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Research Article

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Distal Chevron Osteotomy without Fixation for Correction of Hallux Valgus: A Ten Year Retrospective Study

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Abstract

Introduction: *More than eighty surgical methods have been proposed to correct Hallux Valgus Deformity. This study evaluates the efficacy of Distal Chevron Osteotomy by means of assessing pre-operative and post-operative radiographic parameters and clinical results.*

Methods: *The authors performed a ten-year retrospective study, on patients treated with Chevron Osteotomy alone without internal fixation, by the senior author, at the Toronto Western Hospital, between the years 2000-2009. The association of Hallux Valgus with demographics, other pre-operative foot pathology, etiology, intra-op pathology, complications (late and early) and radiographic parameters (pre-operative and post-operative IMA and HVA's) were studied.*

Results: *Two hundred and eight-five Chevron osteotomies were performed, on one hundred and seventy-eight patients with Hallux Valgus. In the study group 89% were female, the average age was 44 years ± 14 (range 16 to 77), 60% were bilateral. Radiographic measurements of the Hallux Valgus angle (HVA) and Intermetatarsal angle (IMA) demonstrated a statistically significant difference in pre-operative and post-operative measurements ($p < 0.05$) t-test. The mean correction in the HVA for the left foot was 14.94 degrees compared with 14.98 degrees for the right foot. A mean correction of 1.99 degrees in the IMA for the left foot and 2.05 degrees for the right foot was obtained. The recurrence rate for Hallux Valgus was 0.70% (2 feet). In 12.36% of the study group, unexpected intra-operative findings such as EHL tendon contracture, bursae, intra-osseous ganglion cysts, and osteoporosis or capital osteophytes resulted in adding to, or modifying, the standard operative procedure.*

Conclusion: *Despite minor and largely reversible post-operative complications, this study demonstrates that with distal Chevron osteotomy excellent radiographic and cosmetic correction of the deformity was achieved with a high level (99.30%) of patient satisfaction. Patients should be advised pre-operatively about their risk for developing Keloids 5.61%, transfer metatarsalgia 4.56% and recurrence 0.70% when treated by Chevron osteotomy.*

Introduction

The purpose of this review was to compare results of patients treated by Chevron osteotomy for Hallux Valgus at this Institution with those treated by different or the same techniques elsewhere noting current recommendations and guidelines.

This study was undertaken in order to field commonly asked pre-operative questions from prospective patients such as 1) who is a candidate for Chevron osteotomy 2) what is the usual profile/etiology/demographics of Hallux Valgus 3) does Hallux Valgus exist as an isolated condition or in association with co-existant pathology 4) how do you objectively measure post-operative results and 5) what can you tell us about expected surgical outcomes?

Material and Methods

The authors performed a ten-year retrospective study, on one hundred and seventy-eight patients (285 feet) treated with Chevron Osteotomy alone without internal fixation, by the senior author, at the Toronto Western Hospital, between the years 2000-2009. The association of Hallux Valgus with age, other pre-operative foot pathology, gender, ethnicity, etiology, intra-op pathology, complications (late and early) and radiographic parameters (pre-operative and post-operative IMA and HVA's) were studied.

Non-operative management, including use of modified shoe wear, non-steroidal anti-inflammatory medications, orthotics, toe spacers, hallux valgus night splints or a combination of these methods, had failed in all patients. All patients complained of pain ranging from

moderate to severe attributable to the hallux valgus deformity.

All patients were considered candidates for Chevron osteotomy provided that their foot was skeletally mature on x-ray examination (age 16-18). No patients were excluded in their senior years on the basis of age alone (eldest 77 years). Exclusion criteria included: 1) the presence of moderate to severe osteoarthritis (OA) of the MTP joint 2) the presence of fixed soft tissue contractures preventing passive correction of the Hallux valgus deformity 3) the presence of arterial vascular insufficiency 4) a normal HVA on x-ray with valgus confined to the IP joint of the great toe (Figure 4 and 5) those patients, without pain, seeking surgery for cosmetic reasons only.

All patients were placed in a specially designed weight-bearing fiberglass forefoot cast post-operatively within one week of surgery, which they wore for six weeks (Figures 5 & 6). Once the cast was removed, patients wore a toe spacer for an additional period of six weeks in their regular shoes.

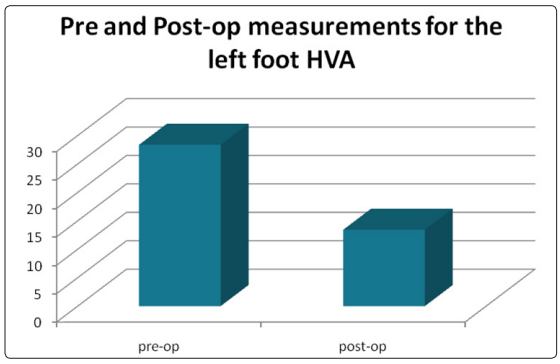

Figure 1: HVA Correction for the left foot

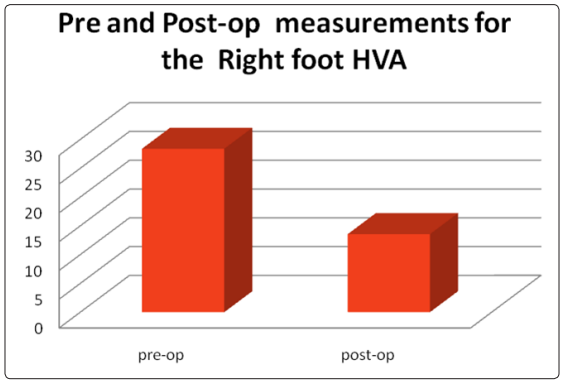

Figure 2: HVA Correction for the right foot

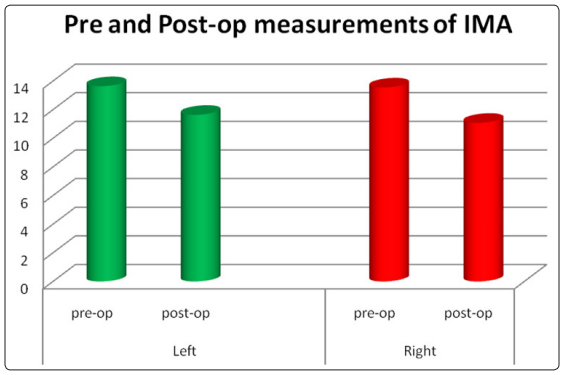

Figure 3: Results for IMA correction

Figure 4: Normal HVA patient with IP Valgus

Figure 5: Specially Designed Post-op Chevron cast

Figure 6: Specially Designed Post-op Chevron cast

Clinical Assessment

Pre-operatively each patient's gender, age, ethnicity and concurrent foot pathology (ies) were recorded. All patients underwent a detailed physical examination of the foot to include vascular status, range of motion of the ankle, subtalar, midtarsal and all metatarsophalangeal and interphalangeal joints. The pain level was assessed on direct questioning, if not volunteered, and graded as mild, moderate and severe. Post-operatively patients were assessed for completeness of removal of the bony prominence (bunion) and the success of cosmetic correction of the valgus deformity.

Radiographic Assessment

Anterior, posterior and lateral weight-bearing radiographs were obtained preoperatively and post-operatively. The IMA, HVA angular measurements were measured according to guidelines set forth by the Ad Hoc Committee of the American Orthopaedic Foot and Ankle Society on Angular Measurements with the use of digitalized imaging software called fusion e-film. A hallux valgus angle of 150 or less was considered normal. Mild hallux valgus was defined as an HVA of 200 or less. A moderate hallux valgus was defined as an HVA of 200 to 400. Severe hallux valgus was defined as an HVA of 400 or more. The normal intermetatarsal angle was

90 or less. A normal hallux interphalangeal angle is 100 or less. Retrospective radiographic measurements were measured by two well-trained individuals to avoid bias.

Surgical technique

Lying supine on the Operating Room table, under one of several different anesthetic techniques, the lower extremity was prepped with Betadine scrub followed by Proviodine solution and free draped. The extremity was exsanguinated using either an Esmarch bandage or a tourniquet on the proximal limb. A dorso-medial incision was made and deepened down through skin and subcutaneous tissues. Care was taken to preserve the dorsal artery, vein and nerve which was freed up and retracted out of harm's way laterally. A distal based flap was developed in the capsule and secured with 1 Vicryl. The proximal limb of this flap was elevated by sharp dissection and secured with 1 Vicryl. The prominent bunion was removed after crosshatching with an oscillating saw. The metatarsal head was smoothed down with rasp and rongeur.

Using a drill bit, a signal hole was made at the metatarsal neck in the area of the intended osteotomy. Using an oscillating saw, 45-degree angular cuts were developed in a 10-degree caudal-cranial direction, which effected 5 mm of lateral displacement of the head and neck. The spike of bone on the proximal fragment was removed using the oscillating saw. Copious irrigation with normal saline followed next.

The capsule was reapposed holding the toe in the corrected position with 1-0 Vicryl. At this point, either the Esmarch bandage or tourniquet was released or hemostasis was achieved with electrocautery. Subcutaneous tissues were closed using buried inverted 2-0 Vicryl. The skin was closed using a running 3-0 subcuticular Vicryl. Steri-strips were applied followed by a specially developed compression dressing maintaining the toe in the corrected position.

Statistical Methods

The student t-test was used to evaluate the difference between the pre- operative and postoperative measurements of hallux valgus and intermetatarsal angle measurements. The level of significance was set at $p < 0.05$.

Results

Two hundred and eight-five Chevron osteotomies were performed, on one hundred and seventy-eight patients with Hallux Valgus. In the study group, 89% were female and 11% were males. The average age was 44 years ± 14 (range 16 to 77), in 60% of patients Hallux Valgus was bilateral, in 21% the right foot only was affected and in 19% only the left foot (Table 1).

Table 1: Patient Demographics

Laterality	Male	Female	Total Number of patients
Left	6 (18%)	27 (82%)	33 (19%)
Right	6 (15%)	32 (85%)	38 (21%)
Bilateral	8 (7%)	99 (93%)	107 (60%

Radiographic measurements of the Hallux Valgus angle (HVA) and Intermetatarsal angle (IMA) demonstrated a statistically significant difference in pre-operative and post-operative measurements ($p < 0.05$) using the student t-test. The left HVA improved from an average of 28.36º ± 7.8º (range, 12º to 45º) to a post-operative average of 13.42º ± 5.7º (range, 3º to 25º) (Figure1). The right HVA improved from an average of 28.39º ± 7.9º (range, 11º to 37º) to a post-operative average of 13.55º ± 5.6º (range, 4º to 24º) (Figure 2). The mean correction in the HVA for the left foot was 14.94º (99.60%) compared to the mean correction of the HVA on the right foot of 14.98º (99.87%) (Table 1) The mean correction of the left foot IMA was 1.99º, from a preoperative left IMA of 13.64 ± 2.4º (range, 9º to 10º) to a postoperative average of 11.64 ± 1.8º (range, 8º to 9º). The preoperative right IMA was 13.12 ± 2.0º (range, 9º to 9º) compared to a postoperative average of 11.08 ± 1.6º (range, 7º to 9º) and the mean correction of the right foot IMA was 2.05º (Table 2, Figure 3).

Table 2: Radiographic Correction

Radiographic Parameter	Pre-op Mean		Pre-op Range		Post-op Mean		Post-op Range		Mean Correction	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Hallux Valgus Angle (HVA)	28.36	28.39	33	37	13.42	13.41	25	24	14.94 *(99.60%)	14.98 *(99.87%)
Intermetatarsal Angle (IMA)	13.64	13.13	10	9	11.64	11.08	9	9	1.99 **(22.1%)	2.05 **(22.78%)

* To determine HVA correction we divided the mean correction by 15 and multiplied by 100.
** To determine IMA correction we divided the mean correction by 9 and multiplied by 100.

While Hallux Valgus does present as an isolated condition, in more than one-half of the patients in this study (51.12%) it was associated with one or more of twenty-two other identifiable foot pathologies such as flat feet (27 patients, 15.17%), splay foot (25 patients, 14.04%), metatarsalgia (16 patients, 8.99%),claw toe (13 patients, 7.30%) and callosities (9 patents, 5.06%) (Table 4).

In 12.36% of the study group, unexpected intra-operative findings such as EHL tendon contracture, bursae, intra-osseous ganglion cysts, and osteoporosis or capital osteophytes resulted in adding to, or modifying, the standard operative procedure (Table 3).

Table 3: Intra-Operative Findings

	Intra-operative pathology	Number of Patients	Percentage (%)
1	EHL tendon contracture	7	3.93%
2	Osteoarthritis- First MTP Joint	5	2.81%
3	Bursa	3	1.69%
4	Intra-Osseous Cyst	3	1.69%
5	Degenerative changes of metatarsal neck	2	1.12%
6	Osteopenia	2	1.12%
7	Osteophyte	1	0.56%

Table 4: Co- existant Pre-Operative Pathology

	Co- existant pre-op pathology	Patients (#)	Percentage (%)
1	Flat feet	27	15.17%
2	Splay foot	25	14.04%
3	Metatarsalgia (26 feet)	16	8.99%
4	Claw toe	13	7.30%
5	Callus	9	5.06%
6	Tailor's Bunionette	7	3.93%
7	Plantar fasciitis	6	3.37%
8	Heel Spur	6	3.37%
9	Hammer toe	4	2.25%
10	Metatarsus Primus Varus	4	2.25%
11	Metatarsal boss	2	1.12%
12	Pes Cavus	1	0.56%
13	Achilles Tendinitis	1	0.56%
14	Stiff MTP	1	0.56%
15	Ankle ligament laxity	1	0.56%
16	Corn	1	0.56%
17	Subluxed/dislocated second toe MTP	1	0.56%
18	Valgus 2nd Toe	1	0.56%
19	Morton's neuroma first web space	1	0.56%
20	Subungual hematoma	1	0.56%
21	Varus 2nd Toe	1	0.56%
22	Marfenoid Spindly foot	1	0.56%

One hundred and ten patients had the procedure performed under General Anaesthesia, 10 under Spinal Anaesthesia, 9 with Popliteal block, 41 with an Ankle block and 8 patients, four of whose ankle blocks failed, had both an Ankle block and General Anaesthesia (Table 5).

Table 5: Method of Anaesthesia

Type of Anaesthesia	Total Number of Patients
General	110
Spinal	10
Popliteal Block	9
Ankle Block	41
General and Ankle	8 (4 failed ankle blocks converted to general anaesthesia)

Among the two hundred and eight five Chevron osteotomies performed, the early complication rate was 16.84% compared to a late complication rate of 21.05% (Table 6). The majority of the early complications were due to minor wound problems (24) and swelling (16) while the majority of late complications were caused by Keloids (16) and Metatarsalgia (13) respectively (Table 6) [1]. In contrast to other series fortunately no patient developed post –operative avascular necrosis of the metatarsal head or non-union at the osteotomy site. The recurrence rate for Hallux Valgus was 0.70% (2 feet).

Table 6: Complications of Operative Procedure

Complications	Early	Late
Swelling	16	5
Numbness 2º ankle block	1	0
Minor wound problem	24	9
Osteotomy displacement	2	0
EHL tendon contracture	1	6
Recurrence Hallux Valgus	1	2
Prolonged nausea and vomiting (Post-Anaesthesia)	1	0
Plantar fasciitis	1	0
Varus Overcorrection	1	0
Keloid	0	16
Metatarsalgia (1^{st}, 2^{nd}, 3^{rd} metatarsal heads)	0	13
Metatarsophalangeal joint stiffness	0	5
Metatarsophalangeal joint spur	0	1
Numbness Great Toe	0	1
March fracture (2^{nd} metatarsal)	0	1
Osteoarthritis metatarsophalangeal joint	0	1
TOTAL	48	60
PERCENTAGE	16.84%	21.05%

Discussion

Like other authors, in the study a screw or Kirschner wire was not used to fix the osteotomy [1, 2]. The shape of the V-osteotomy, impaction of the first metatarsal head and soft tissue balancing of the capsular flap provides stability after the osteotomy. In this study it was not necessary to use a lateral soft tissue release in conjunction with Chevron osteotomies since the complications of metatarsal-phalangeal joint stiffness, digital neuritis and cosmetic dissatisfaction with the scar were felt to outweigh any purported benefits [1].

While some authors advocate waiting three months before doing the second foot, in this study, patients with bilateral hallux valgus, in the absence of a compelling rationale underwent bilateral Chevron osteotomies during the same operation [1].

Previous studies have concluded that measurements of the Hallux Valgus and intermetatarsal angles are often not substantially changed following first distal metatarsal osteotomies [3, 4]. The results of this study corroborate the opinion that the intermetatarsal angle is not often substantially changed by Chevron Osteotomy (Figure 3). This study, in contrast however, concludes that a statistically significant reduction in HVA can be routinely achieved (Figures 1 & 2). The key factors in reducing the HVA are lateral displacement of the neck and head by 5 mm and resuturing the capsular flaps with ideal soft tissue tension while maintaining the toe in the corrected position (Figures 7 & 8).

Figure 7: Pre-op x-ray, note large HVA

Figure 8: Post-op Chevron osteotomy, note marked improvement in HVA

Like other series, patients in this study were universally satisfied (99.30%) if the surgery resulted in complete removal of the bony prominence (bunion) and cosmetic correction of the abnormal Hallux Valgus angle [5].

A successful surgical correction can be guaranteed when four simple intra-operative rules of thumb are followed: 1) precise bone cuts 2) 5 mm lateral displacement of the head and neck 3) good impaction at the osteotomy site and 4) correct soft tissue tensioning, while maintaining the toe in the corrected position when reapposing the capsular flaps. Avascular necrosis of the metatarsal head reported to vary from 0° to 20° can be avoided by making the apex of the osteotomy cut at the junction of the metatarsal head and neck and not more distal [1].

To guarantee an overall excellent result, an excellent operative correction must be complimented by ongoing exceptional post-operative care. At this Institution, the standard post-op protocol includes use of a specially designed dressing of 4-8 gauze and Kling bandage applied in the Operating Room to be used with a Darko shoe until the cast is applied (Figures 9, 10 & 11). All patients were in receipt of IV administered broad-spectrum antibiotics in the operating room, which they continued orally for 5 days post-operatively. Specially designed full weight-bearing fiberglass casts were applied when the initial swelling subsided, usually at between 2 and 5 days post-op, and were worn for a total of 6 weeks (Figures 5 & 6). When the cast was removed, a toe spacer in the first web space was worn in shoes for an additional 6 weeks until the scheduled 3-month post-op visit. Routine follow-up was not scheduled longer than 3 months post-op.

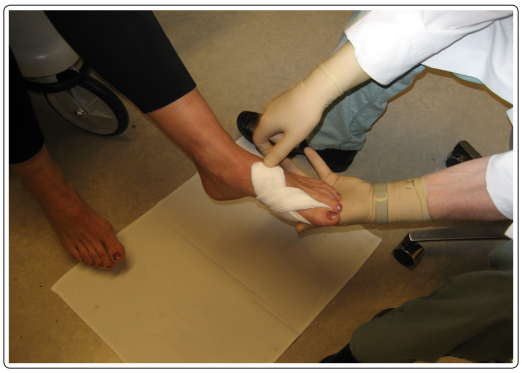

Figure 9: Immediate post-op dressing with 4x8 gauze

Figure 10: Stage 2

Figure 11: Completed dressing

The high incidence of Keloids in this study was reflective of increased risk in the study population. The development of post-operative second and third metatarsalgia has been associated with dorsal angulation or dorsal displacement of the metatarsal head and can be limited intra-operatively by attention to this detail. In this study, patients with pre-operative metatarsalgia were rendered more symptomatic and should be warned before surgery.

Studies of sex differences and ethnic prevalence have elucidated factors contributing to the development of Hallux Valgus. In women a lower BMI, high-heel use between the ages of 20 and 64, non-manual work (4), increased adduction of the first metatarsal and abduction of the hallux in the female compared with the male foot(12) predispose to the development of Hallux valgus. In the literature in males, hallux valgus was associated with a higher BMI and pes planus [6]. In this study, 25% of males with Hallux valgus had associated flat feet compared with 15.17% for the general population [7]. In the United States J.E. Dunn et al found that bunions and pes planus were most frequent in African Americans followed by non-Hispanic whites and finally Puerto Ricans. N.H. Cho studied the incidence in a Korean population [8]. The present study differs from others, reflecting the multicultural referral base of the senior author in addition to subtle Canadian nuances. The largest ethnic groups represented were Hispanic and non-Hispanic whites followed by Blacks and South Asians. In contrast to American incidence studies, blacks in this study were new immigrants from Africa or the Caribbean and the Hispanic whites hailed from Spain, Portugal, Central and South America and not the Caribbean. Fifty percent of the 22 East Asians in this study were Korean.

A positive family history was reported in 83% of patients by Coughlin, 63% by Hardy and Clapham, 58% by C. Leslie Mitchell and 19.1% in this study [9]. A literature review highlighted the universally increased incidence of female involvement [6-12]. While some authors implicate maternal transmission others maintain that it is autosomal dominant (McElvenny 1964), or autosomal dominant with incomplete penetrance [9, 10, 13]. In all, four methods of transmission for Hallux Valgus have been postulated 1) X-linked 2) autosomal dominant 3) autosomal dominant with incomplete penetrance and 4) polygenic transmission.

Further research studies are required to validate which of the above four methods of transmission best applies and whether shoe wear contributes primarily or secondarily to the development of Hallux Valgus. The physiologic effects of wearing shoes and alternatively the consequences of walking barefoot on the shape of feet has been known since antiquity. Approximately 1700 years ago, an unidentified young man approached Hillel the Elder and questioned him why it is that Africans have flat feet. Off the cuff, Hillel answered that it is because Africans dwell alongside ponds and river banks. The Medieval Biblical scholar and commentator Rabbi Shlomo bar Yitzchak (Rashi, b. 1040-1105) expounds on Hillel's answer noting that flatfeet prevents drowning (a prerequisite for all riverbank dwellers) and that since a foot assumes the shape of the shoe, the feet of those individuals such as Africans who do not wear shoes-widen and become flat [14-16]. In addition to genetic predisposition and shoe wear, other series have discussed conflicting notions about the contribution to Hallux Valgus from occupation and pes planus, both of which merit further study [8, 9].

Conclusion

Despite minor and largely reversible post-operative complications, this study demonstrates that with distal Chevron osteotomy excellent radiographic and cosmetic correction of the deformity was achieved with a high level (99.30%) of patient satisfaction. Patients should be advised pre-operatively about their risk for developing Keloids 5.61%, transfer metatarsalgia 4.56% and recurrence 0.70% when treated by Chevron osteotomy. While more than, 80 operations have been described for the surgical treatment of symptomatic Hallux Valgus the treating Orthopaedic Surgeon should familiarize himself/herself with one procedure and perfect the technique to the best of their ability to optimize postoperative results for the benefit of their patients. The three most important guarantors of a satisfactory result are: 1) careful patient selection, 2) close attention to operative technique and 3) fastidious postoperative management.

Level of Evidence

This was a level IV evidence retrospective case series study undertaken without a comparative randomly assigned cohort.

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