Injury, Int. J. Care Injured 47 (2016) 2326–2330

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

A combined approach for the treatment of lateral and posterolateral tibial plateau fractures

Peng Zhang[a], Kejian Lian[a], Deqing Luo[a], Zunxian Huang[a], Teng Li[a], Dasheng Lin[a,b,*]

[a] Department of Orthopaedic Surgery, The Affiliated Southeast Hospital of Xiamen University, Zhangzhou, China
[b] Experimental Surgery and Regenerative Medicine, Department of Surgery, Ludwig Maximilians University, Munich, Germany

ARTICLE INFO

Keywords:
Tibial plateau fracture
Lateral
Posterolateral
Approach

ABSTRACT

Introduction: The treatment of tibial plateau fractures involving the lateral and posterolateral column is a demanding and fine surgical challenge. The purpose of this study was to evaluate the safety and clinical efficacy of combined approach for the treatment of lateral and posterolateral tibial plateau fractures.
Methods: A prospective study was performed in 17 patients with lateral and posterolateral tibial plateau fractures between January 2009 and December 2012. There were 12 males and 5 females with a mean age of 40 years. All of them received dual-plate fixation through the combined approach, with the patients in a floating position. The combined approaches included a conventional anterolateral approach and an inverted L-shaped posterolateral approach. Operation time, intraoperative blood loss, fracture healing time, Hospital for Special Surgery (HSS) knee score, knee flexion and extension range of motion, and complications were recorded to evaluate treatment effects.
Results: There were no intraoperative complications related to this technology. Mean operation time was 144 min with a mean intraoperative blood loss volume of 233 mL. The mean follow-up was 23 months. All 17 patients had good postoperative fracture healing. Mean union time was 12 weeks. At the final follow-up, the average HSS score was 92.5, with the average knee flexion of 125° and an average knee extension of 2°. Two patients had complications in postoperative incisions with aseptic fat liquefaction. After thorough debridement, second-stage wounds healing were achieved. No neurovascular injury occurred. No collapse of reduced articular surface was detected.
Conclusions: The combined approach with dual-plate offers direct and complete surgical exposure and provide an effective method for the treatment of lateral and posterolateral tibial plateau fractures.

Introduction

Tibial plateau fractures are commonly encountered in clinical practice, whereas posterolateral tibial plateau fracture is rarely reported in the past, with an incidence of 7% [1]. This posterolateral fracture has the following features: the mainly displaced fragment is located at the posterior half of the lateral condyle and/or a fracture line impacts the posterior aspect of the lateral plateau [2]. Most of the current classification systems for tibial plateau fractures are the AO/OTA and Schatzker classifications, which established on the basis of anteroposterior radiographs of the proximal tibia, two-dimensional superimposed images of its coronal plane. This posterolateral fracture is a special fracture pattern that is not well described by the AO/OTA or Schatzker classification systems. With careful review and application of the computed tomography (CT) scan for the evaluation for these fractures, Luo et al. [3] proposed a theory of Three-column classification that the tibial plateau is divided into three columns: the medial, the lateral and the posterior, and the posterior column is subdivided into the posteromedial and posterolateral columns.

Realizing the importance of fixation in posterolateral tibial plateau fractures, various approaches have been explored to achieve reduction and fixation for posterolateral fracture [4–6]. Lobenhoffer et al. [7] described a combined approach for the treatment of posterior tibial plateau fractures, but the fibula neck needed to be osteotomized in his method. More scholars introduced a posterolateral approach without fibular head osteotomy, which favored direct reduction and placement of a posterolateral buttress plate [8–10]. However, these methods all demonstrate a trend toward using posterior approaches for this kind of fractures. Posterior column fractures of tibial plateau, especially those involving the posterolateral section, are quite difficult to manage in clinic. When lateral and posterolateral

* Corresponding author at: Department of Orthopaedic Surgery, The Affiliated Southeast Hospital of Xiamen University, Zhangzhou, China.
E-mail address: linds@xmu.edu.cn (D. Lin).

http://dx.doi.org/10.1016/j.injury.2016.07.004
0020-1383/

column fracture were existed simultaneously, it is more difficult to operate for orthopaedic surgeons. Thus, we have tried to use dual-plate fixation through a combined approach for the treatment of lateral and posterolateral tibial plateau fractures, with the patients in a floating position. The combined approaches included a conventional anterolateral approach and an inverted L-shaped posterolateral approach. This study aimed to evaluate the safety and clinical efficacy of this combined approach for lateral and posterolateral tibial plateau fractures.

Material and methods

We obtained institutional review board approval for this study. Between January 2009 and December 2012, 17 patients with lateral and posterolateral tibial plateau fractures were operated via the combined approach with dual-plate fixation. Patients with osteofascial compartment syndrome, pathologic fractures, autoimmune diseases, blood disorder, severe multiple trauma (Injury severity scale, ISS > 16) [11], and surgical contraindications were excluded. Anteroposterior and lateral radiographic views and three-dimensional CT reconstruction images of the tibial plateau were taken in all patients.

The patients consisted of 12 males and 5 females, with a mean age of 40 (26–54) years. The reasons for injury included 7 motor vehicle accidents, 5 falls from a height, and 5 motorcycle crashes. Five patients had associated injuries. None of the patients sustained neurovascular injury (Table 1). Preoperative management included distal bony traction and splint. All operations were performed by the same experienced trauma surgeons after the soft tissue condition was stable, which the striae appeared.

Surgical technique

All patients underwent surgery under spinal anesthesia or general anesthetic, and were operated in a lateral floating position that could facilitate combined posterior and anterior approaches by rotating the lower limb [12]. The knee was maintained in a slightly flexed position. The incision for the inverted L-shaped posterolateral approach was a composite of horizontal and vertical incisions, which was approximately 10 cm to 12 cm in length (Fig. 1). The horizontal incision began at the center of the popliteal fossa. It traversed along the crease to the outside, then turned distally and extended longitudinally along the lateral margin of the lateral head of gastrocnemius muscle. The subcutaneous tissue and popliteal fascia are incised by sharp dissection. Full-thickness

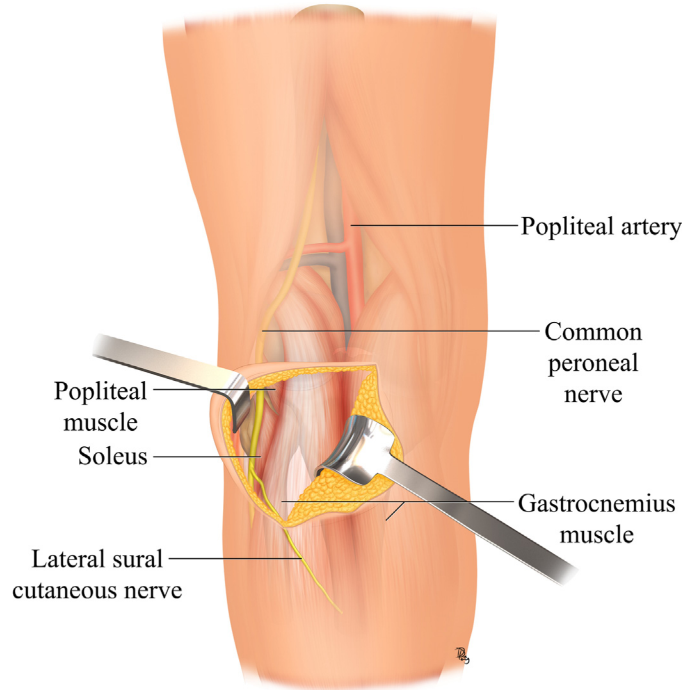

Fig. 1. The surgical approach performed.

fasciocutaneous flaps were elevated, which aimed to protect the lateral sural cutaneous nerves and common peroneal nerve. The lateral head of gastrocnemius muscle and common peroneal nerve was retracted laterally. Then the popliteal neurovascular bundle, which lies medially, were retracted medially by a Langenbeck retractor. Next, we will see the popliteal muscle and soleus. The fibular origin of the soleus is dissected along the medial border of the proximal fibula, and the tibial origin of the soleus is partially divided from lateral to medial. Precautions were taken to protect the anterior tibial vessel in the distal end of the incision. The joint capsule and posterolateral condyles of the tibial plateau were exposed between the popliteal muscle and the soleus muscle. Then the inferior border of the popliteus muscle is dissected and retracted upward, and the inferior lateral genicular vessels on the surface of the popliteus muscle are ligated only if necessary. The posterior joint capsule was incised longitudinally, and the lateral posterior horn of the meniscus was displaced upwards, so that the

Table 1
Patient characteristics.

Patient	Age (y)	Sex	Associated injury	Operation time (min)	Blood loss (mL)	Follow-up (mo)	Healing time (week)	HSS score	Knee flexion (°)	Knee extension (°)	Complications
1	31	M	–	128	220	30	12	94	125	2	–
2	47	M	–	143	180	15	10	96	130	0	–
3	39	F	–	120	150	36	11	94	125	2	–
4	44	M	Head trauma	142	220	21	12	90	120	3	Fat liquefaction
5	47	M	–	160	300	27	14	93	130	5	–
6	28	F	–	157	280	15	15	87	115	0	–
7	34	F	Head trauma	146	250	18	13	96	130	2	–
8	26	M	–	150	220	24	12	94	125	0	–
9	48	M	Humeral fracture	145	190	18	12	90	120	3	–
10	35	M	–	180	200	21	13	96	130	5	Fat liquefaction
11	37	M	–	152	350	24	15	87	115	0	–
12	44	F	Chest injury	160	250	27	11	90	120	3	–
13	42	M	–	147	260	12	10	96	130	0	–
14	54	M	Radius fracture	135	180	24	12	93	125	5	–
15	41	F	–	95	200	33	10	90	120	0	–
16	43	M	–	137	230	24	12	94	130	5	–
17	37	M	–	150	280	21	10	93	130	0	–

posterolateral condyle of the tibial plateau can be seen. Fractures involving the posterolateral column could be clearly observed. The fracture was fixed temporarily with Kirschner wires, and then a precontoured T buttress plate (3.5-mm system plates) was placed for supportive fixation.

The patients were then moved to the supine position. A traditional anterolateral approach to the proximal tibia is used. It was worth noting that the sufficient length of the minimum distance of 7 cm between the incisions was applied, which avoid ischemic necrosis of the skin bridge and wound complications. Then the lateral joint capsule and coronary ligament are incised, and the lateral meniscus is identified, so that we could retract it laterally and superiorly to aid in visualization of the joint surface. A cortical window below the area of depression was made to evaluate the articular surface and graft bone, which was obtained from the iliaccrest of the patient or the bone bank. Multiple Kirschner wires were used as a temporary fixation for the fragments if necessarily. Subchondral raft screw formation of the lateral or anterolateral plates (4.5-mm system plates for proximal tibia) was attempted [13]. Under fluoroscopic guidance, the quality of joint reduction, location of the plates, and length of the screws were confirmed. The meniscus was carefully sutured back to its attachment. Then the subcutaneous tissue and skin were closed over suction drains.

Postoperatively, a passive motion machine was used for several hours everyday and physical therapy with emphasis on muscle strengthening exercises was prescribed. Within the second postoperative week, patients began partial weight bearing. At 12 weeks after the operation, the patients were encouraged to progress to full weight bearing. Radiographs were taken monthly in the first three postoperative months. Thereafter, patients were followed up regularly, physical examination was performed and standard X-ray radiographs were obtained at each follow-up visit. The quality of fracture reduction was evaluated on the basis of four radiographic parameters: articular reduction, tibial plateau angle (TPA), the femorotibial angle (FTA) and the medial posterior slop angle (PA). All measurements were performed by the first author. Malreduction was defined as articular step-off of $\geq$2 mm, or a TPA $\geq 95^\circ$/TPA $\leq 80^\circ$, or PA $\geq 15^\circ$/PA $\leq -5^\circ$ [14]. At the final follow-up, measurements of the knee range of motion were done and all the functional outcome were evaluated using the Hospital for Special Surgery (HSS) knee scoring system [15].

Results

There were no intraoperative complications related to this technology. The mean operation time was 144 (95–180) minutes with mean intraoperative blood loss volume of 233 (150–350) mL. Seventeen patients all have been followed up, and the mean time of follow-up was 23 (12–36) months. After surgery, Bony union occurred at a mean of 12 (10–15) weeks. At the final follow-up, the average HSS score was 92.5 (87–96), with the average knee flexion of 125° (115°–130°) and an average knee extension of 2° (0°–5°). All patients had a satisfactory articular reduction ($\leq$2 mm step), with no fracture displacement or plate rupture observed. Two patients had complications in postoperative incisions with aseptic fat liquefaction. After thorough debridement, second-stage wounds healing were achieved. No neurovascular injury occurred. No collapse of reduced articular surface was detected (Table 1). The typical case is shown in Fig. 2.

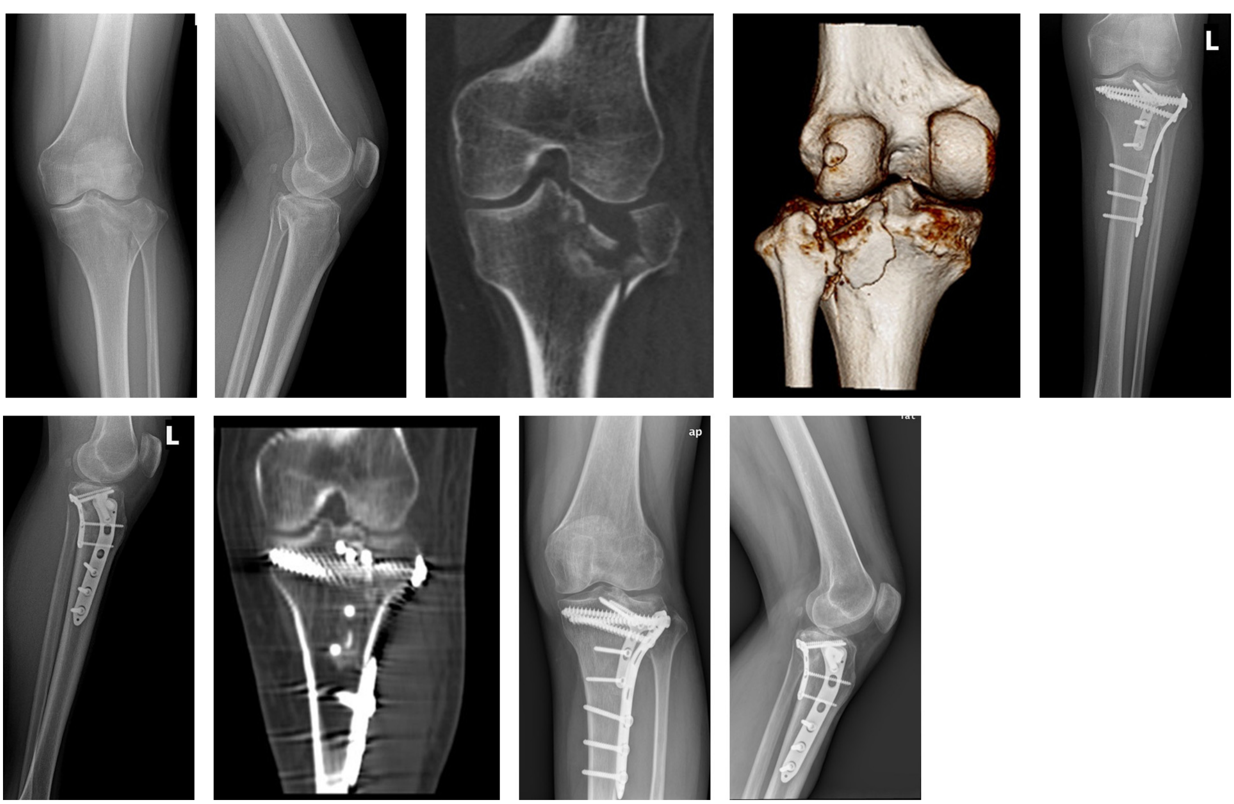

Fig. 2. A 38-year-old woman had left-sided tibial plateau fractures after high energy trauma. Her preoperative anteroposterior radiograph and CT show (a–d) that the tibial plateau fractures involved lateral and posterolateral column. This case was treat with dual plates through the combined approaches included a conventional anterolateral approach and an inverted L-shaped posterolateral approach (e–g). Follow-up anteroposterior radiograph after 1 year shows complete union of fracture (h, i). The clinical outcome was excellent.

Discussion

When the tibial plateau fractures involve the lateral and posterolateral columns simultaneously, the barrier structures, fibular head, and common peroneal nerve make it very difficult to address the two columns fractures via a single approach [11]. Although the anterolateral approach is relatively simple and safe, but it could not entirely meet the requirements of anatomical reduction and stiff supporting fixation of posterior column fractures [12]. Yu et al. [16] described an anterolateral approach by removing partial or full head of the fibula, which they considered beneficial to reduction and fixation of posterolateral tibial plateau fractures. But it was not advisable to sacrifice important normal structures for the sake of fracture exposure and management. Frosch et al. [8] introduced a new surgical approach for posterolateral tibial plateau fractures, which involved a lateral arthrotomy for visualizing the joint surface and a posterolateral approach for the fracture reduction and plate fixation. Such an approach, providing exposure and internal fixation but at the cost of the wide range of soft tissue stripping and the exposure of the common peroneal nerve. Tao et al. [10] presented a modified posterolateral approach for posterolateral shearing tibial plateau fractures, in which an L-shaped incision was initiated at the midline point of the popliteal fossa and then curved transversely and extended distally, without necessity of osteotomy, tenotomy, or division of muscles. Then the full restoration of alignment in the proximal tibia by this approach achieved knee stability and satisfactory clinical outcome. We note that most orthopaedic surgeons used the posteromedial reversed L-shaped approach to expose posterior column [12,17–19], because it is sufficient to reduce the risk of neural injury. However, comparing to posterolateral approach to exposure of posterolateral column, it requires massive dissection of soft tissue envelope which may affect joint movement, even sometimes the exposure of posterolateral column is difficult due to the gastrocnemius-soleus muscles are too strong in some cases and it is difficult to retract them laterally.

In terms of the lateral and posterolateral tibial plateau fractures, it is considered to be a marked feature of severe and complex tibial plateau fractures, when including the lateral and posterolateral column. We used an inverted L-shaped incision, placed on the posterolateral corner of the knee, with an anterolateral approach, which achieved adequate exposures both of the lateral and posterior aspect. Advantages of the combined approach include the following: (1) patient underwent surgery in a lateral floating position that could facilitate combined posterior and anterior approaches by rotating the lower limb, and the operative time was significantly shorter than secondary surgical field draping; (2) providing sufficient operation space to avoid neurovascular injury, without fibular head resection; (3) the compression and cleavages fractures of posterolateral column can be manipulated with direct vision, which is more favorable for reduction; (4) fully using of the skin folds of the popliteal crease to reduce the tension on the incision, helping to avoid postoperative flexion contractures and dysfunction. The posterolateral exposure could not be extended distally yet. Trifurcation vessels traversing the interosseus membrane and the mass of muscle and tissue medial to the fibula make an exposure past approximately 8–10 cm distal to the lateral joint line difficult [10]. The direct posterolateral plate could be used as a buttress and plays an important role in maintaining the reduction of the posterolateral fragment. The dual-plate, a posterolateral buttress plate with an anterolateral plate, which could support the articular surface and strong enough to resist axial loading. But for other more serious tibial plateau fractures, the dual-plate is not enough to fix stably, some articles introduced multi-plate can provide more stable fixation [12,18,19].

The tibial plateau fractures result from impaction of the femoral condyle into the tibial plateau, caused by axial loading with valgus or varus forces. Because the tibial plateau is made of cancellous bone, a compression fracture usually cause bone defect. Therefore, Impaction bone grafting can promise results as an adjunct to the surgical stabilisation of tibial plateau fractures, and provide enough fracture stability for patients to mobilise weight-bearing as tolerated immediately after surgery [20]. Meanwhile, Impaction bone grafting can also avoid collapse of articular surface and promote fracture healing.

The combined approach included an anterolateral approach and an inverted L-shaped posterolateral approach, with dual-plate, offers direct and complete surgical exposure and provide an effective method for the treatment of lateral and posterolateral tibial plateau fractures. However, the current study has limitations. A prospective study with a larger number of patients would help confirm the advantages of the combined approach for the treatment of lateral and posterolateral tibial plateau fractures.

Conflict of interest statement

The authors have no conflict of interest.

Funding

No funds were received in support of this work.

Acknowledgment

We acknowledge the written consent for publication obtained from the patient featured in the manuscript.

References

[1] Partenheimer A, Gösling T, Müller M, Schirmer C, Kääb M, Matschke S, et al. Management of bicondylar fractures of the tibial plateau with unilateral fixed-angle plate fixation. Unfallchirurg 2007;110:675–83.
[2] Hsieh CH. Treatment of the posterolateral tibial plateau fractures using the anterior surgical approach. Int J Biomed Sci 2010;6:316–20.
[3] Luo CF, Sun H, Zhang B, Zeng BF. Three-column fixation for complex tibial plateau fractures. J Orthop Trauma 2010;24:683–92.
[4] Hu SJ, Chang SM, Zhang YQ, Ma Z, Du SC, Zhang K. The anterolateral supra-fibular-head approach for plating posterolateral tibial plateau fractures: a novel surgical technique. Injury 2016;47:502–7.
[5] Yoon YC, Sim JA, Kim DH, Lee BK. Combined lateral femoral epicondylar osteotomy and a submeniscal approach for the treatment of a tibial plateaufracture involving the posterolateral quadrant. Injury 2015;46:422–6.
[6] Solomon LB, Stevenson AW, Lee YC, Baird RP, Howie DW. Posterolateral and anterolateral approaches to unicondylar posterolateral tibial plateau fractures: a comparative study. Injury 2013;44:1561–8.
[7] Lobenhoffer P, Gerich T, Bertam T, Lattermann C, Pohlemann T, Tscherne H. Treatment of posterior tibial plateau fractures via posteromedial and posterolateral exposures. Der Unfallchirurg 1997;100:957–67.
[8] Frosch KH, Balcarek P, Walde T, Stürmer KM. A new posterolateral approach without fibula osteotomy for the treatment of tibial plateau fractures. J Orthop Trauma 2010;24:515–20.
[9] Chang SM, Zheng HP, Li HF, Jia YW, Huang YG, Wang X, et al. Treatment of isolated posterior coronal fracture of the lateral tibial plateau through posterolateral approach for direct exposure and buttress plate fixation. Arch Orthop Trauma Surg 2009;129:955–62.
[10] Tao J, Hang DH, Wang QG, Gao W, Zhu LB, Wu XF, et al. The posterolateral shearing tibial plateau fracture: treatment and results via a modified posterolateral approach. Knee 2008;15:473–9.
[11] Sun H, Zhai QL, Xu YF, Wang YK, Luo CF, Zhang CQ. Combined approaches for fixation of Schatzker type II tibial plateau fractures involving the posterolateral column: a prospective observational cohort study. Arch Orthop Trauma Surg 2015;135:209–21.
[12] Zhai Q, Hu C, Luo C. Multi-plate reconstruction for severe bicondylar tibial plateau fractures of young adults. Int Orthop 2014;38:1031–5.
[13] Cross 3rd WW, Levy BA, Morgan JA, Armitage BM, Cole PA. Periarticular raft constructs and fracture stability in split-depression tibial plateau fractures. Injury 2013;44:796–801.
[14] Luo CF. Reference axes for reconstruction of the knee. Knee 2004;11:251–7.
[15] Ranawat CS, Insall J, Shine J. Duo-condylar knee arthroplasty: hospital for special surgery design. Clin Orthop Relat Res 1976;120:76–82.

[16] Yu B, Han K, Zhan C, Zhang C, Ma H, Su J. Fibular head osteotomy: a new approach for the treatment of lateral or posterolateral tibial plateau fractures. Knee 2010;17:313–8.
[17] Qiu WJ, Zhan Y, Sun H, Xu YF, Wang YK, Luo C. A posterior reversed L-shaped approach for the tibial plateau fractures—a prospective study of complications (95 cases). Injury 2015;46:1613–8.
[18] Chang SM, Hu SJ, Zhang YQ, Yao MW, Ma Z, Wang X, et al. A surgical protocol for bicondylar four-quadrant tibial plateau fractures. Int Orthop 2014;38: 2559–64.
[19] Lin W, Su Y, Lin C, Guo W, Wu J, Wang Y, et al. The application of a three-column internal fixation system with anatomical locking plates on comminuted fractures of the tibial plateau. Int Orthop 2016;40:1509–14.
[20] van de Pol GJ, Iselin LD, Callary SA, Thewlis D, Jones CF, Atkins GJ, et al. Impaction bone grafting has potential as an adjunct to the surgical stabilisation of osteoporotic tibial plateaufractures: early results of a case series. Injury 2015;46:1089–96.