Quality Improvement Study

Medicine

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Intertrochanteric valgus osteotomy for post-traumatic coxa vara after proximal femur fractures

A retrospective study

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Abstract

To investigate the clinical effects of a new intertrochanteric valgus osteotomy technique designed by the authors for treatment of post-traumatic coxa varus after proximal femur fractures. Retrospectively analyzed 11 patients who developed coxa vara after sustaining proximal femoral fractures were treated with intertrochanteric valgus osteotomy from December 2005 to December 2018 in our hospital. This study included 6 cases of intertrochanteric fracture deformity union, 3 cases of subtrochanteric fracture nonunion and 2 cases of femoral neck fracture nonunion. Measured the degree of coxa varus, the differences in the lower limb length and force line in all patients. Evaluated hip function with the Harris hip score. All injuries were treated with the authors' intertrochanteric valgus osteotomy technique. The average follow-up period was 3 years and evaluated the clinical effects by radiological examination and the Harris hip score. The average neck–shaft angle increased 35.0° (99.1°–134.1°) and the average limb shortening lengthened 1.9 cm (2.9–1.0 cm) after surgery. The average operating time was 67.2 minutes and blood loss was 237.7 ml. The osteotomy position healed in all patients 3 months later. Union of the 2 old femoral neck fractures was achieved 4 and 6 months after surgery, respectively, and no femoral head necrosis occurred during follow-up. The Harris hip score increased an average of 49 points (44.1–93.1 points) at 1 year postoperatively. Our self-designed intertrochanteric valgus osteotomy technique showed a favorable clinical effect to treatment coxa vara and can be used in the clinical setting.

Abbreviations: *D* = difference value, Final = final follow-up, Pre = preoperative.

Keywords: coxa vara, dynamic condylar screw, intertrochanteric, osteotomy, proximal femur

1. Introduction

Coxa vara is a common complication of proximal femoral fractures and is caused by nonunion and malunion of intertrochanteric, subtrochanteric, and femoral neck fractures. Andruszkow et al[1] reported that the incidence of coxa vara in patients with intertrochanteric fractures was 54% after conservation treatment and 12% after surgery. Coxa vara is defined as a neck–shaft angle of <110°. It is often associated with hip pain, lower limb length discrepancy, gluteus muscle weakness, limping, and hip abduction restriction and seriously affects patients' quality of life.[2] At present, the main methods of treating coxa vara are intertrochanteric valgus osteotomy and total hip arthroplasty. Although total hip arthroplasty can achieve satisfactory results,[3] valgus osteotomy is more suitable for younger patients.[4–9]

No uniform standard for intertrochanteric valgus osteotomy has yet been established. Intertrochanteric valgus osteotomy began in the 1970s and 1980s,[10–12] which can be broadly classified as Pauwels' osteotomy, modified Pauwels' osteotomy and fixed osteotomy using special plates.[4–6] However, these techniques have some disadvantages, such as complicated preoperative planning, difficult operation, long learning curve and some need for special internal fixation devices. From December 2005 to December 2018, we treated 11 patients with coxa vara after trauma with a self-designed intertrochanteric valgus osteotomy technique that showed a favorable clinical effect. It's preoperative planning is simple, intraoperative operation is easily and result is reliable that can be used in the clinical setting. This paper introduces the main point and clinical effects of this technique.

2. Materials and methods

2.1. Patients

The patients in this study comprised 7 males and 4 females with an average age of 44.4 years (range, 17–73 years). Six patients had coxa vara on the left and 5 had coxa vara on the right. Seven

Editor: Arjun Ballal.

The authors have no funding and conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are publicly available.

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How to cite this article: Tian S, Liu M, Zhang J, Zhang L, Peng A. Intertrochanteric valgus osteotomy for post-traumatic coxa vara after proximal femur fractures: a retrospective study. Medicine 2021;100:45(e26829).

Received: 9 June 2019 / Received in final form: 6 July 2021 / Accepted: 18 July 2021

http://dx.doi.org/10.1097/MD.0000000000026829

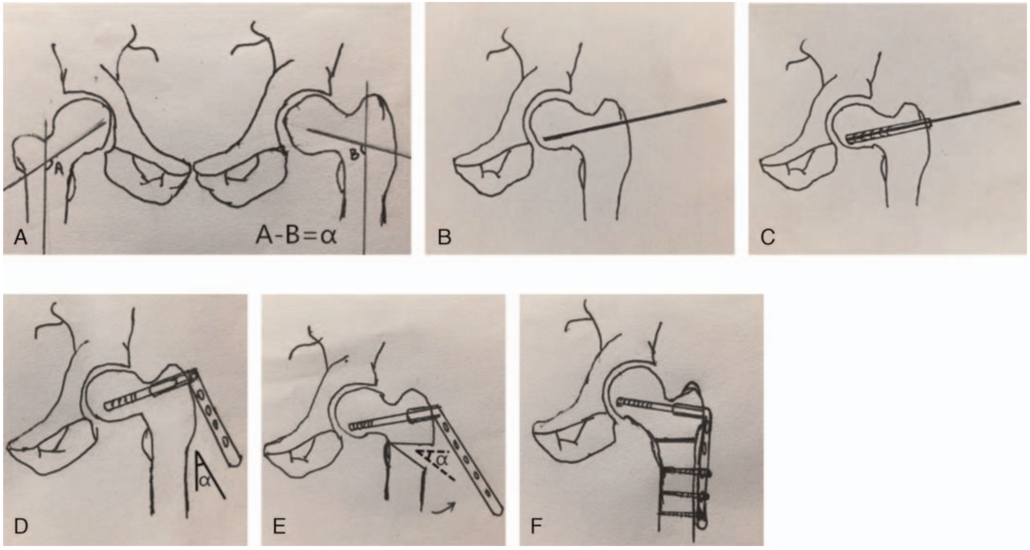

Figure 1. (a) A preoperative radiograph of the pelvis was obtained to measure the neck–shaft angle on both sides (A, healthy side; B, injured side; A – B = α, which is termed the osteotomy angle. (b, c) A guide wire was placed in the lower part of the femoral head 1.5 to 2.0 cm below the tip of the greater trochanter, and a dynamic condylar screw was introduced. (d) A dynamic condylar plate was temporarily installed, and the angle between the plate and the lateral cortex of the femoral shaft was measured by X-ray (the predicted osteotomy angle). In theory, this should be the same as the α angle. (e) A wedge-shaped bone was cut with the apex of the α angle at the level of the lesser trochanter, and the injured limb was abducted, closing the two ends of the osteotomy. (f) After the ends of osteotomy were closed, cortical screws were used to fix the dynamic condylar plate.

patients had experienced a fall and 4 had been injured in traffic accidents. The cause of the coxa vara included 6 cases of intertrochanteric fracture deformity union (4 underwent conservative treatment and 2 were a result of failed internal fixation), 3 cases of subtrochanteric fracture nonunion (all were a result of failed internal fixation), and 2 cases of femoral neck fracture nonunion (one was a result of conservative treatment and one was a result of failed internal fixation). The main clinical manifestations of the patients were hip abduction restriction, limping, and pain while walking. We measured the neck–shaft angle by X-ray examination; we calculated the difference in the angle between the healthy limb and injured limb and termed this the α angle (Fig. 1a). The length and force line of both lower extremities were measured in all patients.

Approval for the current study was provided by the Ethics Board of the Third Hospital of Hebei Medical University, and all patients gave signed informed consent.

3. Therapeutic method

3.1. Surgical technique

All patients underwent general anesthesia or epidural anesthesia and were placed supine on a traction bed with the injured limb resting in a neutral position. A longitudinal skin incision was made to expose the fascia of the femur. If the malunion deformity was the result of failure of internal fixation, the fixation was first removed. Under the direction of the C-arm X-ray machine, a guide wire was placed in the lower part of the femoral head 1.5 to 2.0 cm below the tip of the greater trochanter, and a dynamic condylar screw was introduced along the guide wire (Fig. 1b, c). A dynamic condylar plate was temporarily installed, and the angle between the plate and the lateral cortex of the femoral shaft was then measured on X-ray films (the predicted osteotomy angle). In theory, this angle should be the same as the α angle (Fig. 1d). After removing the plate, we cut a wedge-shaped bone with the apex of the α angle at the level of the lesser trochanter the same angle as that between the plate and the lateral cortex of the femoral shaft measured on the X-ray films (Fig. 1e). The traction rack was relaxed and the injured limb was abducted, thus closing the two ends of the osteotomy. If the ends were difficult to close, two 4.5-mm cortical screws were screwed into each end, and the ends were then closed with reduction forceps. Once again, the dynamic condylar plate was installed and fixed with cortical screws (Fig. 1f). During the operation, the patella was placed in a neutral position to correct the internal rotation deformity of the lower limb. For subtrochanteric fractures, the position of the osteotomy was moved down appropriately to overlap the fracture line, and the other methods were performed as described above. The incision was then closed under drainage. The operation time and intraoperative blood loss were recorded.

3.2. Postoperative management

Static quadriceps training was performed on the day of the operation. The drainage tube was removed, and active and passive motion of the injured limb was begun. After 6 weeks, the limb was partially loaded. Full weight-bearing exercises were avoided until radiography indicated that the end of the osteotomy had healed. Patients with old femoral neck fractures were allowed full weight bearing after the femoral neck fracture had healed. All patients were followed up for 2 to 5 years (average of 3 years). Radiographic examinations were regularly performed to observe the osteotomy and fracture healing and the neck–shaft angle. One year after surgery, the function of the hip joint was evaluated based on the Harris hip score.

4. Results

The average preoperative neck–shaft angle was 99.1° (range, 90°–110°) among all patients, and this angle increased by 35°

Table 1

Neck-shaft angle, limb shorten and Harris score preoperative and final follow-up data.

			Neck-shaft angle (°)			Limb shorten (cm)			Harris score (score)				
N	Gender	Age	Pre	Final	*D*	Pre	Final	*D*	Pre	Final	D	Operation time (min)	Blood loss (ml)
1	F	37	95	135	40	3.2	1.0	2.2	40	94	44	58	165
2	M	32	100	130	30	2.8	1.2	1.6	53	97	44	60	210
3	M	51	105	135	30	2.9	0.9	2.0	45	90	45	66	190
4	M	17	110	135	25	3.5	1.0	2.5	48	96	48	54	180
5	F	66	90	125	35	3.1	1.3	1.8	37	88	51	86	310
6	M	44	105	140	35	3.0	0.8	2.2	52	98	46	67	255
7	F	49	95	135	40	2.8	1.1	1.7	50	92	42	75	275
8	F	45	100	140	40	2.2	0.5	1.7	46	96	50	65	260
9	M	14	110	140	30	2.4	0.6	1.8	40	92	52	68	290
10	M	60	90	135	45	2.9	0.8	2.1	42	95	53	70	280
11	M	73	90	125	35	4.3	1.5	2.8	32	86	54	70	200
Mean		44.4	99.1	134.1	35	2.9	1.0	1.9	44.1	93.1	49	67.2	237.7

D = difference value, Final = final follow-up, N = number of patients, Pre = preoperative.

postoperatively to 134.1° (125°–140°). The preoperative limb shortening was 2.9 cm (range, 2.2–4.3 cm) and decreased to 1.0 cm (range, 0.5–1.5 cm) after surgery; thus, the limb was lengthened by an average of 1.9 cm. The average preoperative Harris hip score was 44.1 points (range, 32–53 points) and increased by 49 points to 93.1 points (range, 86–98 points) 1 year after surgery. The average operation time was 67.2 minutes (range, 54–86 minutes), and the total blood loss was 237.7 ml (range, 165–310 ml). The average postoperative follow-up period was 3 years (range, 2–5 years). All incisions healed, no infections occurred, and the osteotomy end was healed at 3 months. Two old femoral neck fractures healed at 4 and 6 months after surgery, respectively; the Pauwels angle improved from 60° and 70° preoperatively to 30° and 40° postoperatively, respectively, and no femoral head necrosis occurred during the follow-up period. None of the patients had recurrence of their deformity. Neck-shaft angle, Limb shorten and Harris score preoperative and final follow-up data are shown in Table 1. Typical cases are shown in Figures 3–5.

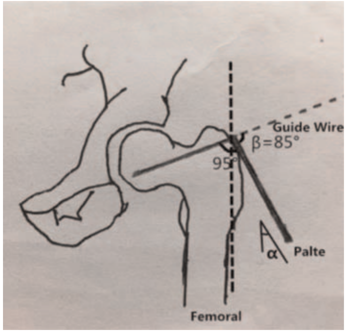

Figure 2. Intraoperative presetting of the guide wire. The lateral cortex of the femoral shaft was used as a marker. The angle between the guide wire and the lateral cortex of the femoral shaft was $\alpha + \beta$; α was the predicted osteotomy angle and was equal to the difference in the angle between the healthy limb and injured limb. β is a fixed value of $85° = 180° - 95°$ (the angle between the dynamic condyle and the side plate is 95°). Accordingly, when the wire is present during the operation, the angle between the guide wire and lateral cortex of the femoral shaft should be kept at $\alpha + 85°$.

5. Discussion

Today, over 70 diseases and health conditions are known that negatively affect the bone quality directly or indirectly by their medical treatment.[13] Hip fracture is becoming more common and its incidence has been increasing in recent years.[14,15] Improper treatment such as improper selection of internal fixation materials and premature early weight loading after surgery can lead to a deformity of the hip. According to the biomechanical and anatomical characteristics of the hip joint,[16] the medial cortex and trabecular structure of the proximal femur are subjected to tremendous compressive stress from above and most of the weight load is transferred to distal through these structures. The proximal femur is always prone to varus based on these characteristics. Once the proximal femur is broken, several forces act upon the intertrochanteric region of the femur. The psoas muscle flexes, abducts, and externally rotates the proximal fragment. The adductors acting on the distal fragment cause shear forces as the proximal fragment is abducted by the gluteus minimus and maximus. The 1200-lb per square inch force in the subtrochanteric region must be considered for any fracture in this region.[17,18] This huge shear force is the main reason for malunion of proximal femoral fractures and the failure of internal fixation. Nonunion of intertrochanteric fracture and varus collapse are in vicious cycle.[4] Desai[19] reported that only by restoring the normal neck angle can this vicious circle be terminated and the fracture end be healed. Thus, the performance of intertrochanteric osteotomy to correct this shear force is an effective method to treat deformity of the hip.

The performance of intertrochanteric valgus osteotomy began in the 1970s and 1980s,[10–12] which can be broadly classified as Pauwels' osteotomy, modified Pauwels' osteotomy and fixed osteotomy using special plates. Vidyadhara et al[4] reported that 7 patients with coxa vara after hip fracture were treated with valgus osteotomy combined with dynamic hip screw fixation. The performed the osteotomy at the lower edge of the lesser trochanter in the lateral femoral cortex and performed fixation with a dynamic hip screw. During an average follow-up of 11 months, all patients showed improvement in their coxa vara and shortening deformity. Sangkaew and Piyapittayanun[5] treated 15 patients with coxa vara using a self-designed osteotomy technique involving a double-angled blade plate to fix the two ends of the osteotomy. The average postoperative

Figure 3. (A) A 44-year-old man sustained a right intertrochanteric fracture by a fall. Coxa varus deformity occurred after 2 mo of conservative treatment. The preoperative neck–shaft angle was 105° and the preoperative limb shortening was 3.0 cm. (B) The postoperative neck–shaft angle was 140°. (C) The osteotomy end was healed at 3 mo after surgery and internal fixation was successful. (D) One year after surgery, the osteotomy site had healed well. (E, F) The patient's hip pain disappeared, and the limb shortening reduced to 0.8 cm. The Harris hip score was 98.

follow-up period was 3 years, and the average neck–shaft angle was restored from 113.0° preoperatively to 138.2° postoperatively. Magu et al[6] performed a modified Pauwels osteotomy for 48 patients with old femoral neck fractures and coxa vara. The average postoperative follow-up period was 2 years, the femoral neck fracture healed in 46 patients, and the average neck–shaft angle was restored from 107.3° preoperatively to 132.7° postoperatively.

No uniform standard for intertrochanteric valgus osteotomy has yet been established. Traditional techniques have some

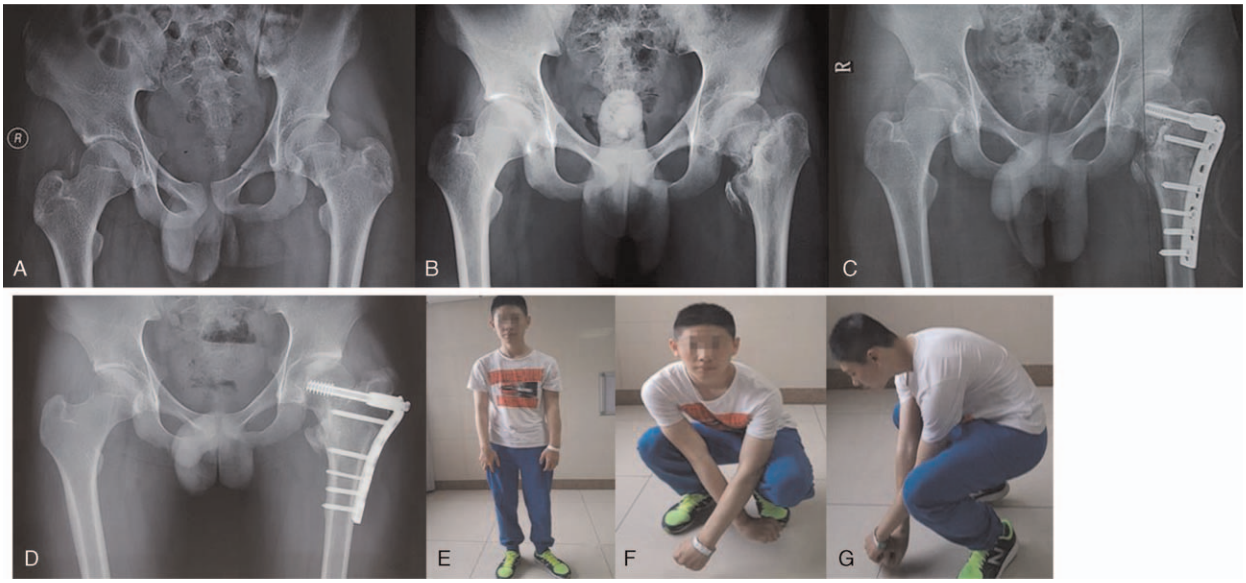

Figure 4. (A) A 17-year-old male patient sustained a left femoral neck fracture by a fall. (B) Fracture nonunion occurred after 4 mo of conservative treatment. The preoperative neck–shaft angle was 110°, the Pauwels angle was 70°, and the limb shortening was 3.5 cm. (C) The postoperative neck–shaft angle was 135°, and the Pauwels angle was 40°. (D) The neck fracture and osteotomy end had healed well 6 mo after surgery, and the deformity did not recur. (E–G) During the follow-up period, the patient's hip pain disappeared, and no femoral head necrosis or limping occurred. The limb shortening decreased to 1.0 cm, and the Harris hip score was 96.

Figure 5. (A) A 32-year-old man sustained a left subtrochanteric fracture in a traffic accident. A coxa varus deformity appeared 6 mo after the internal fixator was removed, and the patient was diagnosed with union of the subtrochanteric fracture. The preoperative neck–shaft angle was 100°, and the limb shortening was 2.8 cm. (B, C) A guide wire was placed in the lower part of the femoral head from 1.5 cm below the tip of the greater trochanter, and a dynamic condylar screw was introduced. (D) A dynamic condylar plate was temporarily installed, and the angle between the plate and the lateral cortex of the femoral shaft was 30°. (E) A wedge-shaped bone with an apex angle of 30° was cut to overlap with the fracture line. (F) The injured limb was abducted, closing the two ends of the osteotomy and using cortical screws to fix the dynamic condylar plate. (G) The osteotomy end was healed and the neck–shaft angle was 130° at 3 mo after surgery. (H, I) The patient's hip pain disappeared 1 yr later and he exhibited no limping. The limb shortening was 1.2 cm and the Harris hip score was 97.

disadvantages, such as complicated preoperative planning, a difficult operation, a long learning curve, and the need for special internal fixation devices for some methods. Additionally, some operators focus too much on limb extension, thus reducing the contact area of the osteotomy end; this results in instability, and some patients need continuous traction or must wear a brace after the operation. The advantages of our technique are as follows. First, the effect is reliable; each case of coxa vara is corrected by more than 25°. Second, our technique does not require a special plate and is easy to master. Therefore, it is suitable for primary care hospitals. Third, the osteotomy ends are stable after fixation, eliminating the need for bone grafting; this ensures that patients can perform functional exercises immediately after surgery. Finally, the limb can be lengthened while the coxa vara is corrected. In this study, our valgus osteotomy technique reduced the deformity of the limb from 2.9 cm (range, 2.2–4.3 cm) preoperatively to 1.0 cm (range, 0.5–1.5 cm) postoperatively, and no patients exhibited a limp while walking.

Several intraoperative factors and surgical techniques must be considered. First, the radiograph of the pelvis should be taken with both lower limbs internally rotated by 15° to accurately show the size and shape of the bilateral neck–shaft angle.[20] The difference in the angle between the healthy limb and injured limb (the osteotomy angle) should be calculated. Second, the guide wire is preset as shown in Figure 2. In patients with more severe coxa vara, the entry point of the guide pin should be close to the tip of the greater trochanter, and the tip of the pin should be placed as close as possible to the bottom of the femoral head to maximize the angle between the guide wire and the lateral femoral cortex. This will allow for the greatest correction of the coxa vara. Third, for subtrochanteric fractures, the section of the osteotomy should be moved down appropriately to overlap the fracture line. Grafting is not necessary because the contact area of the osteotomy is large enough. Fourth, if the osteotomy ends are difficult to close, two 4.5-mm cortical bone screws can be screwed into each side of the osteotomy ends, and the osteotomy ends can then be closed with a reduction forceps clamp. Finally, in the present study, 1 patient had an obvious internal rotation deformity of the limb. In this patient, a 4.5-mm Kirschner wire was driven into the distal end of the osteotomy while working it as a joystick, and the internal rotation deformity was then corrected.

6. Conclusion

Our self-designed intertrochanteric valgus osteotomy technique showed a favorable clinical effect to treatment coxa vara after proximal femur fractures. It's simple and reliable and can be used in the clinical setting. However, the deficiency of our study is that the sample size is not large enough, and it is a retrospective study. Prospective, multi-center and large sample studies are still needed to back up our conclusions.

Author contributions

Data curation: Shuwei Tian, Jing Zhang, Lefang Zhang.
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Resources: Aqin Peng.
Writing – original draft: Shuwei Tian.
Writing – review & editing: Aqin Peng.

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