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Medial femoral epicondyle upsliding osteotomy with posterior stabilized arthroplasty provided good clinical outcomes such as constrained arthroplasty in primary total knee arthroplasty with severe valgus deformity

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Abstract

Purpose A modified technique referred to as a medial femoral epicondyle upsliding osteotomy was proposed to address severe valgus deformity with unconstrained posterior stabilized (PS) arthroplasty. The study compared the effectiveness of the technique and PS arthroplasty with constrained arthroplasty during primary total knee arthroplasty (TKA).

Methods Fifty-three patients presenting with valgus knees with a mean valgus angle (VA) greater than 30° were prospectively randomized and divided into two groups, and both groups received primary TKA. Upsliding osteotomy with PS arthroplasty was performed on the knees of 27 patients (group A), while the remaining 26 patients (group B) received a constrained arthroplasty. The Knee Society function score (KSF), Hospital for Special Surgery knee score (HSS), range of motion (ROM), mediolateral stability and hospitalization expenses were recorded. The hip–knee–ankle angle (HKA), femorotibial angle (FTA) and VA were analysed. Complications were also recorded.

Results The patients received follow-up care for more than 50 months. The postoperative KSF, HSS and ROM showed marked improvement in both groups ($p < 0.05$). Radiological assessments showed that HKA, FTA and VA for group A were restored to $(179.9 \pm 3.0)°$, $(173.0 \pm 2.4)°$ and $(7.0 \pm 2.4)°$, respectively. For group B, the HKA, FTA and VA were restored to $(181.5 \pm 2.3)°$, $(172.5 \pm 2.3)°$ and $(7.5 \pm 2.3)°$, respectively. Only two patients from group A demonstrated mild medial laxity in their knees, and the remaining patients from both groups were stable medially and laterally. However, the total hospitalization expenses and material expenses of group A were less than those of group B because of the more expensive constrained prosthesis and stems. No late-onset loosening or recurrent valgus deformity was displayed.

Conclusions Both medial femoral epicondyle upsliding osteotomy with PS arthroplasty and constrained arthroplasty showed good outcomes for the restoration of neutral limb alignment and soft tissue balance, which are demonstrated to be safe and effective techniques for correcting severely valgus knees. Therefore, the clinically important finding of this study is that medial femoral epicondyle upsliding osteotomy with PS arthroplasty can be an alternative method for correcting severe valgus knees.

Level of evidence II.

Keywords Total knee arthroplasty · Valgus knee · Upsliding osteotomy · Posterior stabilized arthroplasty · Constrained arthroplasty

Introduction

The challenge presented by severe valgus deformity when performing total knee arthroplasty (TKA) is to restore well-balanced soft tissue utilizing the least amount of constraint [1, 23, 29]. Soft tissue variations, including contracture of the lateral and elongation of the secondary medial [especially the medial collateral ligament (MCL)], pose great

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challenges for orthopaedic surgeons [14, 30, 36, 37]. Thus, achieving a well-balanced TKA can be extremely difficult.

For valgus knees, there are several options for TKA: a lateral parapatellar approach [1, 39, 40], unconstrained implants with release of the lateral and tightening of the medial collateral ligament [14], unconstrained implants with release of the lateral ligaments, or constrained implants [8, 41]. However, when considering the lateral parapatellar approach, lack of familiarity, inadequate exposure requiring tibial tubercle osteotomy and associated complications after tibial tubercle osteotomy are unavoidable [9, 11, 40]. With the utilization of constrained implants, aseptic loosening is more feasible, and faster polyethylene wear due to stress concentration may increase reoperation and revision rates [4, 24]. Additionally, the revision risk has been reported to be increased if the lateral collateral ligament (LCL) and popliteus tendon (POP) are released [10, 25, 32]. Moreover, when managing severe valgus deformity, to equalize the tension between the lateral and medial ligaments, it is possible to release overzealously, leading to immediate peroneal nerve injury and late-onset instability [2, 8]. Healy et al. [14] reported a technique of proximal MCL advancement to restore soft tissue balance. However, imbricating the MCL along the direction of the tendon fibres may result in failed ligament loading and recurrent medial instability. Therefore, addressing severe valgus deformity is consistently a concern among orthopaedic surgeons.

A modified technique, referred to as medial femoral epicondyle upsliding osteotomy, was proposed to address severe valgus deformity with unconstrained posterior stabilized (PS) arthroplasty. The purpose of this study was to primarily investigate the clinical outcomes of the modified technique and PS arthroplasty to correct severe valgus deformity relative to constrained arthroplasty. It was hypothesized that for severe valgus deformity, medial femoral epicondyle upsliding osteotomy with PS arthroplasty would perform at least as well as constrained arthroplasty.

Materials and methods

From 2009 to 2015, patients were investigated prospectively. Data including patient demographics, clinical range of motion (ROM), alignments, stability and numerous functional scores were recorded.

The inclusion criteria were as follows: patients who were diagnosed with end-stage gonarthrosis and were scheduled to undergo a primary TKA; knees of the patients were classified as Krackow II and valgus angles exceed 20°; and LCLs and MCLs of the knees were intact. The exclusion criteria were as follows: valgus angles less than 20° and soft tissue balance could be achieved with a routine technique; knees were unstable due to ligamentous injury; or patients concomitantly presented with severe osteoporosis or obesity (BMI ≥ 28 kg/m^2). We prospectively randomized patients who would undergo TKAs. We divided patients into two groups: medial femoral epicondyle upsliding osteotomy with PS arthroplasty (group A) and only constrained arthroplasty (group B). All participants provided signed informed consent for surgery. Ultimately, group A contained 26 patients (28 knees), and group B contained 28 patients (28 knees). All knees were type II according to Krackow's classification [17]. A total of 56 TKAs were performed by the senior surgeon. Follow-up for all patients was conducted using both clinical and radiographic protocols, but three patients (1 of group A and 2 of group B) died of causes unrelated to the procedure and were excluded from the analysis. The clinical details are presented in Table 1. All implants utilized for group A during the procedures were unconstrained PS prostheses (25 Sigma PFC DePuy, USA and 2 NRG Scorpio Stryker, USA). All implants utilized for group B during the procedures were constrained prostheses (Sigma TCP III DePuy, USA). The patients requiring TKA for both knees underwent a separate surgical procedure for each knee.

Surgical techniques

After exposure to medial parapatellar arthrotomy, we released the iliotibial band (ITB) using the "pie-crusting" technique. During the release process, we examined the lateral tension on extension and flexion. If the lateral tension was still tight, the posterolateral capsule was released, avoiding the LCL and POP. Then appropriate-thickness spacers were used to obtain proper tension of the lateral soft tissue. After attaining satisfactory limb alignment, medial stability was examined. If the medial aspect of the knee demonstrated instability upon examination, it was addressed accordingly.

Medial femoral epicondyle upsliding osteotomy was performed on group A to tighten the MCL after cementing a suitable tibial prosthesis. A femoral prosthesis one size smaller than the estimated size was utilized to reserve sufficient bone mass for the epicondyle osteotomy and the insertion of an appropriate-thickness polyethylene insert.

Table 1 Demographic characteristics of all recruited patients

Total patients (no = 51)	Group A (no = 25)	Group B (no = 26)	*p* value
Mean age (years)	63 ± 11	66 ± 9	n.s.
Mean height (cm)	164 ± 8	158 ± 8	0.05*
Mean weight (kg)	63 ± 8	56 ± 6	0.05*
Mean BMI (kg/m^2)	24 ± 2	23 ± 2	n.s.
Follow-up (years)	55 ± 11 months	58 ± 13 months	n.s.

p values with statistical significance are marked with *

p values with non-statistical significance are marked with n.s.

The three-step procedural details are as follows: (1) identify the origin of the MCL and osteotomize the epicondyle and the MCL origin, whose thickness must be not less than 8 mm; (2) pull the osteotomized bone fragment proximally into position along the long axis of the femur using an Allis clamp to tighten the MCL as much as possible and temporarily fix the bone flap using Kirschner wires in an upper lateral direction with the knee in 90° of flexion; (3) after reconfirming mediolateral balance and knee stability with the knee in extension and flexion, use two or three 4.5-mm hollow screws combined with washers for final fixation (Fig. 1).

Group B was surgically managed with constrained prostheses. We utilized the special trial prosthesis of TCP III and performed constrained arthroplasty according to the instructions of the manufacturer.

Finally, the articular cavity was irrigated, a drainage tube was placed and the incision was sutured in a routine manner for both groups.

Perioperative interventions

Postoperatively, according to the standard rehabilitation protocol, after recovery from anaesthesia, quadriceps-strengthening exercises and active extension–flexion ankle motion were initiated. The drainage tube was removed within 48 h, and prophylactic intravenous antibiotics were administered for 1 day. Additionally, low molecular weight heparin (LMWH) and painkillers were systematically used to prevent deep venous thrombosis (DVT) and relieve pain, respectively.

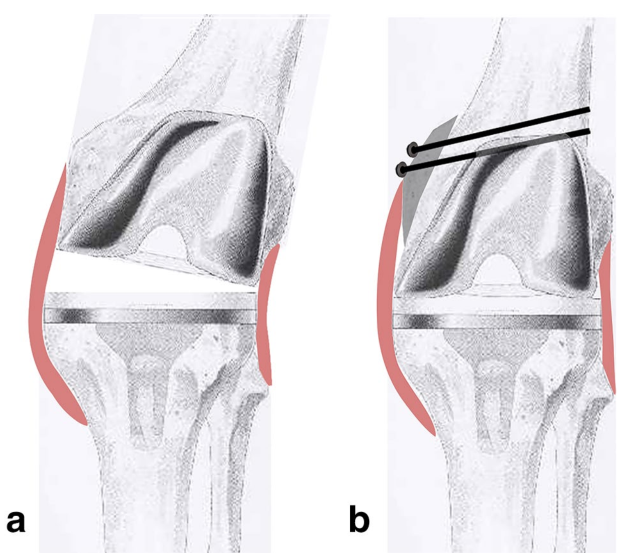

Fig. 1 The schematic drawing of medial femoral epicondyle upsliding osteotomy. **a** The medial is lax after cementing the prosthesis and inserting the polyethylene spacer. **b** The osteotomized bone fragment is up-slid and fixed by hollow screws and washers

On and following the first postoperative day, patients in group A were allowed to perform full range of motion as tolerated without knee braces in bed. Weight-bearing exercises on foot were allowed as tolerated with the protection of long leg knee braces. Varus–valgus knee motion was strictly prohibited using a brace for 3 months. However, if X-ray imaging revealed bony union of the osteotomized fragment before 3 months postoperatively, the braces were removed. Patients in group B were routinely allowed to perform full range of motion and weight-bearing exercises as tolerated without braces.

Clinical measurements

Preoperatively and postoperatively, clinical details were recorded. ROM was measured using a goniometer positioned along the axis of the femur and the tibia with the patient in a supine position [38]. Additionally, the Hospital for Special Surgery knee score (HSS) and the Knee Society function score (KSF) were recorded [15, 16]. Moreover, according to the literature [5], we examined mediolateral stability with the knee in 20° of flexion. Laxity was defined by degrees as none (0–5)°, mild (6–9)°, moderate (10–14)° or severe (≥ 15)°. The examiners were two senior doctors with extensive experience. The examiners performed their measurements separately. To manually measure medial laxity, a goniometer was used with the knee in 20° of flexion. Final results were determined by each examiner. If the final classification by one examiner was different from that of the other, the examiners repeated the measurements until a consensus was reached. Finally, the costs of hospitalization for each recruited patient were obtained from the Hospital Information System and included total expense, material expense and other expenses. Costs were calculated in United States dollars (USD, $).

Radiological measurements

Preoperatively and postoperatively, radiological measurements were obtained. All patients received full-length weight-bearing radiographs as well as anteroposterior and lateral films. The hip–knee–ankle (HKA) angle, femoral–tibial angle (FTA) and valgus angle (VA) were recorded and evaluated from the films. The VA was defined as the difference between 180° and the FTA. Additionally, for group A, we analysed whether the osteotomized fragment had achieved bony union after surgery. For both groups, we evaluated whether there were radiolucent lines or visible implant loosening, which may make the procedure subject to revision.

Complications

The complications after TKA were closely examined and recorded. Early-onset complications included wound problems, peroneal nerve injury, patellar tracking dysfunction, infection and pulmonary embolism [12]. Late-onset complications included knee instability, recurrent valgus deformity, implant loosening, osteolysis and postoperative motion deficits requiring manipulation [12]. Osteolysis was defined as an expanding area of focal radiolucency measuring ≥ 1 cm in diameter [31]. Any component with a circumferential radiolucency at the bone–cement or implant–cement interface was considered to be loose [9].

Study approval was obtained from the Clinical Trials and Biomedical Ethics Committee of West China Hospital (ID: 317), and all participants provided signed informed consent for surgery.

Statistical analysis

Statistical analysis was performed using IBM Statistics 22.0 (SPSS). The results were expressed as means ± standard deviation. The intra-group preoperative and postoperative comparisons were analysed using paired samples *t* tests, while the inter-group preoperative and postoperative comparisons were analysed by independent samples *t* test. A value of $p < 0.05$ was considered statistically significant.

The sample-size estimate was based on the difference in the primary outcome (ie, postoperative decrease in valgus angle) among the two study groups using G*Power Version 3.1.7 (Franz Faul; Uni Kiel, Germany) software. A previous study showed that the mean reduction in postoperative VA (and standard deviation) was (5.4 ± 1.3)° [14]; to detect a treatment difference of 10%, the sample size required for each arm of the study was 22 patients. This sample size was calculated for independent samples *t* test assuming a standard effect size (d) = 0.76, an alpha level (two-tailed) = 0.05, and power = 0.8. Furthermore, we assumed the standard deviation within each group to be 1.3°. The sample size was increased by 20% to compensate for expected dropouts, resulting in 28 knees per group and a total number of 56 knees.

Results

All patients were satisfied with the surgery results, both because pain had decreased and knee function had improved markedly compared with the preoperative status. None of the patients showed any extensor lag or residual flexion deformity in their knees postoperatively. For both groups, KSF, HSS and ROM improved markedly compared with preoperative status (Table 2). Preoperatively, the knees of all patients in group A were stable laterally, while medial instability was mild in the knees of 7 patients, moderate in 14 patients and severe in 6 patients. Comparably, the knees of all the patients in group B were stable laterally, while 7 patients had knees with mild instability, 14 had moderate instability and 5 had severe medial instability. Postoperatively, only two knees from patients in group A had mild medial laxity; the knees of the other patients in both groups were stable medially and laterally. In addition, the costs of hospitalization of group A were less than that of group B (Table 3).

The knees of all patients in both groups were type II according to Krackow's classification, indicating severe valgus deformity. The mean VA of group A was 31.6° ± 8.0°, while the mean VA of group B was 31.1° ± 4.2°. Postoperatively, the mean VAs of group A and group B were (7.0 ± 2.4)° and (7.5 ± 2.3)°, respectively. Additionally, the HKA and FTA were restored to (179.9 ± 3.0)° and (173.0 ± 2.4)° for group A and (181.5 ± 2.3)° and

Table 3 The hospitalization expenses of all recruited patients

	Group A	Group B	*p* value
Material expenses ($)	4335 ± 112	6243 ± 69	< 0.05*
Other expenses ($)	4756 ± 799	4641 ± 681	n.s.
Total expenses ($)	9091 ± 845	10885 ± 683	< 0.05*

p values with statistical significance are marked with *.

p values with non-statistical significance are marked with n.s.

Table 2 KSF, HSS and ROM of all recruited patients preoperatively and postoperatively of both two groups

Valgus knee	Group A		Group B		Intra		Inter	
	Pre	Post	Pre	Post	Group A	Group B	Pre	Post
KSF	33 ± 4	94 ± 6	33 ± 5	94 ± 6	$p < 0.05$*	$p < 0.05$*	n.s.	n.s.
HSS	30 ± 6	91 ± 3	32 ± 7	89 ± 3	$p < 0.05$*	$p < 0.05$*	n.s.	$p < 0.05$*
ROM	(83 ± 11)°	(115 ± 7)°	(88 ± 13)°	(112 ± 6)°	$p < 0.05$*	$p < 0.05$*	n.s.	n.s.

p values with statistical significance are marked with *

p values with non-statistical significance are marked with n.s.

KSF Knee Society Function score, *HSS* Hospital for Special Surgery knee-rating scale, *ROM* range of motion, *Intra* intra-group comparisons, *Inter* inter-group comparisons

(172.5 ± 2.3)° for group B (Table 4) (Figs. 2, 3). At the 6-month clinical follow-up, the osteotomized bone fragments of all patients in group A had achieved bony union, as indicated by radiography. None of the radiographs showed radiolucent lines or visible implant loosening during the follow-up for both groups.

In group A, one postoperative periprosthetic femoral fracture occurred due to an unexpected in-hospital fall, which was immediately and effectively managed by applying cortical bone plate allografts medially and a condylar plate with internal fixation laterally. The radiograph taken 9 months postoperatively displayed union of the fracture and the osteotomized fragment. At the last follow-up, although the HKA was 186° and the knee demonstrated mild medial instability, pain had decreased and function had improved significantly compared to preoperative status. In group B, early in the postoperative period, one patient experienced superficial wound breakdown in which the wound did not make contact with the articular cavity. The wound was debrided and sutured immediately. Furthermore, the duration of antibiotic delivery was extended. No infection occurred, and the wound healed well. One patient experienced a patellar fracture at the 1-year follow-up due to an accidental fall when walking down stairs. During emergency surgery, we performed open reduction and internal fixation using Kirschner wires and tension band wires. The case was handled effectively, and the patient recovered well. Between the two groups, no other patients experienced any of the aforementioned complications.

Discussion

The most important finding of this study was that medial femoral epicondyle upsliding osteotomy with PS arthroplasty was a safe and effective method to restore soft tissue balance for severe valgus knees; however, many orthopaedic surgeons currently agree that primary TKA for VA greater than 10° may be challenging [30]. The approach to address severe valgus deformities was to simultaneously restore neutral limb alignment and well-balanced soft tissue utilizing the least amount of constraint. In our study, both groups realized neutral alignment according to Park et al. [32]. The VAs of groups A and B were (7.0 ± 2.4)° and (7.5 ± 2.3)°, respectively ($p > 0.05$). Additionally, mediolateral stability was obtained in most cases. Knee function demonstrated marked improvement and pain decreased. Moreover, there were no complications related to our surgery. Therefore, both approaches can be considered effective to address severe valgus knees.

Although there is no agreement on the optimal degree of constrained implants for type II deformity, most studies recommend the least amount of constraint necessary to achieve stability [22, 25, 29]. The TCP III prosthesis, which can provide coronal stability, compensates for soft tissue imbalance using an enlarged cam-post-mechanism [26]. Additionally, to distribute the interface stress away from fixation interfaces to the diaphyseal bone, stem extensions are used [3, 26, 41, 47]. A recent study reported good clinical outcomes with constrained prostheses in primary TKA [18]. The strengths of choosing constrained prostheses are avoiding excessive lateral release, simplifying operation procedure and shortening operation time. However, weaknesses have also been reported in the literature, such as increased cost, more bone loss and a high incidence of leg pain [3, 7, 41]. The rate of constrained component revision for any reason was two times greater at 10 years postoperatively and three times greater at 20 years postoperatively [24]. Moreover, constrained TKA was associated with more significant joint line changes for the valgus knee compared with unconstrained TKA [33].

Ligament reconstruction may help decrease the level of constraint required [26]. However, for severe valgus deformity, the objective of simultaneously correcting the deformity and balancing soft tissues with the least amount of constraint is not easy to achieve [27]. According to national databases, aseptic loosening is the most common mode of failure and is possibly secondary to inherent soft tissue imbalance [46, 47]. Therefore, balanced and normal soft tissue tension plays a key role in implant longevity. The "pie-crusting" technique, recommended by the literature [37], is a safe and effective approach for releasing

Table 4 Comparison of several angles by radiography preoperatively and postoperatively of all recruited patients

Valgus knee	Group A		Group B		Intra		Inter	
	Pre	Post	Pre	Post	Group A	Group B	Pre	Post
HKA	(203.1 ± 6.7)°	(179.9 ± 3.0)°	(204.8 ± 4.8)°	(181.5 ± 2.3)°	$p < 0.05$*	$p < 0.05$*	n.s.	$p < 0.05$*
FTA	(148.4 ± 8.0)°	(173.0 ± 2.4)°	(148.9 ± 4.2)°	(172.5 ± 2.3)°	$p < 0.05$*	$p < 0.05$*	n.s.	n.s.
VA	(31.6 ± 8.0)°	(7.0 ± 2.4)°	(31.1 ± 4.2)°	(7.5 ± 2.3)°	$p < 0.05$*	$p < 0.05$*	n.s.	n.s.

p values with statistical significance are marked with *

p values with non-statistical significance are marked with n.s.

HKA hip–knee–ankle angle, *FTA* femorotibial angle, *VA* valgus angle, *Intra* intra-group comparisons, *Inter* inter-group comparisons

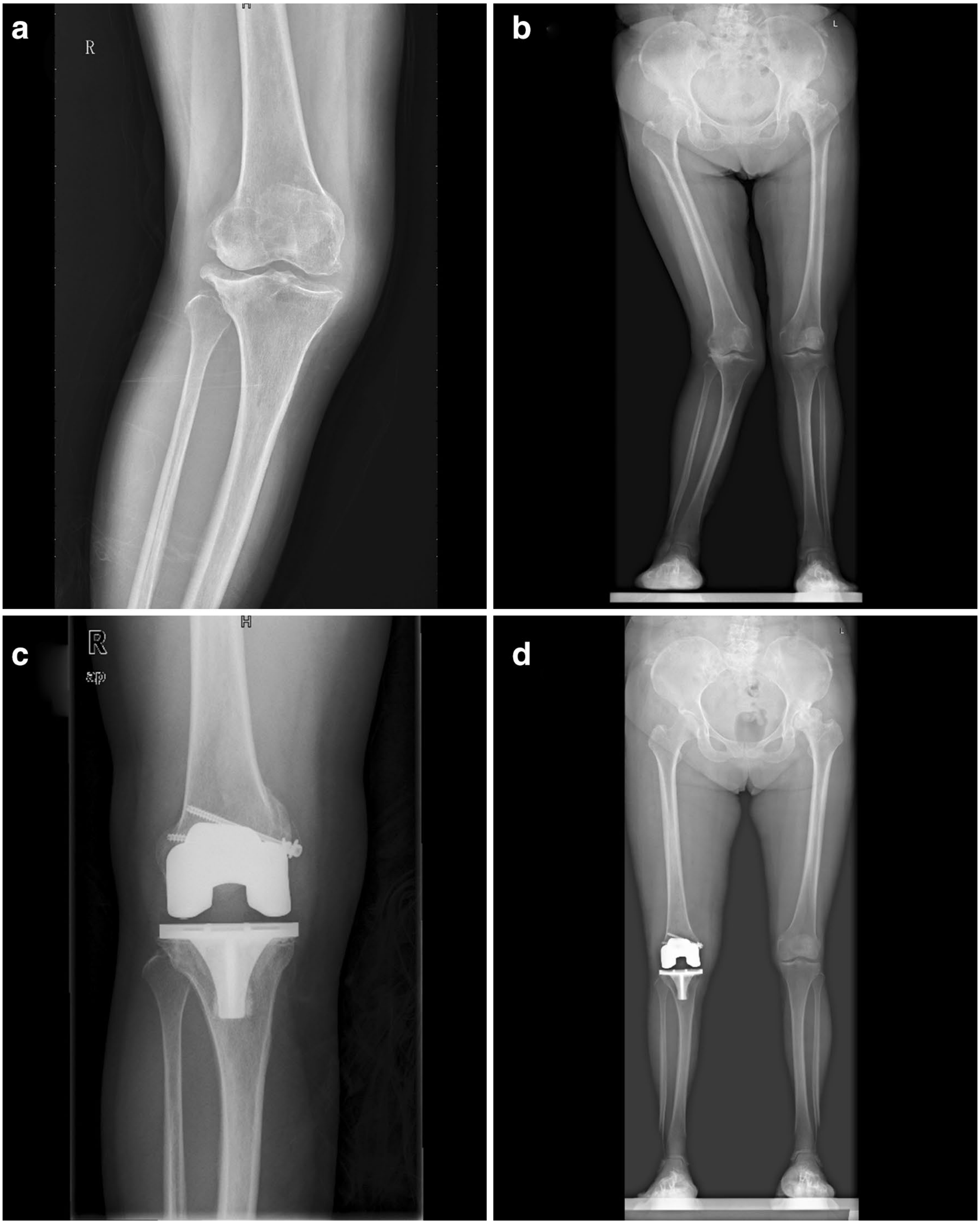

Fig. 2 The radiographs of a 62-year-old woman treated by medial femoral epicondyle upsliding osteotomy. **a** Anteroposterior preoperative knee radiograph showing severe valgus deformity. **b** Preoperative standing radiograph of both lower limbs showing valgus angle more than 30°. **c** Anteroposterior knee radiograph at the 5-year follow-up. **d** Standing radiograph of both lower limbs at the 5-year follow-up showing satisfactory alignment

soft tissue. However, there is no consensus on the optimal releasing range or the sequence of lateral release. The LCL, which is easily released due to overzealous intervention, is the primary lateral stabilizer [5]. And POP was described by Rossi et al. [36] as a vital structure for rotational and valgus stability in flexion. Studies [8, 10, 25] have reported an unacceptably high rate of late-onset instability and increased revision risk due to the release of

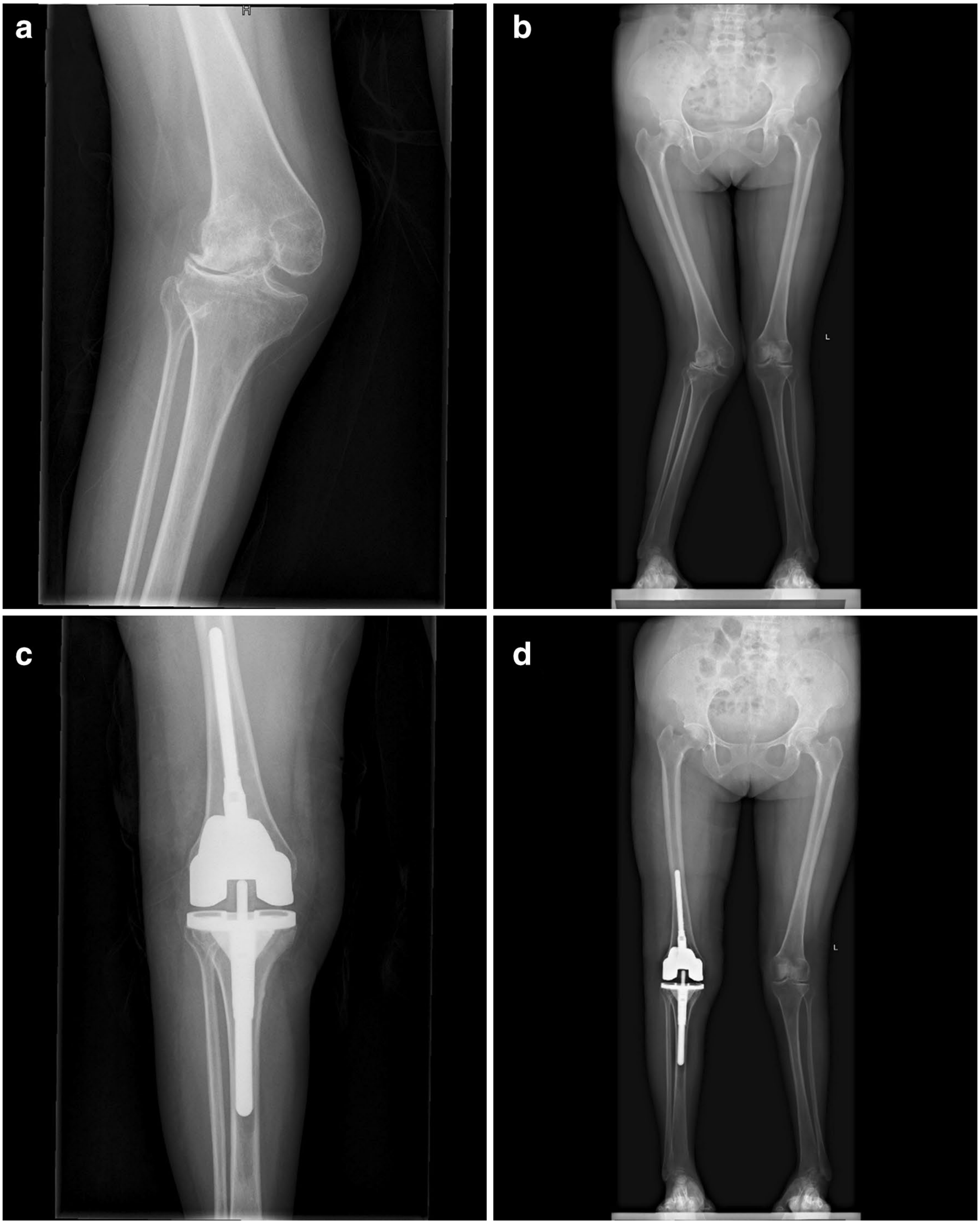

Fig. 3 The radiographs of a 60-year-old woman treated by constrained TKA. **a** Anteroposterior preoperative knee radiograph showing severe valgus deformity. **b** Preoperative standing radiograph of both lower limbs showing valgus angle more than 30°. **c** Anteroposterior knee radiograph at the 5-year follow-up. **d** Standing radiograph of both lower limbs at the 5-year follow-up showing satisfactory alignment

the LCL and POP. Furthermore, extensive lateral release can lead to peroneal nerve injury [8, 17]. Therefore, to avoid instability, we first release the ITB and then the posterolateral capsule using the "pie-crusting" technique.

Reconstruction of the MCL using tendon grafts is an alternative for restoring medial stability. Currently, allografts or autografts primarily consist of Achilles, semitendinosus and gracilis tendons [6, 21, 22, 34]. The most common reason for MCL reconstruction with tendon grafts during TKA is iatrogenic injury with an incidence rate of 0.43% [42]. MCL reconstruction using tendon grafts has several disadvantages. First, the procedure may increase operative time, and the risk of periprosthetic fracture theoretically increases due to fixation of the graft, especially at the femoral condyle [42]. Second, harvesting the allograft is a technically demanding procedure [43], and Peters et al. [34] reported an unsuccessful attempt to harvest semitendinosus tendon. Additionally, this procedure damages neighbouring medial supporting structures when the allograft is the semitendinosus tendon [35], and suboptimal graft reconstruction can lead to residual instability or graft loosening [49]. Finally, the most common complication after MCL-related surgery is postoperative arthrofibrosis [21, 49]. Comparatively, lower expense is associated with medial femoral epicondyle upsliding osteotomy with PS arthroplasty, and the average postoperative ROM of patients was $115 \pm 7°$. Additionally, at the last follow-up, no radiograph showed radiolucent lines or visible implant loosening. Therefore, we considered medial femoral epicondyle upsliding osteotomy to be a better technique for reconstructing MCL.

Restoration of soft tissue balance is a key element of satisfactory TKA outcome [13], but there are concerns about nonisometricity of the displaced fragment and nonphysiological strains on the MCL. Healy et al. [14] reported proximal medial collateral ligament advancement with bone plug recession in situ and a nonabsorbable suture woven into the MCL during TKA. Additionally, Krackow et al. [17] utilized the technique of ligament plication in type II valgus knees. However, the suture was woven into the MCL in the direction of the tendon fibres, and patients typically present concomitantly with osteoporosis, which may result in recurrent medial instability. Furthermore, extensive literature [5, 28, 44, 45] described satisfactory results of femoral sliding osteotomy to address varus or valgus deformity. Our results emphasize this point once again. However, what is the origin of this discrepancy? In our opinion, when medial epicondylar osteotomy was used for chronic MCL laxity without performing TKA, the outcomes may be influenced by other tissues around the knee, while the biomechanics has changed after TKA, which can account for the outcome differences. The reason why some are concerned about nonphysiological strains on the MCL is that abnormal strains may disturb the early bony union of the fragment. Sim et al. [44] suggested fixation with screws and wafers could offer a higher probability of bony union. Additionally, the fragments were fixed to the contralateral cortex, which has an enhanced ability to resist strains from knee flexion and extension. Most of all, early limitation of varus–valgus knee motion ensures bony union. Our results also demonstrated early bony union of the fragments and stability of knees.

There are doubts regarding whether the already attenuated and lax MCL and posteromedial capsule can function as a ligament when their proximal insertion has been changed. According to Healy [14], among seven patients with type II valgus deformity who received MCL advancement during TKA with nonconstrained arthroplasty, none had medial laxity during follow-up. Recently, Mullaji et al. [28] also reported sliding medial condylar osteotomy achieved gap balance. All the knees in this study were restored to grade 1 (< 5 mm) mediolateral stability. Furthermore, many other studies [19, 20, 48] have also reported that patients with type II valgus deformity could achieve good stability with nonconstrained arthroplasty. Our results at the mean 55-month follow-up similarly suggested PS arthroplasty could be used in type II valgus knee with MCL advancement. Therefore, we believe that MCL reconstruction with sliding medial condyle osteotomy can result in good stability, although the medial supporting structure may be lax.

The primary advantage of the technique described in this study is that it may be an alternative approach to addressing severe valgus deformity using the least amount of constraint, which may not only decrease complications but also minimally influence early functional rehabilitation. However, the primary concern of the technique is whether the fragment achieves bony union. In our opinion, initial stable fixation, sufficient time-limiting varus–valgus knee motion and flexion–extension function exercise in bed facilitate bony union and ideal function.

One of the primary limitations of the study is the small study population and the short follow-up. Furthermore, because our hospital did not have the specialized Telos stress device to complete measurements, stress radiography was not used to measure residual medial laxity objectively after surgery. Two experienced senior doctors were relied on to perform these measures manually.

Conclusion

Medial femoral epicondyle upsliding osteotomy with PS arthroplasty is a safe and effective technique for the correction of a severely valgus knee. The technique performed with PS arthroplasty showed good outcomes and was similar to constrained arthroplasty in terms of the restoration of neutral limb alignment and soft tissue balance.

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Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest or personal relationships with other people or organizations that might inappropriately influence this study.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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