



The risk of avascular necrosis following chevron osteotomy : A prospective study using bone scintigraphy

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Controversy exists with regard to the effects of chevron osteotomy on blood supply and subsequent development of avascular necrosis (AVN) of the first metatarsal head. The aim of this study was to assess the incidence of avascular necrosis in our centre following chevron osteotomy for hallux valgus, using bone scintigraphy.

Thirty nine patients who had a chevron osteotomy for treatment of hallux valgus were prospectively studied. Mean follow-up was 14 months. Bone scintigraphy was used to assess metatarsal head perfusion at an average 8.5 weeks post operatively.

Three patients (7.7%) showed abnormal bone scan around the metatarsal head. Further evaluation of these patients did not show any sign of AVN. We conclude there appears to be a risk of circulatory disturbance to the metatarsal head following chevron osteotomy of the first metatarsal (7.7% in this study); however this does not translate into clinically significant AVN.

Key words : chevron osteotomy ; hallux valgus ; circulatory disturbance ; bone scintigraphy.

INTRODUCTION

Hallux valgus is the commonest deformity in the forefoot region (10) ; when it requires surgical correction, this may include distal osteotomy of the first metatarsal bone and possibly distal soft tissue release. Although various osteotomies are performed, the chevron osteotomy is probably the most

popular procedure used in the correction of this deformity (1,5). It is indicated in symptomatic hallux valgus with an intermetatarsal angle of less than 15° and a hallux valgus angle of less than 30° (3,13). The chevron osteotomy disrupts the intraosseous blood supply to the metatarsal head. If a lateral capsular release is also carried out, this further endangers the extraosseous blood supply to the metatarsal head (1,2,4). For this reason, avascular necrosis is a

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common complication described after this procedure. However literature is divided over the prevalence of this risk : the incidence has reportedly ranged from 0% to as high as 40% (6,7,9).

Although several studies have been performed retrospectively to assess AVN rates following chevron osteotomy (5-8), looking at clinical and radiographic findings, only few have prospectively used bone scintigraphy to look at the circulatory disturbance leading to AVN (9).

The aim of this study was to prospectively assess the incidence of AVN following chevron osteotomy in the treatment of hallux valgus at our centre. The outcome was assessed in terms of patient satisfaction with the procedure, and by the use of bone scintigraphy to look for circulatory disturbances which might indicate AVN.

PATIENTS AND METHODS

In this prospective study, 39 consecutive patients were treated for hallux valgus using the chevron osteotomy. All procedures were carried out by the senior author (GA) using a standard surgical technique as detailed below. Follow-up was at 4 weeks, 3 months and 12 months post operatively for clinical and radiographic evaluation. In addition each patient underwent a 3-phase technetium bone scan 6 weeks post operatively, as earlier scans showing reduced or absent perfusion can later show reperfusion and healing. The patients also answered a satisfaction questionnaire looking at post-operative pain relief at rest and whilst walking.

Operative technique

The procedure was carried out under general anaesthesia with an ankle tourniquet, using a medial incision through the skin and capsule. Dorsal and plantar capsular stripping was kept to a minimum. A medial exostectomy followed by a standard chevron osteotomy was performed. The head was displaced between one third and half the width, depending on the extent of the deformity. The osteotomy was held using a 1.25 mm Kirschner wire. The foot was then placed in a standard hallux bandage. Post operatively heel weight bearing was allowed in a forefoot protecting surgical shoe. At 4 weeks post operatively, the K wire was removed in outpatient clinic prior to the scan.

RESULTS

The mean age of the patients was 47.38 years (range : 22-75) ; the male : female ratio was 31:8.

The mean follow-up time was 14 months (range : 7-33).

The mean bone scan time was 8.5 weeks (range : 6-12 weeks).

Pain : On the visual analogue scale, mean pre-operative pain was 7.75 and post operative pain was 1.45.

Bone scan results : 92.3% (36 patients) had a negative bone scan, suggesting adequate post-operative blood supply to the region ; 7.7% (3 patients) were reported as having a risk of AVN. The bone scan in these patients showed reduced uptake indicating reduced blood supply to the region hence a risk of AVN. The uptake in these patients was however not completely absent, as this would have indicated that the blood supply was interrupted, and a definite diagnosis of AVN would have been made.

None of the patients were symptomatic at the last follow-up visit, and this included the 7.7% of patients who had a risk of AVN, based on the scintigraphy findings. These three patients whose bone scans suggested a risk of AVN reported no evidence of pain at rest or on walking at the last follow-up appointment. The radiographs at follow-up in all these patients showed good bony union with no evidence of AVN. Figure 1 show the pre-operative radiographs of the right foot in one of the patients who was shown to be at risk of AVN on the bone scan post operatively. Figure 2 shows the post operative radiograph of the same patient at 6 months post operatively. This patient had no symptoms suggestive of AVN at final follow-up.

DISCUSSION

The Chevron osteotomy is one of the procedures most commonly performed for hallux valgus correction ; it has known complications : intra operative fractures, non-union, transfer metatarsalgia, failure of the procedure and AVN amongst others (3,4,13).

Any study looking at the risk of AVN following chevron osteotomy needs to take into account the understanding of the vascular anatomy to this



Fig. 1. — Pre-operative radiographs of right foot



Fig. 2. — Radiograph of right foot at 6 month follow-up showing good bony healing. This patient was found to be at risk for AVN on the bone scan, but had no clinical symptoms at final follow-up.

region. The blood supply to the 1st metatarsal head has been well studied (3,14). Shereff *et al* studied the vascular anatomy to this region in cadaveric specimens using vascular injection techniques (11).

The first metatarsal head has an extraosseous and an intraosseous blood supply.

The extraosseous blood supply is from three main branches – the first dorsal metatarsal artery, the first plantar metatarsal artery and the superficial branch of the medial plantar artery (1,2,11). The first dorsal metatarsal artery principally supplies the dorsal and lateral aspects of the metatarsal head (2,11). The plantar cruciate anastomosis is believed to be formed by the first plantar metatarsal artery and the medial plantar artery according to Shereff *et al* (11). However Jones *et al* believe it is formed by an anastomosis of the first dorsal metatarsal artery and the medial plantar (3). This plantar cruciate anastomosis is believed to supply the medial and lateral plantar aspects of the metatarsal head (1). Overall the dorsolateral part of the metatarsal head has a more extensive blood supply than the plantar aspect (11).

The intraosseous blood supply has three principal sources – the periosteal capillary system, the metaphyseal – capital vessels and the principal nutrient artery (1). The nutrient artery may enter the

shaft at the junction of the middle and distal third (11) or the proximal and middle thirds (3).

The chevron osteotomy potentially can give rise to AVN by disrupting the intraosseous blood supply to the metatarsal head; the extraosseous blood supply being the only source of perfusion to this region may be further put to risk by making the subcapital osteotomy cut intracapsularly, excessive lateral penetration of the saw or displacement of the head may cause injury to the first dorsal metatarsal artery. All the above were noted by Jones *et al* when they used latex injection and a modified Spalteholz technique in cadaveric specimens to demonstrate the effect of chevron osteotomy on the vascular supply to the metatarsal head. They however found that if the osteotomy was performed correctly, then the vascular supply (intraosseous and extraosseous) was well preserved (3).

An interesting study done by Kuhn *et al* (4) looked at the vascular insult to the metatarsal head using a laser Doppler flowmeter intraoperatively during the various steps of a chevron osteotomy with adductor tenotomy and lateral release. They found the greatest vascular insult occurring during the medial capsulotomy, with a decrease in blood flow of 45% at this stage. The addition of adductor release was associated with 13% further decrease,

and the chevron osteotomy with a 13% further reduction in blood flow. The total reduction in blood flow was 71% below baseline recordings when all these procedures were combined. Interestingly none of these patients had any evidence of AVN at follow-up, suggesting that the insult the metatarsal head suffers during this procedure is reversible. This study however did suggest that bone scintigraphy could have been used to assess AVN, which may not have been picked up on radiographs. Our study had all the above procedures performed in the patients, and bone scintigraphy done at follow-up showed a positive risk of AVN in 7.7% of patients, none of which were symptomatic at follow-up.

AVN is necrosis of the metatarsal head resulting from sustained vascular insult, but this radiographic finding may not necessarily lead to clinical symptoms (1,9). It can manifest as pain, swelling, erythema, transfer metatarsalgia and pain on range of movement (1,2). Typical radiographic findings include crescent shaped subchondral lucencies, cysts, bony collapse, fragmentation and joint space narrowing (2,9,12). According to the classification by Mier *et al* of AVN on radiographic findings – Stage I (precollapse), Stage II (collapse) and III (arthritis), the precollapse stage will initially show a cold bone scan although radiodensity is normal, and in the later part of the precollapse show up as ‘hot’ when the osteotomy has healed (6). Bone scintigraphy is hence a much more sensitive investigation of AVN than plain radiographs (9).

Mier *et al* have reported an AVN rate of 20% (12 out of 60 feet) with chevron osteotomy alone, rising to as high as 40% (4 out of 10) when combined with lateral adductor release, but this was in a series with only 36% follow-up (50/138 patients), and a mix of chevron and Mitchell osteotomies. They concluded that the combination of the two procedures is contraindicated (6). Other studies have refuted the claim that chevron osteotomy with lateral release can result in AVN (12). Several studies have shown minimal AVN rates clinically and radiographically following a chevron osteotomy – from 0% (4,5,14) to 2% (8).

The only other study which we were able to find in literature, in which bone scans were used to

assess AVN was by Resch *et al* (9). In this prospective study of 41 osteotomies, scans done 2-9 days post operatively showed abnormal radioisotope uptake in four (cold scans), whilst all the other feet showed increased activity of the foot as a whole. However repeat scans of these feet showed increased activity at the 2-4 week stage. These patients more importantly had no clinical symptoms or radiographic changes of AVN at final follow-up. The authors concluded that chevron osteotomy associated with lateral release is a reliable procedure with minimal risk to the blood supply. Our patients had scans done 6 weeks after operation, when post operative healing is expected to be taking place, and this showed a 7.7% risk of AVN in our patient population ; despite this all of our patients were asymptomatic at their last follow-up visit, and radiographs did not show any anomalies suggesting AVN. Hence we concluded to a 0% rate of AVN in our patient population, which is in keeping with studies by Mann and Peterson (5,8). If we had repeated the bone scans in those 7.7% of patients who showed a risk of AVN initially, the scans might have showed increased activity at a later date. The drawback in our study is that we did not perform repeat scans in those patients with abnormal early bone scans, but despite that we can confidently conclude that these patients did not have AVN as they did not have any clinical or radiological evidence at their last follow-up visit.

Careful operative technique with minimal capsular stripping, preservation of the metatarsophalangeal joint capsule and careful use of the power saw, helps keep the risk of AVN to a minimum (3,4,7).

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