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Comparison of Clinical and Radiological Results of Two Fixation Materials after Distal Chevron Osteotomy for Hallux Valgus? – Two Kirschner Wires versus Single Screw Fixation

Porovnání klinických a radiologických výsledků použití dvou typů fixace u distální „chevron“ osteotomie u hallux valgus – dva K-dráty versus fixace jedním šroubem

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ABSTRACT

PURPOSE OF THE STUDY

Although distal chevron osteotomy (DCO) is considered as an intrinsically stable osteotomy, various fixation methods have been used to date. The purpose of this study was comparison of two commonly used methods in DCO, Kirschner (K)-wire and titanium fully threaded headless cannulated screw fixation, based on the clinical and radiological results, and their complications.

MATERIAL AND METHODS

Thirty patients were included in K-wire group and 36 patients were included in screw group. Mean age was 43.4   11.1 (rage; 19–65) years, and mean follow-up was 21.2   5.5 (range; 12–35) months. American Orthopaedic Foot   Ankle Society (AOFAS) metatarsophalengeal-interphalangeal score was used for clinical evaluation. For radiological evaluation, hallux valgus angle (HVA), first-second intermetatarsal angle (IMA), distal metatarsal articular angle (DMAA), medial sesamoid grade (MSG), and lateral sesamoid distance (LSD) to mid-axis of the second metatarsal were measured for all patients on both preoperative and postoperative final follow-up radiographs.

RESULTS

Mean AOFAS scores were significantly improved and radiographic measurements were significantly reduced at postoperatively in both groups ($p < 0.01$ for AOFAS, HVA, IMA, DMAA and MSG; $p = 0.01$ for LSD). Mean preoperative and mean postoperative, as well as the mean difference (difference between postoperative and preoperative) of the radiographic measurements, and AOFAS scores were not significantly different between two groups ($p > 0.05$). A total of 5 complications were observed (four in K-wire group, one in screw group). Complication rates between two groups was not statistically significant ($p = 0.12$).

DISCUSSION

Initial description of DCO did not include any fixation material. Afterwards, the procedure was modified by using single K wire in order to enhance the stability of the osteotomy. Previous studies were unable to demonstrate significant differences between K-wire fixation and cortical or Herbert type screw fixation based on clinical and radiological outcomes. Differently, in this study we compared two K-wire fixation with 3.5-mm titanium fully threaded headless cannulated screw fixation. Our results demonstrated that function and radiological measurements significantly improved after both fixation methods. Despite the increased complication rate in K-wire group, it was not statistically significant. Moreover, none of the complications was associated with unstable osteotomy, and required re-operation.

CONCLUSIONS

Both fixation methods provided comparable radiological and clinical outcomes with favourable results after DCO.

Key words: hallux valgus, distal chevron osteotomy, Kirschner wire, headless cannulated screw, fixation method.

INTRODUCTION

Distal chevron osteotomy (DCO) is a frequently preffered technique in early stages of HV, because of its simplificity, lower complication risk and less invasiveness compared to the proximal osteotomies (7). It was considired as an intrinsically stable osteotomy when it was first introduced in 1981. Therefore, in orginal description, osteotomy was performed without the use of any internal fixation (3). However, various fixation materials including Kirschner (K)-wires, metallic screws, absorbable implants, staples and plates have been used to date for the fixation of DCO (4, 24).

K-wires were the first metallic fixation material considered for HV surgery. Although K-wires can be readily inserted and removed, percutaneous fixation may cause some discomfort to the patient and increase the risk of pin tract infection (24). Moreover, they have a limited contribution on fragment stability and are unable to provide interfragmentary compression. In more recently screws, in particular headless and cannulated forms, have become a popular choice for the orthopaedic surgeons in order to enhance the stability and decrease the risk of skin irritation and the necessity of screw removal (4, 13).

Previous studies widely assessed the stability of K-wire and screw fixation for distal metatarsal osteotomies (10, 19, 21). Fixation with two K-wires or cortical screw was reported to provide comparable biomechanical properties after DCO (21). Furthermore, some clinical studies were also unable to demonstrate significant difference between K-wire fixation and different type of metallic screw fixation other than the operation time or cost (2, 9). In these studies, K-wire was compared with the Herbert cannulated screw or cortical screw. However, to our knowladge K-wire fixation has not been yet extensively compared with the titanium fully threaded headless cannulated screw fixation based on clinical and radiological results after DCO.

The purpose of the current study was performing a comparison of the clinical and radiological results of two K-wires and single titanium fully threaded headless cannulated screw fixation based on functional scores, radiographic measurements, and their complications. We hypothesized that two fixation methods provide similar clinical and radiological outcomes after DCO.

MATERIAL AND METHODS

The study was conducted after approval of the local Ethics Committee (approval no: 2019/12-6). The patients who underwent DCO because of symptomatic HV between January 2016 and December 2018 were retrospectively reviewed. The patients aged over 18 years old with at least 12-month follow-up, whose osteotomy was fixated with two K-wires or one titanium fully threaded headless cannulated screw, who did not underwent lateral soft tissue release or additional metatarsal osteotomy were included into the study. Exclusion criteria were presence of previous trauma history, and rheumatologic or neurologic disorders of the foot.

The patients were operated in supin position under spinal or general anestesia. After skin preperation, a longitudinal incision starting from the base of the proximal phalanx exceeding 5 cm proximally was made over the medial side of the first MTP joint. V-shaped capsulotomy was performed and medial bunion was resected with an oscillating microsaw parallel to the medial cortex of the first metatars. Chevron osteotomy was made in standard technique with forming a 60^0 V-osteotomy at the center of the first metatars. The apex of the osteotomy was located at 1 cm proximal to the distal articular surface of first metatarsal. Distal capital fragment displaced laterally approximately 5 to 7 mm and medial osseous prominence of the proximal fragment was flattened.

Fixation of the osteotomy was obtained with the use of two 1.6-mm K-wires or single 3.5-mm titanium fully threaded headless cannulated screw (Youbetter Medical Apparatus Co Ltd, Suzhou, China) from dorsal-medial to plantar-distal according to the surgeon's preference. Following the excision of the redundant capsule, remaining medial capsule was plicated with obtaining first MTP joint congruency and restoring the alignment of the great toe. Lateral soft tissue release or additional metatarsal osteotomy were not performed.

The patients were mobilized the day after the surgery with allowing partial weight bearing on the hell. At the end of the two weeks, the splint and sutures were removed, and the alignment of the great toe was maintained with a 2-inch elastic bandage for 3 weeks. First MTP joint manuplation was started immidiately after splint removal in order to prevent joint stiffness. K-wires were removed 6 to 8 weeks following the surgery under local anesthesia. Full-weight bearing was allowed after 8 to 10 weeks after the radiographic evidence of healing.

The American Orthopaedic Foot & Ankle Society (AOFAS) hallux metatarsophalangeal-interphalangeal scale was used for clinical assessments at preoperative and postoperative final follow-up visit. A total of 100 points AOFAS scale with indicating 0 point worse outcome consists of the evaluation of pain (40 points), function (45 points), and alignment (15 points).

Radiological evaluations were performed with obtaining weight bearing anteroposterior and lateral conventional radiographs. Five different radiological parameters including hallux valgus angle (HVA), first-second intermetatarsal angle (IMA), distal metatarsal articular angle (DMAA), medial sesamoid grade (MSG) and lateral sesamoid-second metatars distance (LSD) were measured from the hospital's database with the use of the Picture Archiving and Communication System. All the measurements were performed both preoperatively and postoperatively at final follow-up visit.

HVA and IMA were measured according to center-of-head method (18). The angle between the longitudinal axis of the proximal phalanx of the great toe and longitudinal axis of the first metatarsal determined by the line connecting the center of the first metatarsal head and center of the base was defined as HVA (Fig. 1).

Fig. 1. HVA: hallux valgus angle, IMA: intermetatarsal angle, DMAA: distal metatarsal angle, LSD: lateral sesamoid distance measurements.

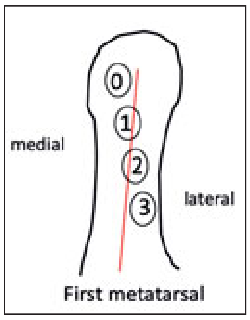

Fig. 2. Medial Sesamoid Grade

IMA was defined as the angle between the longitudinal axis of first metatarsal and mid-diaphysial axis of second metatarsal (Fig. 1). DMAA was obtained by measuring the angle between the the longitudinal axis of first metatarsal and the line drawn perpendecular to the line connecting the most medial and most lateral distal articular surface of the first metatarsal (Fig. 1) (8).

MSG was defined by the position of the medial sesamoid as grade 0, 1, 2 or 3 in relation to line bisecting the first metatarsal shaft (Fig. 2) (20). LSD was calculated by measuring the perpendicular distanance between the most lateral edge of the lateral sesamoid and second metatarsal axis (Fig. 1) (5). All the clinical evaluations and radiological measurements were performed by the same author (TK).

The patients were divided into two groups based on the fixation materials as K-wire group and screw group. Two groups were compared based on the AOFAS scores and 5 different radiographic parameters mentioned above. Complications such as superficial or deep infection, pin tract infection, implant failures including pin migration, skin irritation, malunion or nonunion, avascular necrosis (AVN) of the first metatarsal head were also noted during the follow-up visits.

Statistical Package for Social Sciences (SPSS) version 24.0 was used (IBM Corp., Armonk, New York, USA) for statistical analyses. Chi-squared test or Fisher exact test was used to compare the categorical data. Shapiro-Wilk test was used to test normality. If the data was evaluated as normally distributed, t test was used to compare the continious data and if the data was evaluated as non-normally distributed Mann-Whitney U test was used to compare the continious data. Mean, standard deviation and minimum-maximum values were calculated for age and follow-up times of the patients. A p value < 0.05 was accepted as statistically significant.

RESULTS

Totally, 66 feet of 66 patients were evaluated. None of the patients underwent bilateral surgery. Ten patients were male and 56 patients were female. The mean±SD age was 43.4 ± 11.1 (range; 19–65) and the mean±SD follow-up was 21.2 ± 5.5 (range; 12–35) months. Clinicodemographic characteristics of the groups were summarized in Table 1.

The mean±SD AOFAS scores were significantly improved in both groups postoperatively (p<0.01). There was no significant difference based on the mean±SD preoperative, the mean±SD postoperative final follow-up, and the mean±SD difference (difference between postoperative and pre-operative) AOFAS scores between the groups (p = 0.24, 0.82, 0.31, respectively) (Table 2).

The mean±SD HVA, IMA, DMAA, MSG and LSD were significantly reduced at postoperatively in both groups (p<0.01 for HVA, IMA, DMAA and MSG; p = 0.01 for LSD). The mean±SD preoperative and postoperative final follow-up values of these measurements were not significantly different between the groups (p > 0.05 for all variables). In addition, the mean±SD difference (difference between preoperative and postoperative

Table 1. Clinicodemographic characteristics of the groups

Variable	K-wire group	Screw group	p value
Number	30	36	
Gender male female	 4 26	 6 30	0.49*
Mean±SD age (min–max)	44.2±9.9 (23–63)	42.7±12.0 (19–65)	0.59**
Mean±SD follow-up (month) (min–max)	21.9±6.1 (12–35)	20.5±4.8 (12–32)	0.29**
Operation Side right left	 19 11	 19 16	0.34*

* Fischer exact test
** Student's t-test

Table 2. AOFAS scores of the groups

AOFAS score	K-wire group	Screw group	p value
Mean±SD preoperative (min–max)	50.7±9.3 (32–65)	52.4±12.1 (24–68)	0.24*
Mean±SD postoperative (min–max)	86.8±10.9 (57–100)	87.7±8.0 (60–100)	0.82*
Mean±SD difference (min–max)	36.0±9.8 (11–51)	35.3±9.1 (20–58)	0.31**
Preoperative vs postoperative final follow-up	<0.01*	<0.01*	

AOFAS: American Orthopaedic Foot and Ankle Society
*Mann-Whitney U test
** Student's t-test

Table 3. HVA and first-second IMA measurements of the groups

HVA(°)	K-wire group	Screw group	p value
Mean±SD preoperative (min–max)	33.4±4.4 (25.8–41.5)	32.4±4.2 (25.0–40.3)	0.37*
Mean±SD postoperative (min–max)	15.2±4.1 (8.5–24.5)	14.5±3.8 (5.3–23.5)	0.48*
Mean±SD difference (min–max)	18.2±4.7 (8.1–24.7)	17.9±4.7 (6.5–25.7)	0.81*
Preoperative vs postoperative	<0.01*	<0.01*	
1-2. IMA(°)	K-wire group	Screw group	p value
Mean±SD preoperative (min–max)	13.1±2.1 (8.2–16.3)	12.6±1.9 (8.4–16.3)	0.40*
Mean±SD postoperative (min–max)	7.0±2.0 (2.4–12.3)	6.7±1.9 (3.2–11.5)	0.69**
Mean±SD difference (min–max)	6.1±2.3 (1.9–9.5)	5.9±2.5 (2.0–12.6)	0.80*
Preoperative vs postoperative	<0.01**	<0.01*	

HVA: hallux valgus angle, IMA: intermetatarsal angle
* Student's t-test
** Mann-Whitney U test

final follow-up) of the radiographic measurements between two groups was not significant ($p > 0.05$ for all variables) (Tables 3 and 4).

A total of 5 complications (7.6%) were observed in both groups (one in screw group, four in K-wire group). In K-wire group, complications included superficial wound infection in one patient, pin tract infection in two patients and pin migration in one patient. In screw group, superficial wound infection occurred in one patient. None of these patients underwent re-operation. Pin tract infections and superficial infections were healed with local wound care and oral antibiotherapy. Implant related skin irritation was not observed in screw group. In both groups, there were no deep infection, AVN, malunion, nonunion and capital displacement even in the patient with the migrated pin (Fig. 3). Complication rate was higher, but not significantly in K-wire group compared to the screw group ($p = 0.12$).

Fig. 3. Early postoperative plain radiograph of the patient with migrated pin (a). Plain radiograph of the same patient at postoperative final follow-up shows no capital displacement of the first metatarsal (b).

Table 4. DMAA, MSG and LSD measurements of the groups

DMAA(°)	K-wire group	Screw group	p value
Mean±SD preoperative (min–max)	17.1±7.0 (4.2–35.1)	18.8±6.0 (5.7±32.7)	0.30*
Mean±SD postoperative (min–max)	10.6±4.2 (4.8–22.5)	11.0±4.1 (3.2-24.2)	0.35**
Mean±SD difference (min–max)	6.5±5.0 (-5.2–16.4)	7.8±5.1 (-0.4–22.6)	0.33*
Preoperative vs postoperative	<0.01**	<0.01*	
MSG(0-3)	K-wire group	Screw group	p value
Mean±SD preoperative (min–max)	2.0±0.7 (1–3)	2.2±0.6 (1–3)	0.40***
Mean±SD postoperative (min–max)	0.9±0.7 (0–2)	1.0±0.7 (0–2)	0.70***
Mean±SD difference (min–max)	1.1±0.9 (-1–2)	1.2±0.9 (-1–3)	0.91**
Preoperative vs postoperative	<0.01**	<0.01**	
LSD(mm)	K-wire group	Screw group	p value
Mean±SD preoperative (min–max)	12.39±1.54 (9.38–14.79)	12.59±1.21 (9.45–14.45)	0.75**
Mean±SD postoperative (min–max)	11.25±0.96 (9.32–13.10)	11.52±0.92 (9.73–13.21)	0.24*
Mean±SD difference (min–max)	1.14±1.24 (-1.89–3.08)	1.07±1.05 (-1.12–3.93)	0.79*
Preoperative vs postoperative	<0.01*	<0.01**	

DMAA = Distal metatarsal articular angle, MSG = Medial sesamoid grade, LSD = Lateral sesamoid distance
* Student's t-test,
** Mann-Whitney U test,
***Chi-square testt

DISCUSSION

Our results confirmed the previous studies that K-wire and metallic screw fixation provided similar functional and radiological results after DCO. Differently, the fixation materials were two K-wires or titanium fully threaded headless cannulated screws in the current study. Moreover, we found that although there was an increeased complication rate in K-wire group compared to the screw group.

Because of its distinctive geometry and relation to deforming forces, DCO resists to displacement, and is considered as an intrinsically stable osteotomy (17). Although, initial description did not include the use of a fixation material, afterwards the procedure was modified by using a K-wire in order to prevent capital displacement (3, 15).

Choi et al. reported the results of transarticular lateral release with DCO (6). They fixated the osteotomy with the use of two 0.062-inch K-wires, and burried them under the skin. Mean AOFAS score improved from 49 to 92, postoperatively. Mean HVA, IMA, and MSG decreased significantly. There were no complications such as AVN, nonunion, malunion, stiffness or infection. In current study K-wires were inserted percutenously. We observed pin migration in one patient, and pin tract infection in two patients. Lefting the K-wires under the skin may prevented such pin related complications in the study of Choi et al. However, burried pins may cause some discomfort to the patient due to skin irritation, and require further surgery for removal (6).

In another study, Park et al. reported significantly improved postoperative AOFAS scores, as well as, decreased postoperative HVA, IMA and MSG in DCOs combined with distal soft tissue procedures (16). They fixated the osteotomy with two 1.4-mm K-wires. A total of 11 complications occurred in 122 patients. Complications included first MTP joint stiffness, numbness on the medial side of the great toe, superficial wound infection, thickening of the dorsal first web-space, and persistant bunion pain. In concordance with our results, complications such as AVN, malunion, nonunion and capital displacement did not occur in their study.

Metallic screws are the other popular implants which were widely used for years for the fixation of DCO. Herbert type cannulated screws were used in some studies (9, 12, 14), whereas cortical screws were preferred in the others (2, 11). Goforth et al. used 2.7-mm cortical screw for fixation (11). They reported high rate of patient satisfaction with reduced HVA (from 28.3^0 to 18.1^0), IMA (from 12.6^0 to 6.3^0), and medial sesamoid position (from 5.2 to 3.9) at a mean 5 year follow-up. No patient demonstrated AVN of first metatarsal head.

Viehe et al. mainly focused on the complications in screw fixated DCOs, and reported a total of 15 complications in 95 DCOs (22). The most common complications were soft-tissue infection and painful hardware. The authors reported that there were no AVN, recurrence and hallux varus. In our study, only one patient had superficial wound infection in screw group. In addition, no implant related skin irritation was occurred. We believe that appropriately inserted headless screws are benefical for decreasing the risk of such complication.

To our knowledge, two studies have reported the results of the comparison of K-wire and metallic screw fixation after DCO (2, 9). Amstrong et al. demonstrated no significant differences in terms of postoperative infection, dehiscence, and ROM between single 0.062-inch K-wire fixation and 2.7-mm cortical screw fixation (2). Postoperative IMAs were comparable between two groups. However, operation time was found to be significantly longer in screw group. The authors further concluded that single K-wire was effective as screw fixation for appropriately performed, stable DCO.

Crosby et al. reported the results of 19 DCOs which were either fixated with the use of Herbert screw (n = 6) or K-wire (n = 7), or non-fixated (n = 6) (9). In congruence with our results, postoperative HVAs were not significantly different between the groups. Moreover, no capital displacement or non-union was reported during the follow-up visits. Although mean anesthesia time and operative cost were not significantly different between K-wire fixated group and non-fixated group, these parameters were significantly increased in Herbert screw fixated group compared to non-fixated group. Therefore, the authors concluded that single K-wire can be sufficient if the osteotomy was determined to be unstable.

The comparison of the fixation materials proceeds with the comparison of the K-wires and metallic screws with plates or bioabsorbable implants (1, 14, 23). Although each method had their own advantages and disadvantages, no method has been proven to be completely superior to the others. In the majority, postoperative functional and radiological outcomes were favourable regardless of the fixation method. Furthermore, a recent in vitro study demonstrated that the use of two K-wire or one 3.5-mm cortical screw fixation had similar load-to-failure capacity (21). This fact can likely be explained by the inherent stability of this characteristic "V-shaped" osteotomy.

The major limitation of our study was its retrospective design. In addition, all the radiographic measurements and functional evaluations were performed by the same orthopaedic surgeon (TK). Therefore, interobserver reliability could not be investigated. However, aferomentioned studies which compared K-wire and screw fixation solely assesed the HVA or IMA for radiographic evaluation. In the current study, additionally DMAA, MSG and LSD were measured, as well as, AOFAS score was obtained for each patient. Furtermore, to the best of our knowledge, this study is the first clinical study compared K-wire fixation with titanium fully threaded headless canullated screw fixation for DCO.

CONCLUSIONS

In conclusion, our results demonstrated that use of two K-wires or single titanium fully threaded headless cannulated screw, both provided improvement of the clinical and radiological outcomes with comparable results after properly fixated DCOs. Despite the increased complication rate in K-wire group, it was not statistically significant. Moreover, none of the complications was associated with unstable osteotomy, and required re-operation.

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