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Original article

Tibial plateau fracture management: ARIF versus ORIF – clinical and radiological comparison☆

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ABSTRACT

Introduction: Arthroscopy has enabled minimally invasive procedures to be developed to treat tibial plateau fracture. The aim of the present study was to assess and compare clinical and radiological results between arthroscopically assisted reduction and internal fixation (ARIF) and open reduction and internal fixation (ORIF) procedures. The study hypothesis was that, in selected tibial plateau fractures, ARIF provides (1) clinical results comparable to those of ORIF, and (2) satisfactory reduction and stable fixation.
Material and method: A retrospective multicenter study included adult patients with tibial plateau fracture (Schatzker I to III), over the period January 2010 to December 2014, enabling a minimum 2 years' follow-up. Clinical and radiological data (RoM, IKDC, HSS, Lysholm) were collected at 3, 6 and 12 months and at last follow-up. A total of 317 patients (317 fractures), aged 48 ± 14 years (range, 18–82 years) were followed up for 38 ± 23 months (range, 24–90 months), with 77 fractures (24%) in the ARIF group and 240 (76%) in the ORIF group.
Results: Clinically, there were no significant inter-group differences for active flexion, passive or active extension or Lysholm and IKDC scores, with significant differences for HSS (ARIF: 74 ± 29; ORIF: 70 ± 31; $p < 0.01$) and passive flexion (ARIF: 130 ± 19° (range, 80–160°); ORIF: 130 ± 15.965° (range, 60–140°); $p < 0.05$). Radiologically, there were no significant inter-group differences for reduction quality, lower-limb mechanical axis or signs of osteoarthritis. There were no secondary displacements. There were 7 complications (7/77, 9%) in the ARIF group and 18 (18/240, 8%) in the ORIF group, and 6 surgical revisions for early infection (2 ARIF, 4 ORIF), with no significant inter-group differences.
Discussion: The study hypothesis was confirmed: in Schatzker I–III fractures, ARIF provided clinical results comparable to those of ORIF, with satisfactory reduction and stable fixation. ARIF has its place in the treatment of tibial plateau subsidence and/or separation fracture.
Level of evidence: III, retrospective comparative study.

1. Introduction

Tibial plateau fractures account for 1–2% of fractures in adults [1]. Although rare, they involve various different lesions, with potentially serious consequences if not properly managed [2,3]. Treatment is consensual: restoring joint anatomy and lower-limb mechanical axis, and achieving consolidation.

Various surgical approaches have been developed. Internal fixation by plate and screws after open reduction is the treatment of choice for complex fracture (Schatzker types V–VI). For Schatzker types I–III, the surgical options are arthroscopic reduction and internal fixation (ARIF) and open reduction and internal fixation (ORIF). ARIF in Schatzker types I–III was first described by Caspari and Jennings [4,5]. It is a minimally invasive alternative to ORIF, with lower morbidity, precise assessment of joint reduction and the possibility of treating associated intra-articular lesions [6–17]. Classical drawbacks are higher cost and longer operative time. The recent literature reports good short- and medium-term functional

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and radiological results [9,11,13,14,18–34], although this remains controversial. The aim of the present study was to assess and compare functional and radiological results between ARIF and ORIF. The study hypothesis was that, in selected tibial plateau fractures, ARIF provides (1) clinical results comparable to those of ORIF, and (2) satisfactory reduction with stable fixation.

2. Material and method

2.1. Study design

A multicenter retrospective study conducted in 6 university hospitals (Paris, Strasbourg, Rouen, Toulouse, Grenoble, Marseille), included adults treated for Schatzker I, II or III tibial plateau fracture [35] between January 2010 and December 2014.

Exclusion criteria comprised:

- Schatzker types IV, V and VI [35];
- pathologic fractures;
- fractures managed by external fixation or other non-operative means;
- incomplete patient records;
- follow-up shorter than 2 years.

Patients treated by arthroscopy were included in the ARIF group and those undergoing open surgery in the ORIF group. Fractures were assessed preoperatively on AP and mediolateral X-ray and CT.

Patients provided consent for the study; review board approval was not sought.

Surgical technique, and hence group allocation, were at the surgeon's discretion. Three centers performed both ARIF and ORIF (Paris, Toulouse, Grenoble) and 3 only ORIF (Strasbourg, Rouen, Marseille).

2.2. Series

Between January 2010 and December 2014, 485 patients (mean age, 52 ± 14 years; range, 20–82 years) presented with tibial plateau fracture in the 6 university hospitals.

After application of the exclusion criteria, 317 patients (317 fractures) remained eligible: mean age, 48 ± 14 years (range, 18–82 years); mean follow-up, 38 ± 23 months (range, 24–90 months) (Fig. 1).

Seventy-seven fractures (n = 77/317, 24%) were included in the ARIF group (Figs. 2 and 3) and 240 (n = 240/317, 76%) in the ORIF group (Fig. 4). The 2 groups were comparable for age, gender and operated side (Table 1). Distribution between Schatzker types I, II and III differed significantly: respectively, 26%, 41.6% and 32.4% in the ARIF group and 23.3%, 58.8% and 17.9% in the ORIF group (p = 0.011). ARIF was used especially in type III (36.8%, versus 26.3% and 18.5% in types I and II, respectively).

A tourniquet was applied in 253 cases (n = 253/317, 80%). Irrigation was implemented for arthroscopy, with (n = 48/77; 62%) or without (n = 29/77; 37%) arthroscopy pump.

In the ORIF group, the approach was anterolateral in 201 cases (201/240, 84%), medial in 28 (12%), and combined in 11 (4%).

Graft filling was used in 37.5% of cases (autologous in ¼ of patients, synthetic in ¾), with no significant difference between groups (p = 0.39).

In the ORIF group, fixation used a standard plate (n = 67/240; 27.9%), locking plate (n = 107/240; 44.6%) or 6.5 mm percutaneous screws (n = 66/240; 27.6%). In the ARIF group, fixation used 6.5 mm percutaneous screws (n = 73 ; 94.8%), with 1 (n = 4), 2 (n = 42) or 3 screws (n = 27).

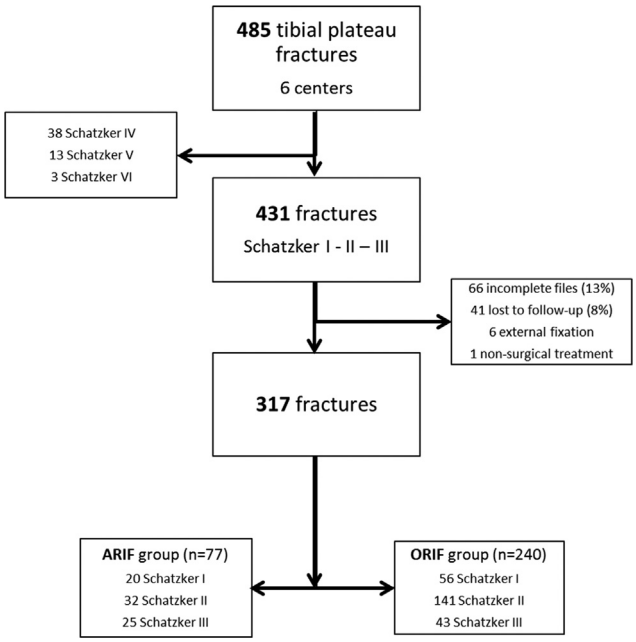

Fig. 1. Study flow chart.

In both groups, 6 weeks' non-weight-bearing was applied, with immobilization between physiotherapy sessions. Immediate postoperative free mobilization was allowed.

2.3. Radiological and clinical assessment

Postoperative reduction was assessed on AP and mediolateral X-ray, analyzing:

- reduction quality, considered satisfactory for frontal and sagittal deficit < 2 mm, on immediate postoperative radiographs and at last follow-up;
- lower-limb mechanical axis (heel-knee-ankle angle: HKA);
- osteoarthritis at last follow-up on Ahlback's classification [36].

Radiographs were read by an independent observer in each center. For ethical reasons, CT was not performed to assess joint reduction.

Clinical assessment was performed in each center, by the patient's surgeon at 3, 6 and 12 months, and by an independent observer at last follow-up. The following scores were used for last-follow-up assessment: Hospital for Special Surgery (HSS) [37], Lysholm [38] and IKDC [39]. Passive and active ranges of motion in flexion and extension were measured. Intra- and post-operative complications were recorded.

2.4. Statistical analysis

The non-parametric Mann-Whitney test for non-matched samples was used to compare HSS and IKDC scores, ranges of motion and HKA angle between groups. Alpha risk was set at 0.05. A bilateral Chi^2 independence test was used to assess association between use of arthroscopy on the one hand and reduction quality and presence of osteoarthritis on the other. Statistical analyses used the EasyMedStat on-line app (www.easymedstat.com; Neuilly-Sur-Seine; France).

3. Results

Results are shown in Table 2.

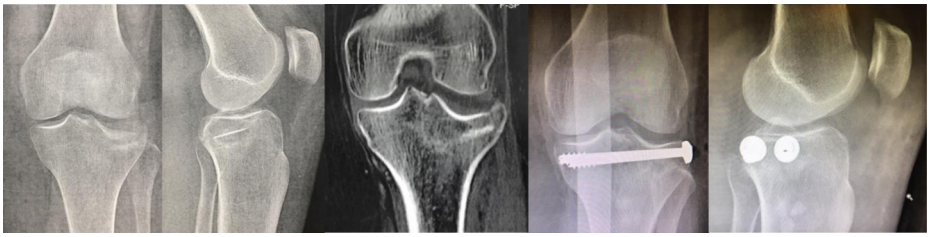

Fig. 2. Schatzker type III fracture treated arthroscopically (ARIF): preoperative radiography and CT, postoperative radiography.

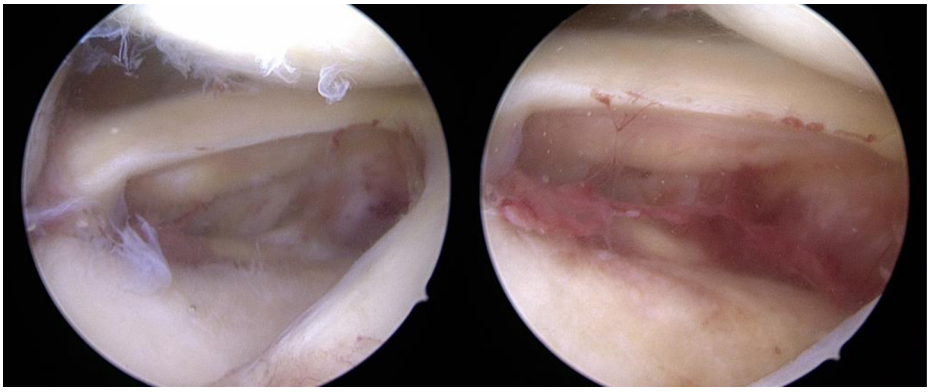

Fig. 3. Schatzker type III fracture treated arthroscopically (ARIF): arthroscopic views.

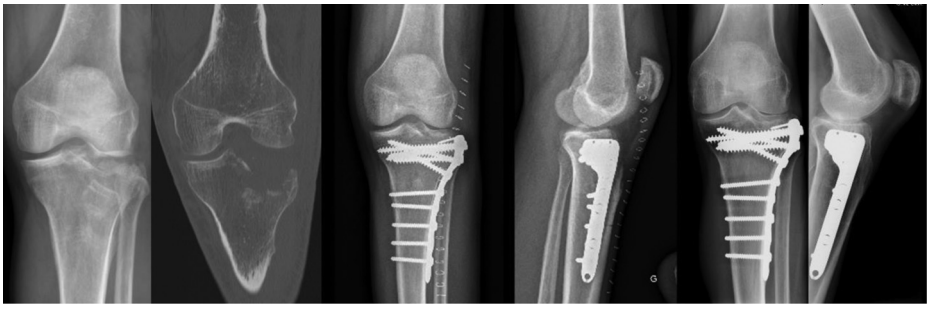

Fig. 4. Schatzker type III fracture treated by open surgery (ORIF): preoperative radiography and CT, immediate postoperative and 5-year radiography.

Table 1
Characteristics of ARIF and ORIF groups.

Variable	ARIF *n* = 77 patients	ORIF *n* = 240 patients	*p*-value
Follow-up (months)	38 ± 23 (24-90)	37 ± 23 (24–87)	*p* = 0.322
Age at inclusion (years)	52 ± 14 (20-82)	53 ± 13 (20–82)	*p* = 0.584
Female gender	no 57.1% yes 42.9%	no 59.2% yes 40.8%	*p* = 0.75360
Side (left/right)	50/27 (65%/35%)	109/79 (58%/42%)	*p* = 0.294 bilateral Chi^2 independence test
Schatzker type [34]	Schatzker I = 26.0% Schatzker II = 41.6% Schatzker III = 32.4%	Schatzker I = 23.3% Schatzker II = 58.8% Schatzker III = 17.9%	*p* = 0.01067
Operative time (mn)	75 ± 15 (20–180)	77 ± 16 (30–180)	*p* = 0.4754
Tourniquet	70 (97%)	28 (91%)	*p* = 0.31
Arthroscopic pump	*n* = 48 (62%) at 50 mm Hg	–	–

Table 2
Inter-group comparison.

Variable	ARIF $n = 77$ patients	ORIF $n = 240$ patients	p-value
Active flexion (°)	123 ± 18.8 (80–145)	123 ± 14.7 (48–135)	$p = 0.577$
Passive flexion (°)	130 ± 19.2 (80–160)	130 ± 16 (60–140)	$p < 0.05$
Active extension (°)	0 ± 2.6 (−10 to 0)	−0.7 ± 3.2 (−20 to 0)	$p = 0.4024$
Passive extension (°)	−0.22 ± 3.9 (−10 to 0)	−0.22 ± 9 (−15 to 0)	$p = 0.483$
HSS score [35]	85 ± 14.6 (40–100)	73 ± 32.8 (10–100)	$p < 0.01$
Lysholm score [36]	85 ± 15.7 (35–100)	85 ± 14.7 (2–100)	$p = 0.489$
IKDC score [37]	74 ± 29.3 (0–100)	70 ± 31.9 (0–100)	$p = 0.543$
Reduction quality	Satisfactory $n = 65$ (84.4%) vs. unsatisfactory $n = 12$ (15.6%)	Satisfactory $n = 192$ (80%) vs. unsatisfactory $n = 48$ (20%)	$p = 0.501$
HKA angle (°)	182 ± 6 (170–195)	182 ± 5 (170–185)	$p = 0.821$
Early complications	$n = 5$ (5.2%) 2 infections 1 deep venous thrombosis 1 neural palsy	$n = 13$ (5.4%) 1 non-union 4 healing delays 4 infections 1 neural palsy 2 deep venous thromboses 1 complex regional pain syndrome	$p = 0.713$
Surgical revision for mechanical complication	2 (2.6%)	5 (2.1%)	$p = 0.5858$
Osteoarthritis (Ahlback > 0)	$n = 47$ (62%)	$n = 161$ (69%)	$p = 0.766$

3.1. Clinical and radiographic results

At follow-up, there were no significant inter-group differences, taking all Schatzker types together, in terms of:

- passive or active extension;
- active flexion;
- Lysholm or IKDC scores;
- reduction quality;
- HKA;
- or radiologic signs of osteoarthritis.

There were significant differences in HSS score (mean 74 ± 29 for ARIF versus 70 ± 31 for ORIF; $p < 0.01$) and passive flexion (ARIF: 130 ± 19 (range, 80–160); ORIF: 130 ± 16 (range, 60–140); $p < 0.05$); these differences, nevertheless, were not clinically relevant.

3.2. Reduction quality

Reduction quality on immediate postoperative views was satisfactory in 65 cases (65/77, 84%) with ARIF and 192 cases (192/240, 80%) with ORIF ($p > 0.05$). There were no cases of secondary displacement between immediate postoperative views and last follow-up. There was no significant association between Schatzker type and clinical results.

3.3. Complications

There were 7 complications (7/77, 9%) in the ARIF group and 18 in the ORIF group (18/240, 8%), which was not significantly different, requiring 13 revision procedures in all: 4/77 in the ARIF group and 9/240 in the ORIF group. Two patients in the ARIF group (2/77) and 4 in the ORIF group (4/240) contracted early postoperative infection, treated by surgical lavage and adapted antibiotic therapy. Two patients in the ARIF group (2.6%) and 5 in the ORIF group (2.1%) required surgical revision, by osteotomy or total joint replacement, for mechanical complications ($p > 0.05$).

4. Discussion

The main findings of the present study are: (1) there were no significant differences in clinical results between ARIF and ORIF except for HSS score and passive flexion, neither of which have significant clinical importance; (2) there was no significant difference in reduction quality; and (3) the complications rates were comparable. This confirms the study hypothesis that, in Schatzker I-III fracture, ARIF provides clinical results comparable to those of ORIF, with satisfactory reduction.

Open internal fixation of tibial plateau fracture has theoretic drawbacks. Arthrotomy with a submeniscal approach or transverse meniscal sectioning are required for joint surface visualization, which may induce stiffness, proprioceptive disorder, severe postoperative pain and scar-related complications [13,21–25,40]. Arthroscopy was introduced to avoid these drawbacks; yet, in the present study, only HSS score and passive flexion were better with ARIF than ORIF; all other clinical criteria (Lysholm, IKDC, active flexion, extension) were comparable, finally indicating that ORIF is a relatively safe procedure. Ohdera et al. [22] confirmed this, with no significant difference in operative time, postoperative flexion or clinical results, although postoperative recovery was quicker with ARIF.

There is consensus that arthroscopy provides good-quality joint reduction. Fowble et al. [41] achieved 100% satisfactory reduction with ARIF, but only 55% with ORIF. Kiefer et al. [27] reported 80% good-quality reduction with arthroscopy. Van Glabbeek et al. [33] reported only 1 reduction failure out of 20 separation/subsidence fractures managed arthroscopically. And Ohdera et al. [22] reported 85% satisfactory reduction with arthroscopy, compared to only 55% with open surgery [22].

Reduction of subsidence under arthroscopy can be considerable, as shown by Gill et al. [29], with mean correction from 7.7 mm to 0.8 mm; internal fixation used isolated screwing in ARIF and plate in ORIF; at 38 months' follow-up, there were no secondary displacements, with mean HKA angle of 180°. The mechanical stability of isolated screwing in Schatzker types I-III is confirmed in the literature [18,22,26,27]. This minimally invasive internal fix-

ation is therefore perfectly adapted to arthroscopically assisted surgery. A ligament reconstruction tibial guide without fluoroscope allows subsidence to be reduced directly on the guide, with optimal positioning of the cannulated screws under the joint subsidence [42].

ARIF incurs technical issues and especially fracture bleeding, hindering the arthroscopic procedure. This can be minimized by using a pump, but with risk of irrigation fluid extravasation and compartment syndrome, although this was not found in the present series, despite a pump being used in 62% of cases. Herbort et al. [7] clearly identified complex tibial plateau fracture as a contraindication for ARIF, due to the high risk of iatrogenic compartment syndrome secondary to irrigation fluid extravasation, however rare in the literature [7,27,43]. The present rate of revision procedures was lower than reported elsewhere (5–7.4% reoperation, 4% revision by tibial osteotomy or total knee replacement [9,30]), doubtless due to the short follow-up in the present series.

The present study had certain limitations:

- choice of technique was at the surgeon's discretion, with a risk of center effect and hence selection bias, with some centers performing both ARIF and ORIF and others only ORIF;
- there was a significant difference in fracture type between the 2 treatment groups: Schatzker type II was most frequent overall, but ARIF was mainly implemented in type III (36.8%, vs. 26.3% and 18.5% for types I and II, respectively);
- 168 files were excluded; even so, this was one of the largest comparative series in the literature;
- systematic CT was not used, for ethical reasons, to assess reduction quality and fixation stability; this makes the reduction assessment criterion less reliable, but this assessment method is quite classical in the literature [9,13,18];
- results were not assessed according to degree of primary subsidence or osteoporosis, both of which have been reported as major limitations for arthroscopy [34].

5. Conclusion

ARIF and ORIF provided comparable satisfactory results in Schatzker I–III tibial plateau fracture, but with HSS score and passive flexion favoring ARIF. Complications rates were low with both techniques. In such selected cases, arthroscopy provides satisfactory reduction and stable fixation by isolated screwing, and is thus suited for minimally invasive treatment of tibial plateau separation and/or subsidence fracture.

Disclosure of interest

X.F.: consultant for Zimmer/Biomet®, Stryker®.

M.E.: educational consultant for Depuy-Synthes®, Newclip®, Amplitude®, Lepine®.

T.B.: consultant for Arthrex®, Zimmer/Biomet®.

The others declare that they have no competing interest.

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Author contributions

M. Le Baron: manuscript writing.
M. Cermolacce: data collection.
X. Flecher: manuscript writing.
C. Guillotin: data collection.
T. Bauer: manuscript re-editing.
M. Ehlinger: manuscript writing and re-editing.

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