fractures represent 1–2% of fractures of adults [1]. The main principles of treatment of those fractures are restoring the articular anatomy, and the mechanical axis of the lower limb and faster healing [2,3].

Different surgical approaches have been developed and used for the treatment of these fractures [3]. Internal osteosynthesis with plates and screws after open reduction is the method of choice for the treatment of complex fractures (types V–VI by Schatzker). For Schatzker type I–III fractures, surgical options include internal fixation with arthroscopic control (arthroscopic reduction and internal fixation, ARIF) and internal fixation with open reduction (open reduction and internal fixation, ORIF) [2].

ARIF was originally described by Caspari *et al*. [4] and Jennings [5] in patients with Schatzker type I–III fractures. This minimally invasive technique has been recognized as an alternative to ORIF, with lower morbidity, precise assessment of joint reduction, and the possibility of treat other intra-articular lesions. Furthermore, direct visualization of chondral surface reduction, joint lavage removal of hematoma and small loose-fracture fragment, and limited soft-tissue dissection reduced morbidity in comparison with arthrotomy, with no need to peripherally detach the meniscus to gain

 DOI: 10.4103/eoj.eoj_129_21

visualization, and improve rehabilitation and postoperative recovery, including decreased pain, shorter hospital stay, and return of knee range of motion. Moreover, ARIF avoids the complications of open approach like infections, septic arthritis, delay in postoperative return to knee range of motion, and stiffness [6–9].

The main disadvantage of the arthroscopic approach is longer operating time with the risk of extravasation of fluid-and-compartment syndrome [10].

Recent literature has reported good functional and radiological results in the short and medium term. However, the fact that ARIF allows better clinical and radiological results to be obtained is still debated [10–14].

The aim of this study was to evaluate and compare the clinical and radiological results of patients treated with ARIF and ORIF. Our hypothesis was that ARIF allows obtaining clinical results similar to ORIF with satisfactory reduction and stable fixation.

Patients and methods

The study included 56 adult patients with a Schatzker [15] I, II, and III tibial-plateau fracture who were admitted to El Hadra University Hospital Trauma Center between January 2017 and December 2019.

The exclusion criteria were:

(1) Types IV, V, and VI of the Schatzker classification.
(2) Pathological fractures.
(3) Open fractures
(4) Associated neurovascular injury or compartment syndrome.

Patients were classified randomly into two groups. The first group (group A) was treated with ARIF. The second group (group B) was treated with classical open reduction and internal fixation.

Patients were assessed preoperatively using frontal and lateral radiograph films and computed tomography scan with 3D-reconstructive images. In all patients, the depressed fragment was elevated and supported by corticocancellous iliac filler graft and was fixed with two or three cannulated screws under fluoroscopic control.

In both groups, absolute nonweight bearing was recommended for 6 weeks with a hinged knee support allowing full ROM from day 1. Partial weight bearing was then allowed as tolerated and full support was gained at about 3 months postoperatively.

A clinical evaluation was made using clinical Rasmussen score [16], Lysholm [17], and International Knee Documentation Committee (IKDC) [18]. Passive mobility and active (flexion and extension) were noted. Complications were identified, intraoperatively and postoperatively. In the Rasmussen score [16], subjective and objective parameters were identified. The results were rated as follows: excellent: 27–30 points, good: 20–26 points, fair: 10–19 points, and poor: less than 10 points.

To assess the postoperative reduction, postoperative and follow-up radiographs were used to assess the quality of the reduction, the mechanical axis of the lower limb, and the presence of osteoarthritis according to the Ahlback classification [19]. In the last follow-up, no computed tomography scan was performed postoperatively for financial and logistic reasons. Also, Rasmussen radiological score [16] was used to assess postoperative reduction. The results were rated as follows: excellent: 18 points, good: 12–18 points, fair: 6–11 points, and poor: less than 6 points.

Statistical evaluation was done using SPSS, version 25 (IBM SPSS Statistics for Windows, Version 25, Armonk, NY: IBM Corp). The P value was set at 0.05. Independent t test was used to compare between the two groups as the data were parametric and normally distributed. χ^2 test was used for qualitative data.

The study was approved by local ethical committee of Alexandria University Faculty of Medicine. An informed consent was taken from every patient submitted to the study. Patients were followed up for 2 years.

Surgical technique

All patients were examined for the soft-tissue envelope of the limb before the operation. Findings like severe swelling, ecchymosis, visible contusions, and blisters were indicative for the severity of soft-tissue injury. Adequate preoperative neurovascular examination and exclusion of compartment syndrome was done. All cases were operated under spinal anesthesia with a high-thigh tourniquet and adequate draping of the graft area. In the ORIF group, the conventional techniques were used with the patient flat on the operative table.

In the ARIF group, the arthroscope requires varying degrees of knee flexion and varus/valgus stress to adequately view the joint and concomitant fluoroscopic viewing is generally with the knee extended. For this purpose, this group of patients was operated with knee flexed and leg freely hanging from the operative table to give best exposure of all compartments of the knee joint and figure-of-4 position during lateral compartment work (Fig. 1).

First, hematoma evacuation for good visualization and quiet examination of the knee joint. Any intra-articular pathology was dealt with before fixation. A figure-4 position allowed good access to the lateral compartment with adequate visualization of the fracture depression (Fig. 2).

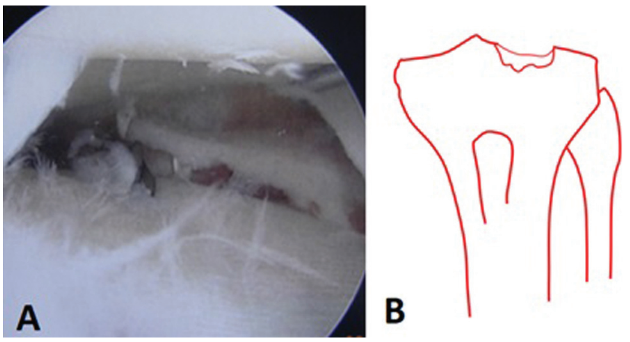
The anterolateral and anteromedial portals were used to insert the arthroscope as well as working instruments. High pump pressure was avoided and only gravity inflow was allowed. When intra-articular visibility becomes sufficient, a shaver can be introduced to assist in removing the clots and small bone fragments within the joint cavity. Once joint lavage is complete, a comprehensive evaluation is performed to identify the bone and cartilage lesions, as well as any damage to other structures such as the menisci and ligaments by probing of the capsuloligamentous structures. When the anterior horn of the lateral meniscus overlaps the depressed area, a meniscal retractor was used to uncover the working area.

The depressed plateau is elevated arthroscopically using the basic tools of ACL reconstruction. A guide wire was initially introduced up through the metaphyseal bone to the apex of the fragment using an ACL guide (C guide). Once the position is checked arthroscopically, the cortical window was then created over a KW with a reamer reaching up to 2 cm below the depression (Figs. 3 and 4).

Figure 1

The ideal position for ARIF with operating leg hanging freely and flexed more than 90°. ARIF, arthroscopic reduction and internal fixation.

Figure 2

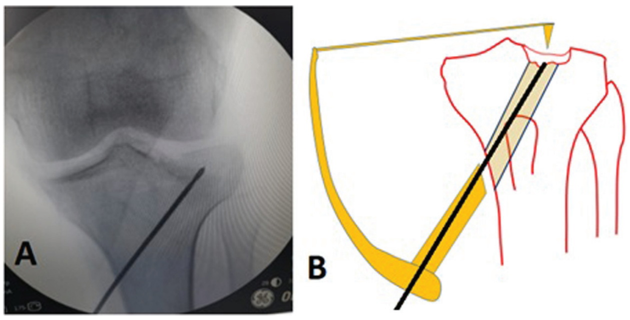


(a and b) The depressed fragment of the lateral compartment.

Figure 3

Use of C guide over the depressed area to insert a KW directed to the depressed fragment.

Figure 4



A KW is inserted into the depressed area with the help of C guide.

The fragment was then elevated using bone tamps or bone-graft impactor. Elevation was performed very gently, under fluoroscopic and arthroscopic guidance. Once the reduction was obtained, temporary stabilization was achieved using one or two pins introduced few millimeters below the joint surface. Pin position was then evaluated on anteroposterior and lateral fluoroscopy views (Figs. 5 and 6).

After impaction of autologous iliac crest bone grafting from the iliac bone, two cannulated screws were inserted to prevent collapse of the elevated fragment. No plates were used in this series. Meniscal sutures were done in some cases of the arthroscopic group (Figs 7–9).

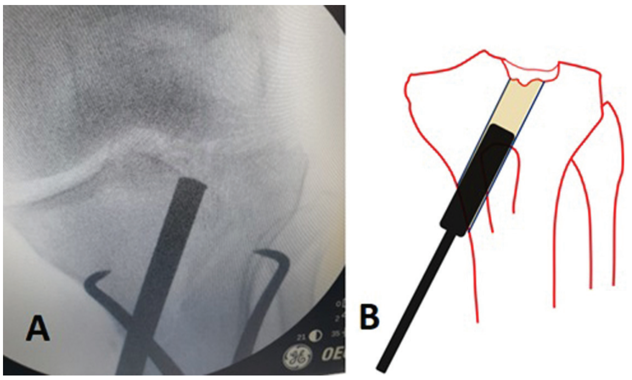
Results

The study included 56 adult patients who were admitted to El Hadra University Hospital. Group A was managed arthroscopically and there were 25 patients. Their mean age was 30.4±6.9 years. Group B was managed conventionally using ORIF and there were 31 cases with mean age 30.3±6.4 years. The difference between the two groups was statistically insignificant denoting adequate matching of the groups. Patients' demographic data are included in Table 1. There was a significant difference between operative time of both groups (Fig. 10). The ARIF group had significantly longer time ($P<0.05$).

Regarding the improvement of the clinical patient scores, there was no statistically significant difference in both groups regarding Rasmussen, Lysholm, or IKDC. This confirms our hypothesis, the ARIF can reach nearly the same results of ORIF. However, there were more cases with stiffness, postoperative flexion deformity, and superficial infection with open-approach group. However, the overall difference was statistically not significant (Table 2).

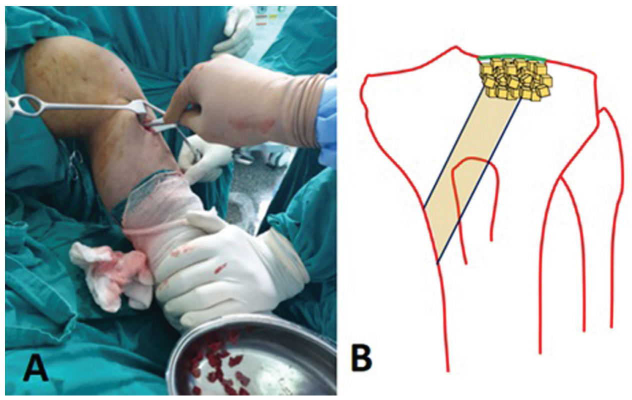
Regarding radiological evaluation, there was no statistically significant difference between the final Rasmussen score nor the incidence of arthritis in both groups. This again confirmed noninferiority of ARIF (Tables 2 and 3) (Fig. 11).

Figure 5



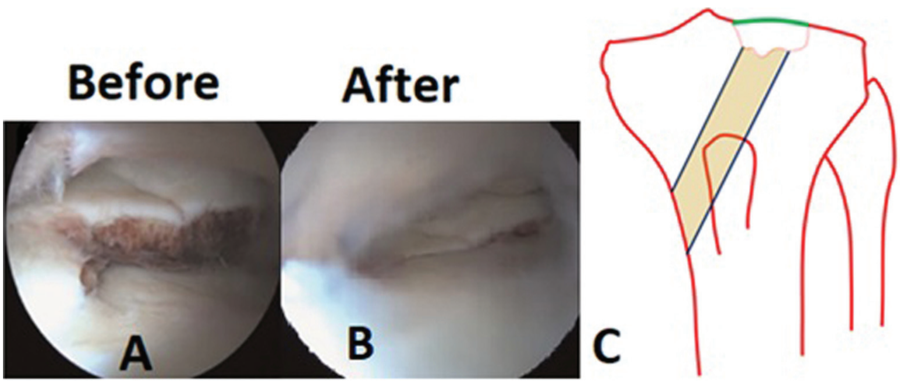
The elevation of the depressed fragment using bone impactors.

Figure 7



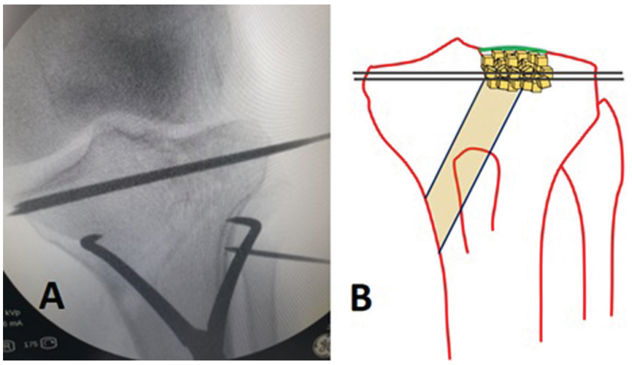
Impaction of bone chips inside the tunnel created under the defect to support the elevated fragment.

Figure 6



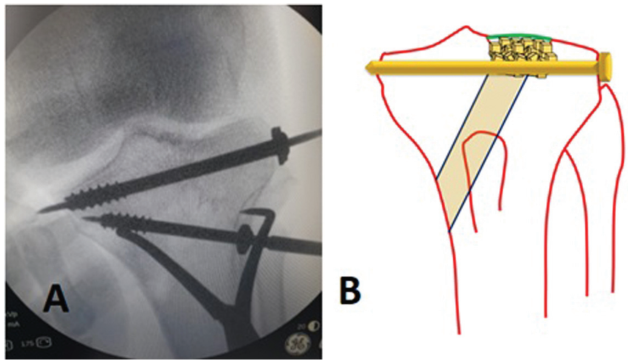
(a) The fragment before elevation, (b, c) after elevation.

Figure 8



Insertion of two subchondral KW for the fixation of bone chips under the elevated fragment.

Figure 9



Fixation with cannulated subchondral screws to avoid fragment collapse.

Table 1 Patients' demographic data

	Group A ARIF (25)	Group B ORIF (31)	Test of significance	*P* value
Age	30.4±6.9	30.3±6.4	t=0.04	0.96
Sex				
Male	17	23	χ^2=0.516	0.472
Female	8	7		
Side affected				
Right	13	17	χ^2=0.045	0.832
Left	12	14		
MOT				
RTA	10	14	χ^2=1.36	0.505
FFH	13	12		
Twisting	2	5		
Schatzker type				
I	4	2		
II	4	11	χ^2=3.35	0.187
III	17	18		
BMI	26.9±2.8	28±2.6	*t*=1.55	0.12
Duration of the operation	93.6±18.9	57.3±12.2	*t*=8.64	0.000*
Associated injuries				
MM tear	1	5		
LM tear	12	10	χ^2=2.94	0.23
Cartilage injury	3	5		

ARIF, arthroscopic reduction and internal fixation; ORIF, open-reduction internal fixation; *t*, independent *t* test; χ^2: χ^2 test. **P* value significant if less than 0.05.

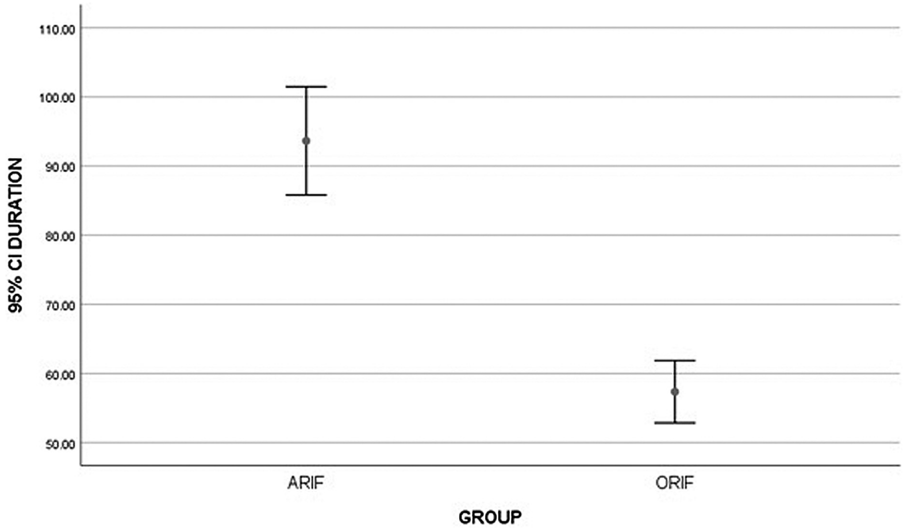
Regarding the fracture type, there was no difference in the postoperative radiological outcomes between the three types included in the study. However, clinically, type III had the best clinical outcomes with about 21 (46%) cases out of 45 that had excellent clinical scores. Type II has the most fair results in the series. About 57% of type II had fair results (Table 4) (Fig. 12).

Discussion

As with any other intra-articular fracture, the tibial-plateau fracture is always challenging for orthopedic surgeons, because of its widely varying trauma, and associated soft-tissue injuries. The major treatment objectives should be reconstructing articular surfaces, obtaining stable fixation for early motion, and repairing all concomitant lesions. Joint congruity and stability should be the main treatment consideration [20].

The main findings of this study are there is no significant difference between the two groups ARIF and ORIF in terms of clinical results, ROM, radiological scores, and complication rate. There is no difference in terms of the quality of the reduction. Furthermore, the complication rate is comparable. This confirms the null hypothesis according to which ARIF, for the treatment of Schatzker I–III fractures, with clinical results, is

Figure 10



An error bar showing the difference in the operative time between both groups.

Table 2 Patients' clinical improvement

	Group A ARIF (25)	Group B ORIF (31)	Test of significance	*P* value
Rasmussen clinical score				
Pain				
Rest pain	2	0		
Constant pain	2	4	χ^2=2.89	0.409
Occasional pain	11	13		
No pain	10	14		
Walking				
Indoor only	3	0		
>15 min	3	6	χ^2=4.68	0.19
Walk 1 h	5	9		
Normal walk	14	16		
Extension				
>10-deg. FD	0	7		
0–10 FD	7	1	χ^2=11.6	0.003*
Normal	18	23		
ROM				
>60	0	5		
>90	5	9	χ^2=5.96	0.114
>120	7	7		
>140	13	10		
Stability				
Stable	25	31	–	–
Unstable	0	0		
Total Rasmussen				
Excellent	16	17	χ^2=0.49	0.781
Good	6	9		
Fair	3	5		
Total clinical Rasmussen	26.2±4.3	25.5±4.4	*t*=0.54	0.59
Lysholm 2 years	89.6±4.5	90.8±5.6	*t*=0.916	0.34
IKDC score 2 years	88.4±8.1	94.5±55.4	*t*=0.998	0.29
Complications				
Infection	0	2		
Arthritis	7	5	χ^2=8.91	0.063
Stiffness	0	6		
Flex def	3	1		
None	15	17		

ARIF, arthroscopic reduction and internal fixation; IKDC; International Knee Documentation Committee; ORIF, open-reduction internal fixation; *t*, independent *t* test; χ^2: χ^2 test. **P* value significant if less than 0.05.

Table 3 Patients' radiological assessment

	Group A ARIF (25)	Group B ORIF (31)	Test of significance	*P* value
Rasmussen radiological score				
Articular depression				
6–10 mm	4	2	χ^2=3.16	0.205
<5 mm	3	9		
No depression	18	20		
Condylar widening				
<5 mm	14	6	χ^2=8.09	0.004*
No widening	11	25		
Angulation				
10–20 deg.	1	0		
<10 deg.	2	1	χ^2=1.94	0.37
No angulation	22	30		
Total Rasmussen				
Excellent	10	17		
Good	12	14	χ^2=4.37	0.112
Fair	3	0		
Total radiological Rasmussen	15.6±2.8	16.7±1.6	*t*=1.6	0.099
Arthritis on 2-year FU radiograph				
Yes	7	4	χ^2=1.99	0.157
No	18	27		

ARIF, arthroscopic reduction and internal fixation; ORIF, open-reduction internal fixation; *t*, independent *t* test, χ^2: χ^2 test. **P* value significant if less than 0.05.

Figure 11

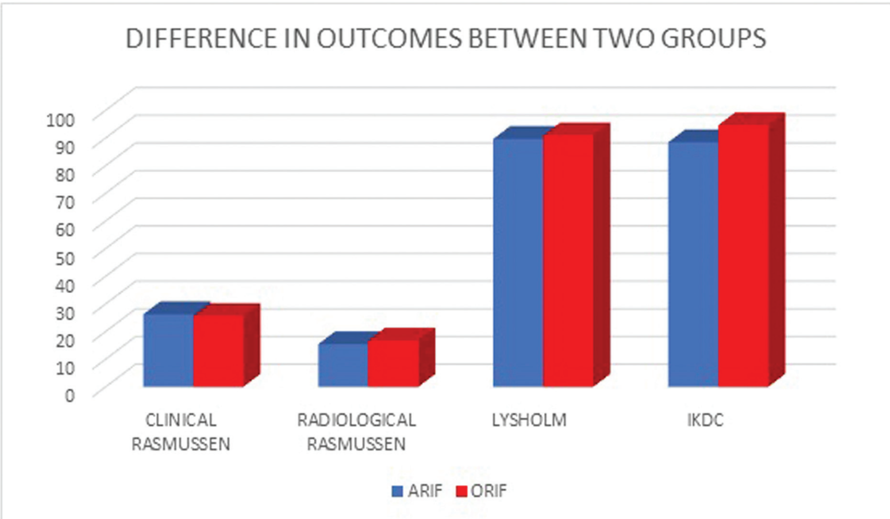


Chart showing no statistical difference between the groups in all scores tested.

comparable to ORIF in addition to satisfactory reduction.

Open fixation of tibial-plateau fractures has a lot of drawbacks. The arthrotomy, and the submeniscal section of the meniscus, should be performed to allow the best visualization of the articular surface. This approach can cause stiffness, proprioception disturbances, severe postoperative pain, and scar complications [21].

Arthroscopy has been suggested to avoid these drawbacks. In our study, the rate of stiffness and PO flexion deformity was more with the ORIF group than ARIF. However, the difference in the overall complication rate was not significant.

There are many advantages of ARIF approach, including better visualization of the articular surfaces, better reduction of the fracture, better anatomical restoration of the joint surface, the

Table 4 Outcomes of each fracture type

	Excellent		Good		Fair		
Schatzker type	Clinical	Rad	Clinical	Rad	Clinical	Rad	*P* value
I	5	4	1	2	0	0	
II	7	6	2	7	12	2	
III	21	17	12	17	2	1	
χ^2 for clinical scores				χ^2=12.5			0.014*
χ^2 for radiological score				χ^2=3.4			0.493

χ^2: χ^2 test. *P value significant if less than 0.05.

Figure 12

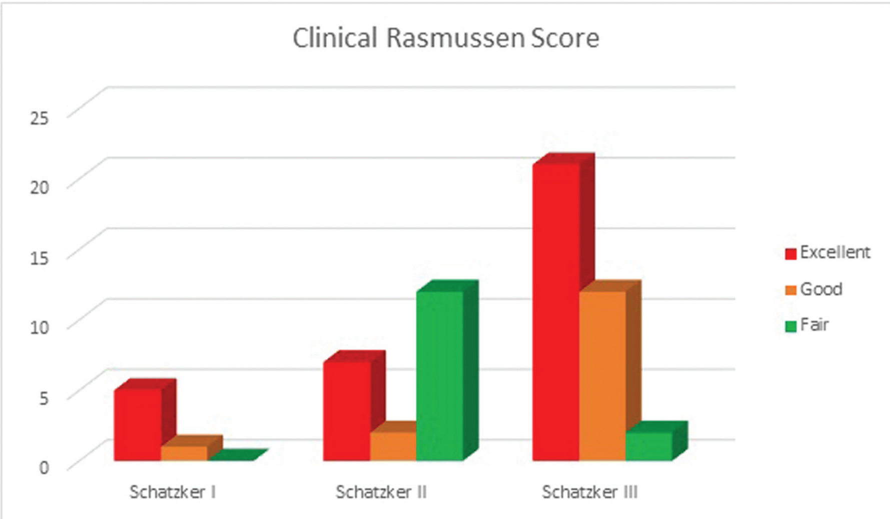


Chart showing the difference in the clinical outcomes between the three types of tibial-plateau fractures.

possibility to assess and treat the associated intra-articular ligamentous and meniscal injuries, the possibility, through joint lavage, to remove loose fragments, the possibility to achieve stable fixation with the least amount of soft-tissue dissection, low risk of complications and low morbidity, the possibility of converting to arthrotomy if necessary, and shorter hospital stay with faster recovery of joint motion [10].

Ohdera *et al*. [22] confirmed no difference in operative duration, postoperative flexion, or clinical results, even though faster postoperative recovery had been noted in the ARIF group. Fowble *et al*. [23] obtained a 100% reduction that deemed satisfactory by ARIF, whereas this rate was only 55% for the ORIFs.

Kiefer *et al*. [24] found satisfactory reduction in only 80% of the ARIF series. Van Glabbeek *et al*. [25] reported only one arthroscopic-reduction failure out of a total of 20 fractures. Ohdera *et al*. [22] found satisfactory reduction in 85% of arthroscopic patients compared with only 55% of open surgical patients.

Le Baron *et al*. [20] found no statistical difference demonstrated between the two groups ARIF and ORIF in all Schatzker types tested (I–III) in terms of passive or active extension, active flexion, Lysholm and IKDC scores, the quality of the reduction, the hip–knee angle, or the presence of radiological signs of osteoarthritis. However, a significant difference existed for the HSS score, but these differences were not clinically relevant.

The mechanical stability of the fracture obtained by isolated screwing for Schatzker type I–III fractures is confirmed by the literature [26]. This minimally invasive osteosynthesis is therefore perfectly suited to arthroscopic-assisted surgery. The use of arthroscopy makes it possible, thanks to an ACL-aiming device and without the use of an image intensifier, to reduce the sinking by acting directly on it, while obtaining an optimal placement of the cannulated screws under the joint depression [20,21].

ARIF exposes to technical difficulties, and in particular, the bleeding of the fracture, which can interfere with the arthroscopic procedure. This difficulty can be minimized by use of a pump, but increases the risk of fluid extravasation and the incidence of compartment syndrome. No compartment syndrome was found in our cases. However, Herbort *et al*. [6] clearly identified complex tibial-plateau fractures as a contraindication to ARIF due to the high risk of iatrogenic compartment syndrome secondary to extravasation of arthroscopic fluid, despite an extreme rarity in the literature [27].

This study has several limitations: small number of cases, lack of a long film to calculate limb alignment postoperatively, the selection bias as the series was not randomized (lack of randomization), and the difference in the prognosis noted between Schatzker fracture types (treatment bias).

Conclusion

ARIF technique was not inferior to ORIF for management of Schatzker I–III fracture types with excellent comparable clinical and radiological outcomes while avoiding the drawbacks of the open approach.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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