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Radiological results of Johnson's modified chevron osteotomy to address hallux valgus

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Purpose. The purpose of this study was to assess the radiological results obtained further to chevron osteotomy of the first metatarsal for the treatment of hallux valgus.

Materials and methods. The sample consists of 24 consecutive patients (27 feet) of whom 21 were female and 3 male, with a mean age of 44.4 years. In all cases weight-bearing radiographs were made on which the following angles were measured both preoperatively and at the end of follow-up: metatarsal-phalangeal (MTP), intermetatarsal (M1-M2), the M1-M5 angle and the distal metatarsal articular angle (DMAA). Likewise, the relative length of the first metatarsal and the position of the sesamoid bones were measured by means of standardized methods.

Results. There were not any significant complications. Average follow-up was 3 months (range: 6-50). The procedure managed to improve all angles considerably ($p=0.01$). Shortening of the first metatarsal was 0.018 (1.8%). As regards sesamoid displacement, a substantial improvement was obtained vis-à-vis the preoperative situation, with 96.2% of results in the G-0 and G-1 range (displacement 0%-50%).

Conclusions. Chevron osteotomy has shown to be an effective method to correct hallux valgus-associated angle deformities in the mid-moderate range, including DMAA angle, which a minimal shortening of the first metatarsal.

Resultados radiológicos de la osteotomía en chevron modificada por Johnson para la corrección del hallux valgus

Objetivo. El propósito del presente estudio fue valorar los resultados radiológicos tras la osteotomía en chevron del primer metatarsiano para el tratamiento del hallux valgus.

Material y método. La muestra consta de 24 pacientes consecutivos (27 pies) de los que 21 fueron mujeres y 3 varones, con una edad media de 44,4 años. En todos los casos se realizaron radiografías en carga donde se midieron preoperatoriamente y al final del seguimiento los siguientes ángulos: metatarsofalángico (MTF), intermetatarsiano (M1-M2), de apertura del antepié (M1-M5) y articular metatarsal distal (DMAA). Asimismo, se midieron las longitudes relativas del primer metatarsiano y la posición de los sesamoideos todo ello mediante métodos estandarizados.

Resultados. No hubo complicaciones de interés. El seguimiento medio fue de 23 meses (6 a 50). Con la intervención se mejoraron todos los ángulos de manera significativa ($p = 0,01$). El acortamiento del primer metatarsiano fue de 0,018 (1,8%). En cuanto al desplazamiento de los sesamoideos se consiguió una mejoría en la posición postoperatoria de los mismos con un 96,2% de resultados G-0 y G-1 (desplazamiento 0%-50%).

Conclusiones. La osteotomía en chevron se ha mostrado eficaz para corregir las deformidades angulares asociadas al hallux valgus leve-moderado, incluido el DMAA, con un acortamiento mínimo del primer metatarsiano.

Key words: hallux valgus, chevron osteotomy.

Palabras clave: hallux valgus, osteotomía en chevron.

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Chevron osteotomy is currently one of the distal osteotomies of the first metatarsal that is most widely used for the treatment of hallux valgus¹. Surgeons use either the original technique or one of its modified versions^{2,3}.

The purpose of the procedure is to correct anatomic and mechanical alterations of the first metatarsal. This means

that it is indicated on the basis of a preliminary study of the deformity, carried out by measuring certain parameters⁴⁻⁶ such as the metatarsophalangeal (MTP) or hallux valgus angle, the intermetatarsal angle (M1-M2) and the distal metatarsal articular angle (DMAA).

In order to compare results across the different series, one must use similar methods, which has led some authors^{2,7,8} to propose standardizing the radiological technique and the ways to measure the different angles in order to be able to evaluate the efficacy of surgical treatment by post-operatively changing the values of the above mentioned angles.

The purpose of the present paper was to analyze the degree of radiological correction obtained in cases of hallux valgus as a result of the use of a chevron osteotomy, as well as to assess the degree to which the length of the first metatarsal is affected when this technique is used.

MATERIALS AND METHODS

Between January 2000 and January 2004 a total of 92 underwent an osteotomy in our hospital for painful hallux valgus. Out of these, 32 were subjected to a chevron osteotomy. The criteria for indicating this procedure were pre-operative MTP and M1-M2 angles smaller than 35° and 15° respectively^{2,3}.

8 patients were excluded from the study because they had associated osteotomies on other metatarsals. This means that the valid sample was 24 patients (27 feet), of whom 21 were female (87.5%) and 3 male (12.5%), with a mean age of 44.4 years (range: 13-69). None of the patients presented with an associate rheumatic or neurological pathology.

The surgical technique used was Johnson's modified chevron osteotomy^{1,3}, where the lower arm is horizontal, parallel to the sole of the foot, and the upper arm extends dorsally from the apex of the V, both arms forming an angle of 75°-80°. When the DMAA angle was larger than 15° a biplanar osteotomy was performed⁹. Fixation was achieved through a double-thread compression screw. In all cases, an Akin/shortening osteotomy of the proximal phalanx was carried out.

An assessment was made of the preoperative radiographs and of those taken at the last postoperative examination. These were obtained using standardized techniques^{2,7} and a focal distance of 1 m; they were centered on the mediotarsal joint and displayed an AP weight-bearing 15-degree cephalic tilt view of both feet and a weight-bearing lateral view of the involved foot.

Pre- and postoperatively the measurements of the MTP, M1-M2 and M1-M5 (forefoot spread) angles were taken by means of the «center of the head» method^{10,11}, whereby a line is drawn from the center of the head to the center of the



Figure 1. «Center of the head» method. Pre- and post-operative measurements were taken of the metatarsophalangeal (MTP), intermetatarsal (M1-M2) and forefoot spread (M1-M5) angles by means of the «center of the head» method, drawing a line from the center of the head to the base of the first metatarsal.

first metatarsal base (fig. 1). DMAA was determined by using the Rush & Banks method¹¹, considering the angle formed by the convergence of the joint line and the perpendicular line to the mechanical axis of the first metatarsal (Figure 2)..

The length of the first metatarsal was assessed according to the Hardy & Clapham method¹¹, which establishes this value by comparing it with the length of the second metatarsal (M1/M2). In this way any errors derived from possible radiological magnifications are eliminated (Figure 3).

The position of the sesamoids was determined by means of the method recommended by the American Orthopaedic Foot and Ankle Society^{5,11}, which describes the position of the medial sesamoid in relation to the bisector of the first metatarsal. According to this, grade 0 indicates no displacement, grade 1 indicates a lateral displacement of less than 50%, in grade 2 lateral displacement is over 50% and in grade 3 lateral displacement is complete.

For the statistical analysis of the results the SPSS statistical software was used. For mean values, a confidence interval of 95% was considered. In order to compare results, a



Figure 2. Rush & Banks method. Measurement of the distal metatarsal articular angle, i.e. the angle formed by the convergence of the joint line and the perpendicular line to the mechanical axis of the first metatarsal. DMAA: distal metatarsal articular angle.

paired Student's t-test was used. A value of $p < 0.05$ was considered significant.

RESULTS

Mean postoperative follow-up was 23 months (range: 6-50). The results of the radiological measurements per-



Figure 3. Method used for the assessment of first metatarsal relative length. TS: Taloscaphoid joint. CC: Calcaneocuboid joint. M1: Length of the first metatarsal (in mm). M2: Length of the second metatarsal (in mm).

formed are reflected in Table 1. Significant differences were found between the pre- and post-operative condition ($p < 0.001$) in all measurements.

An improvement was observed in all angles measured, with a mean postoperative reduction of 21.5° for MTP, 5.1° for M1-M2, 6.4° for M1-M5 and 8.4° for DMAA.

There was a significant pre-/post-operative variation in the relative length (Table 1) of the first metatarsal ($p <$

Table 1. Radiological results

Angle	Preoperative	Postoperative	p
MTP	31.8° (29.3-34.2)	9.8° (7.7-11.9)	0.001
M1-M2	12.9° (12.4-13.5)	8° (7.2-8.7)	0.001
M1-M5	28.3° (26.6-30.0)	22.1° (20.3-23.8)	0.001
DMAA	15.7° (13.9-17.5)	7.6° (6.1-9.0)	0.001
M1/M2	0.99 (0.99-1.00)	0.97 (0.97-0.98)	0.001

Mean values (CI 95%). Metatarsophalangeal (MTP), intermetatarsal (M1-M2), forefoot spread (M1-M5), distal metatarsal articular (DMAA) angles, first/second metatarsal length ratio (M1/M2).

Table 2. Position of the sesamoids

	Preoperative	Postoperative
G-0	1	8
G-1	5	18
G-2	15	1
G-3	6	0
No. of cases	27	27

Grade 0: No displacement.

Grade 1: Lateral displacement < 50%.

Grade 2: Lateral displacement > 50%.

Grade 3: Complete lateral displacement.

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0.001) and, on the basis of Hardy & Clapham's calculations¹¹, ultimate mean relative shortening of the first metatarsal was only 1.8% of its length.

Positional variations of the sesamoids (Table 2) were significant with $p < 0.001$. Preoperatively there were 21 cases (77.3%) with noticeable lateral displacement (G-2 and G-3) and only one G-2 case (3.8) postoperatively.

DISCUSSION

Distal osteotomies of the first metatarsal, such as the chevron osteotomy, are widely accepted for the treatment of mild-moderate hallux valgus, with the most widely accepted limits being a MTP angle smaller than 30°-35° and a M1-M2 angle under 15°^{1,3,12,13}, although some authors have extended this range¹⁴. In cases of mild-moderate hallux valgus with an increased DMAA a Scarf diaphyseal osteotomies is indicated⁶.

The objective result of hallux valgus surgery can be assessed on the basis of the reduction of the MTF, M1-M2 and DMAA angles, since on the basis of that criterion we can compare our outcomes with those of other authors or study groups. However, it should be noted that the method used to take the measurements should be as consistent as possible, which is not always the case^{2,4,7,8}. If we review the literature, we will find numerous publications describing different reproducible measuring methodologies that can help us improve the accuracy of our measurements and minimize errors^{4,7,8,10,15,16}.

In order to measure the MTP and M1-M2 angles, especially in the case of distal and diaphyseal osteotomies, we favor the «center of the head» method, as described by Miller in 1974^{10,11}, since as shown by Schneider¹⁰ it is the most precise way of obtaining those values. The radiological results obtained in our series are similar to those published by Nery⁹, Kernozek¹² and Trnka¹³ and slightly higher than those obtained in other series^{2,17}. In our series we achieved a better correction of the MTP angle (25.5° on average), which we attribute to two factors: on the one hand, to the associated phalangeal osteotomy³, and on the other, to the lateral release that we performed in all cases. We recommend that these manoeuvres be carried out in cases of moderate hallux valgus, together with pulling back the external capsule and a laterally displacing the sesamoids. The fact that the value of this specific angle was not statistically significant is attributed to the wide variability across the different cases, where on occasion the correction achieved was far greater than expected and hence no linear correlation was obtained.

Chevron osteotomy reduces the M1-M2 angle since it laterally displaces the head over the diaphysis¹. The 1 mm displacement provides a 1° correction of the M1-M2 angle, although it should not go beyond 50% of the width of the

metatarsal because this would lead to decreased stability. For this reason we recommend a displacement of 6 mm displacement for males and 5 mm for females^{18,19}. An increased DMAA can be reduced by using a biplanar osteotomy⁹, performed in three of our cases with good results. In our experience, when DMAA is smaller than 15° it can be appropriately corrected by medial impaction of the head, which contains cancellous tissue. In our series we obtained a mean correction of 8.4° - a very satisfactory value, which is in line with those reported in other publications^{2,9}. Our good results are attributable to the fact that the need for DMAA correction was taken into account in the preoperative planning and hence the actual surgical correction could be achieved with a minimum modification of the technique⁹.

Cases of first metatarsal shortening were negligible in our series. We found a 1.8% loss of length with respect to the pre-op situation. In order to avoid this problem, and thereby prevent transfer metatarsalgia, we recommend using a cutting saw no thicker than 1 mm. Also, the osteotomy cuts should be parallel or slightly distal to the third metatarsal.

To conclude, we can say that the results of the present study show that chevron osteotomy can correct angular deformities associated to mild-to-moderate hallux valgus, including DMAA without provoking a substantial shortening of the first metatarsal.

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