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Increased recurrence in Scarf osteotomy for mild & moderate hallux valgus with Meary's line disruption

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ABSTRACT

Background: Scarf osteotomy for hallux valgus is a successful procedure. Neverthless recurrence of deformity is reported as 5–8%. First ray instability is a recognised risk factor for recurrence. We investigate whether a radiographic marker such as Meary's line can be used to predict recurrence.
This paper aims to test the null hypothesis that there is no difference in recurrence for mild and moderate hallux valgus treated with Scarf osteotomy in the presence of a disrupted Meary's line compared to an intact line.
Methods: At a minimum of 3 months follow up we retrospectively analysed radiographs, theatre and clinic notes of 74 (n = 74) consecutive patients treated with Scarf osteotomy for mild and moderate hallux valgus at a single centre. The patients were divided into Group A (n = 30) — patients who on pre-operative weight bearing radiographs had a disrupted Meary's line, and Group B (n = 44) — those with a normal Meary's line on pre-operative weight bearing radiographs.
Results: Our results demonstrate statistically significant five times higher odds of recurrence in Group A compared to Group B with an odds ratio of 5.2 $p = 0.006$ [95% CI 1.6–17]. On this basis we reject the Null hypothesis.
Conclusion: In this paper, we link a disrupted Meary's line with risk of recurrence of deformity. We demonstrate that, when Scarf osteotomy is used to correct mild and moderate hallux valgus in the presence of a broken Meary's line, the odds of recurrence as compared to the same procedure being performed with an intact line are 5.2 times higher.
Alternative corrective techniques such as the Lapidus procedure warrant further investigation for the treatment of mild and moderate hallux valgus in the presence of Meary's line disruption.

1. Introduction

Accepted treatment for mild and moderate hallux valgus – defined by inter-metatarsal angles (IMA) of >10 –13° and >13–20° respectively – is with Scarf osteotomy.

It is uncontroversial that there is an association between hypermobility of the 1st ray and hallux valgus. It is ofcourse possible to have hallux valgus without hympermobility and to have hypermoblity without hallux valgus. Nevertheless, when hallux valgus is present together with 1st ray hypermobility, the controversy lies in whether the hypermobility causes hallux valgus or vice versa.

The Lapidus hypothesis introduced in the 1930s [1] proposed that hallux valgus is due to first ray insufficiency and on this basis proposed the rationale of 1st TMTJ fusion in deformity correction. At the opposite end of the spectrum [2,3] evidence has been presented to suggest that hallux valgus is the cause of first ray instability rather than being a consequence of it. This cause and effect debate continues to the present day.

Our goal was to test the null hypothesis: That there is no difference in recurrence rates between mild & moderate hallux valgus associated with a disrupted Meary's line treated by Scarf osteotomy compared to an intact line.

2. Materials and methods

2.1. Study structure

Retrospective analysis of radiographs, theatre and clinical notes was performed on all consecutive patients treated with Scarf osteotomy for mild and moderate hallux valgus over a 12 months period in a single centre. The surgery being performed under the lead of three Consultant foot and ankle surgeons. The above inclusion criteria gave us 96 (n = 96) patients. 22 patients were

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excluded due to incomplete data in the categories being analysed. 74 patients remained (n = 74) with a median age of 55.5 years. Three patients were male and 71 female. The patients were divided into Group A (n = 30) — patients who on pre-operative weight bearing radiographs had a disrupted Meary's line, and Group B (n = 44), the control group — those with a normal Meary's line on pre-operative weight bearing radiographs.

Meary's line disruption was defined as four degrees or greater (≥4°) apex superior or inferior and measured at the tarso-metatarsal joint (TMTJ) or talo-navicular joint. For the purposes of our study we arbitrarily defined medial column instability as ≥4° Meary's line disruption on weight bearing radiographs [Meary's angle is subtended by a line drawn through the longitudinal centre of the talus and a line through the centre of the first metatarsal]. This was on the basis that on weight bearing foot radiographs, a normal Mearys's angle is conventionally accepted to be 0° to ±4°. It is uncontroversial that a ≥4° apex superior or inferior deviation is defined as representing a cavus and planus foot deformity respectively. Additionally, it was our opinion that a 4° angular difference would be reproducibly observed using modern radiographic software and angular measuring tools.

For each of the two groups, the IMA was quantified by an independent observer to the surgeons with radiographic software [Centricity™] before surgery, immediately post operatively and at ≥3 month follow up. Recurrence was defined as an IMA >10°.

The revision rate, degree of IMA correction achieved and documented complications in both groups were also studied.

2.2. Outcome measures

Primary outcome measure — recurrence rate of hallux valgus at 3 months minimum follow up. In this paper recurrence was defined as an IMA >10°.

Secondary outcome measure — revision.

Tertiary outcome measure — before & after degree of IMA correction achieved.

Quaternary outcome measure — complications.

2.3. Statistics

We used parametric univariate logistic regression to assess the association between Meary's angle disruption and recurrence of hallux valgus in five separate scenarios accounting for confounding variables in isolation and in combination. The results are expressed as odds ratios with p values and their 95% Confidence intervals.

1. In the univariate logistic regression model below shown in Table 1, the association between a disrupted Meary's angle and a recurrence of hallux valgus is tested without adjusting for confounding variables.

The odds ratio of 5.2 demonstrates a relationship between the two variables. Essentially, patients with a disrupted Meary's angle (MAng) have 5.2 times higher odds of recurrence than the baseline in those without a disrupted MAng.

This is a statistically significant result due to the p-value, which is <0.05. Of note, there is a wide confidence interval, which indicates some uncertainty as to where the true result lies. Despite this it appears to be a positive result either way.

Table 1
Association between a disrupted Meary's angle and hallux valgus recurrence without adjusting for confounding variables

Recurrence of hallux valgus	OR	95% CI	*p*-Value
Disrupted Meary's angle	5.2	1.6–17.0	0.006

Table 2
Association between pre-operative intermetatarsal angle (IMA) and hallux valgus recurrence without adjusting for confounding variables

Recurrence of hallux valgus	OR	95% CI	*p*-Value
Pre-op intermetatarsal angle	1.55	1.22–1.96	0.000

2. In the univariate logistic regression model below shown in Table 2, the association between pre-operative intermetatarsal angle (IMA) and a recurrence of hallux valgus is tested.

The odds ratio of 1.55 demonstrates a positive association between the two variables. Specifically, every 1° increase in pre-op IMA is associated with recurrence by a factor of 55% more than the baseline "model patient" with no discrepancy in their IMA.

This is a statistically significant result due to the p-value, which is <0.05. Of note, there is a narrow confidence interval, which indicates a good level of certainty that this is where the true result lies.

3. In the age and gender-adjusted univariate logistic regression model below shown in Table 3, the association between a disrupted Meary's angle and a recurrence of hallux valgus is tested.

The odds ratio of 6.40 demonstrates a positive association that remains apparent, and strengthened, between the two variables after adjustment. There is a similarly large confidence interval, however it is still a statistically significant result.

4. In the univariate logistic regression model below shown in Table 4, the association between pre-operative intermetatarsal angle (IMA) and a recurrence of hallux valgus is tested with adjustment for patient age and gender.

The odds ratio of 1.74 demonstrates a positive association between the two variables that remains apparent, and is strengthened. There is a similarly narrow confidence interval, and it remains a statistically significant result.

5. In the univariate logistic regression model shown below in Table 5 all significant variables are inputed in order to ensure that the previous associations remain significant in the context of adjustment for all possible confounders in the dataset (Table 5).

The odds ratio for disrupted MAng and pre-op IMA still demonstrate a positive association with recurrence of hallux valgus when tested together. Both of these results are also statistically significant.

3. Results

3.1. Primary outcome measure — recurrence rate of hallux valgus at 3 months minimum follow up

Tables 1 and 2 summarise the A and Group B patient groups. In Group A 12 out of 30 patients had recurrence at a mean follow up of 5.5 months. In this paper recurrence was defined as an IMA >10°. In Group B five out of 44 patients had recurrence at a mean follow up of 5.3 months.

Recurrence was statistically significantly higher in group A compared to Group B with an odds ratio of 5.2 $p = 0.006$ [95% CI 1.6–17]. The association between a disrupted Meary's line and increased risk of recurrence for Scarf osteotomy remained valid and strengthened to an odds ratio of 7.1 $p = 0.015$ [95% CI 1.46 –34.4]

Table 3
Association between a disrupted Meary's angle and hallux valgus recurrence with adjustment for confounding variables

Recurrence of hallux valgus	OR_{adj}	95% CI	*p*-Value
Disrupted Meary's angle	6.40	1.77–22.9	0.005
Age	0.99	0.95–1.03	0.666
Gender	13.79	0.90–211.3	0.060

Table 4
Association between pre-operative intermetatarsal angle (IMA) and hallux valgus recurrence with adjustment for confounding variables

Recurrence of hallux valgus	OR_{adj}	95% CI	*p*-Value
Pre-op intermetatarsal angle	1.74	1.29–2.35	0.000
Age	0.96	0.91–1.01	0.10
Gender	37.86	1.18–1213	0.040

Table 5
Hallux valgus recurrence association tested accounting for all variables including a disrupted Meary's angle, pre-operative intermetatarsal angle (IMA), age and gender

Recurrence of hallux valgus	OR_{adj}	95% CI	*p*-Value
Disrupted Meary's angle	7.10	1.46–34.4	0.015
Age.	0.94	0.89–1.00	0.053
Gender	65.27	0.87–4904	0.058
Pre-op intermetatarsal angle	1.79	1.29–2.49	0.001

when adjusted for confounding variables of age, sex and pre-operative IMA. On this basis we reject the null hypothesis.

3.2. Secondary outcome measure — revision

In group A two out of 30 patients had revision surgery whilst in Group B none of the 44 patients had revision surgery.

3.3. Tertiary outcome measure— before & after degree of IMA correction achieved

The IMA "before & after" for Groups A and B were comparable. The mean pre- and post-op IMAs for Group A were 16.0° and 7.9° respectively compared to Group B which were 14.4° and 6.2°. In Group A the mean degree of correction achieved equalled 8.1° whilst in Group B this was 8.2°.

Univariate logistic regression demonstrated a statistically significant positive association between pre-op IMA and recurrence with an odds ratio of 1.55 $p < 0.05$) (95% CI 1.22–1.96). Specifically, every 1° increase in pre-op IMA is associated with recurrence by a factor of 55% more than the baseline "model patient" with no discrepancy in their IMA.

3.4. Quaternary outcome measure — complications

In Group A eight out of 30 patients had complications. These included one case each of neuropraxia, metarsal fracture, 2nd toe hyperextention, scar hypersensitivity, metatarsalgia and three cases of superficial skin infections. In Group B nine out of 44 patients had complications. These included one case each of scar hypersensitivity, medial deviation of 2nd toe, DVT and three cases each of painful metalwork requiring removal and superficial skin infections.

4. Discussion

This paper offers a new way to objectively and quantitatively link medial column instability to recurrence for Scarf osteotomy in mild and moderate hallux valgus.

In this study we rejected our null hypothesis in light of a positive association between a disrupted Meary's line and increased risk of recurrence.

Because there is no accepted definition of recurrence for hallux valgus after scarf osteotomy, then for the purposes of this paper we defined recurrence as an IMA >10°. Recurrence due to different surgeons acting as a confounding variable for recurrence was not specifically considered but it should be noted that both groups were operated on by the same set of surgeons.

Hypermobility is colloquially defined as "double-jointedness". This occurs when joints easily move beyond their normal range of motion. Laxity is a symptom of hypermobility. Hypermobility is quantitatively defined and diagnosed on the Beighton's scale [4] with a score of ≥4 out of 9.

4.1. Measuring hypermobility of the first ray

In the context of the foot and ankle, hypermobility of the first ray is stated to occur at the medial cuneiform-navicular articulation. Clinical tests to determine sagittal instability are the "grasping test" and transverse motion instability by the "squeeze test". On lateral foot weight bearing radiographs, medial column instability can be seen as a broken Meary's line and/or by opening of the plantar aspect joint space between the base of the first metatarsal and cuneiforms.

The "grasping test" technique is performed with the ankle in neutral grasping the hindfoot with one hand and the 1st ray with the second hand. The examiner stresses the 1st metatarsal — medial cuneiform joint and assesses the degree of sagittal plane angulation also comparing it to the opposite foot. Myerson and Badekass [5] defined normal first ray sagittal motion as 4.2–6.6 mm with higher values indicating first ray hypermobility. Glasoe et al. [6] supported these findings with similar results suggesting that 8 mm of sagittal first ray motion equated to hypermobility.

An inherent weakness of the above stress tests is that they rely on the examiner's subjective naked eye assessment of angular deformity. This introduces a degree of error and lack of reliability, especially for borderline hypermobility cases.

Potential objective quantitative assessment methods of first ray instability include those described by Klaue et al. with an adapted ankle foot orthosis attached to a micrometer [7] and CAGA or computer assisted gait system [8]. This is a dynamic and quantitative method of assessing first ray hypermobility. It relies on measuring and plotting the pressure patterns on the first ray across the gait cycle through in-shoe pressure receptors. 1st ray hypermobility is recognised by reduced pressure reading on the 1st ray with the lateral column being subjected to extra load. This method appears to yield rich data but is technologically demanding and not easily and cheaply transferable to the average clinical setting.

4.2. Hypermobility relevance to hallux valgus context and lapidus

In 1928 Dudley J Morton who worked as an anatomist in New York, introduced the circular debate of whether first ray hypermobility is a cause or effect of hallux valgus. Although research exists to support both sides of this argument [9], it is uncontroversial that there is an association between hypermobility of the 1st ray and hallux valgus. Association of course does not equate to causality. Prominent names in the world of foot and ankle surgery [10,11] have suggested that it is indeed 1st ray hypermobility causing hallux valgus rather than vice versa.

This historic dilemma continued in the subsequent decade when in 1934 Dr Paul Lapidus also from New York, introduced the concept of fusing the first tarso-metatarso joint to correct the underlying metatarsus primus varus joint and thus correcting hallux valgus. Not only did this proximal osteotomy with a long lever arm provide a powerful correction, but it was also based on the concept that the metatarsus primus varus – the driver for hallux valgus – was secondary to 1st TMTJ instability [1].

Current indications for hallux valgus correction with a Lapidus procedure are generally regarded to be 1st ray hypermobility, severe deformities >20° IMA, TMTJ OA and as a revision procedure for failed scarf osteotomy. Interestingly, Faber's original paper [2]

as well its more recent counterpart publishing their 10 year results [3] showed that the Lapidus procedure was not clinically superior to a distal metatarsal osteotomy even in the presence of 1st ray hypermobility. They reported no clinical or radiologic differences in outcomes between the two procedures in patients without or with clinically assessed hypermobility. In this context the potential complications of the Lapidus must be carefully considered. These include a non-union rate reported to be in the range of 3.3–12% [12], recurrence of deformity reported as around 8% which is comparable to Scarf type or Chevron osteotomy at also approximately 8 and 5% respectively [13] and excessive 1st ray shortening leading to defunctioning and transfer metatarsalgia.

Kim et al. [14] evaluated the change in dorsiflexion mobility of the 1st ray after a proximal chevron metatarsal osteotomy combined with a distal soft tissue procedure. At 1 year follow they found that 1st ray dorsiflexion mobility had deaccreaed from 6.8 mm to 3.2 mm with pre and post-operative AOFAS scores experiencing an associated improvement from 66.2 to 89.1. On this basis they suggest that a proximal chevron metatarsal osteotomy may be a suitable procedure for patients with 1st ray hypermobility. Its should however be noted that the patient group they studied had a mean preoperative 1st ray dorsiflexion osteoeomy of 6.8 mm which is considered to be within normal range. It is therefore unclear if these results are transferable to patients with hallux valgus in the presence of hypermobility.

4.3. Pathophysiology linking hypermobility to hallux valgus

The foot is divided into the medial and lateral columns and together with the calcaneus form the tripod enabling gait. The medial column consists of the medial three rays, their corresponding cuneiforms, the navicular and talus. The latter column is made up of the lateral two rays, cuboid and calcaneus. The lateral column is relatively rigid and stable whilst the medial is more flexible and adaptable. Compromise to this composite foot architecture through failure of static or dynamic stabilisers can lead to hallux valgus amongst other problems.

Whilst the aetiology of hallux valgus is debated, established risk factors include hypermobility of the 1st ray, family history, female sex, pes planus and high heeled pointed shoes [15].

The patho-mechanics of hallux valgus starts with loss of tensile strength in the medial collateral ligament of the 1st MTPJ. As a result, the 1st metatarsal shifts medially into abduction leading to subluxation of the sesame-metatarsal articulation. In turn this increases tension and changes the line of pull of abductor hallucis and EHL. The hallux then deviates into valgus and pronation, causing the 1st metatarsal head to protrude leading to a formation of a swollen bursal sac.

Medial column instability at the “keystone” cuneiform-metatarsal articulation causes collapse of the medial arch resulting in a valgus foot attitude. In turn, this drives the hallux into valgus and pronation. In this context of hypermobility — through an undefined mechanism, we have shown an increased recurrence of hallux valgus deformity after surgical Scarf osteotomy correction. Whether stabilising the cuneiform-metatarsal “keystone” articulation would lead to lesser recurrence has not been tested by this paper but is the philosophy that underpins the Lapidus procedure.

Limitations of paper include no clinical patient outcome data to link to radiological recurrence. Although recurrence of deformity is pragmatically considered undesirable, we advise caution in interpreting the results of this study as we cannot comment on whether radiographic recurrence correlates with poorer functional outcomes. Further study would also be required to test the validity and reproducibility in using Meary’s line disruption as a marker of 1st ray instability.

5. Conclusion

In conclusion, in this paper, we link a disrupted Meary’s line with risk of recurrence of deformity. We demonstrate that, when Scarf osteotomy is used to correct mild and moderate hallux valgus in the presence of a disrupted Meary’s line, the odds of recurrence as compared to the same procedure being performed with an intact Meary’s line are 5.2 times higher

Conflict of interest

We the authors: Radwane Faroug, Oliver Bagshaw, Luke Conway, Jordi S Ballester, confirm that we have no conflict of interest to declare.

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