Clinical effectiveness of distal metatarsophalangeal mini-invasive osteotomy on hallux valgus

Zixing Bai (✉ 1322847034@qq.com)  
China Academy of Chinese Medical Sciences  https://orcid.org/0000-0003-3116-7287

Xuhan Cao  
China Academy of Chinese Medical Sciences

Binglang Xiong  
China Academy of Chinese Medical Sciences

Yongli Dong  
China Academy of Chinese Medical Sciences

Xudong Sun  
China Academy of Chinese Medical Sciences

Weidong Sun  
China Academy of Chinese Medical Sciences

Research Article

Keywords: Hallux valgus, Minimally invasive, Akin, Osteotomy, Clinical efficacy

Posted Date: March 1st, 2023

DOI: https://doi.org/10.21203/rs.3.rs-2085045/v1

License: ☑️ This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License
Abstract

Background

Minimally invasive treatment of hallux valgus is one of the better surgical methods, which still has the shortcomings of insufficient correction of deformities and poor correction of hallux rotation. Therefore, we have improved the surgical method to further improve the clinical efficacy.

Methods

186 patients (328 feet) who were diagnosed as hallux valgus from January 2019 to January 2020 and underwent DMMO were included in this retrospective study. The preoperative and postoperative hallux valgus angle (HVA), intermetatarsal angle (IMA) and distal articular set angle (DASA) of the patients were collected and compared to evaluate the correction of deformity. To explore the safety and effectiveness of DMMO in improving the function of hallux valgus based on American Orthopaedic Foot & Ankle Society (AOFAS) and visual analogue score (VAS).

Results

The preoperative HVA, IMA and DASA of the subjects were (33.63°±8.74°, 12.95°±2.42°, 9.46°±1.88°), postoperative HVA, IMA and DASA were (11.18°±2.04°, 7.61°±1.46°, 3.25°±1.15°); The preoperative AOFAS and VAS were (49.65 ± 9.32, 5.61 ± 2.12), and the postoperative were (90.21 ± 7.65, 1.65 ± 0.48). The postoperative (12 months) of HVA, IMA, DASA, AOFAS and VAS were better than those before operation (P < 0.05). No postoperative complications were found in all cases.

Conclusion

Distal metatarsophalangeal mini-invasive osteotomy in the treatment of hallux valgus is safety, scientific and effective. It is worthy of clinical application promotion.

Level of Evidence: Level III

Background

Hallux valgus means that the hallux valgus deviates from the midline and tilts outwards greater than the normal physiological hallux valgus angle. It is the most common disease in foot and ankle clinic and is also an extremely challenging disease in foot and ankle surgery[1]. Hallux valgus is a gradual aggravation of the disease, surgery or not depends on whether the patient's medial toe pain, plantar pain, or lead to other toe deformity, affect normal life[2–3]. The methods of hallux valgus surgery are complex and diverse. According to the size of incision, which can be divided into traditional surgery and minimally
invasive surgery (MIS). At present, Chevron, Scarf and Lapdius are commonly used in traditional surgery, all of which have the disadvantages of large incision, long recovery period and many complications \cite{4, 5}. In the 1940s, hallux valgus minimally invasive technique began to rise in the United States. Because of its high complications in clinical application, hallux valgus minimally invasive technique was banned by the American Society of foot and ankle surgery in the late 1980s \cite{6}. However, the prohibition order did not stifle the heart of minimally invasive exploration of foot and ankle scholars, and further applied the latest orthopedic knowledge to the in-depth exploration of minimally invasive technology \cite{7}. Since 2010, MIS combined with new internal fixation technology has become popular in Europe and America \cite{6, 8}. In the past 50 years, the minimally invasive surgery of hallux valgus has gone through wind and rain, and gradually improved through the continuous inheritance and development of several generations.

The main pathological change of hallux valgus is the first metatarsal varus. After minimally invasive distal metatarsal osteotomy, HVA and IMA were well corrected, and sesamoid reduction was satisfactory. However, there were some problems such as insufficient correction of hallux valgus and poor correction of hallux rotation. We found that: Akin osteotomy at the base of the phalanx cuts off the wedge-shaped bone block of the first phalanx, corrects the first phalanx valgus, reduce the HVA and DASA, and correct the hallux valgus by rotating its own longitudinal axis, so as to obtain a good force line for the medial column of the foot and prevent the recurrence of hallux valgus.

This operation combines the advantages of MIS with traditional akin osteotomy concept, forming a unique operation method, achieving the effect of short operation time, small incision, fast recovery and high satisfaction. In this study, 186 patients (328 feet) with hallux valgus were treated by DMMO from January 2019 to January 2020.

**Methods**

**1.1 Patients and methods**

We reviewed 186 cases (328 feet) of hallux valgus patients treated with DMMO in Wangjing Hospital, China Academy of Chinese Medical Sciences from January 2019 to January 2020. There were 142 cases with double feet and 44 cases with single foot; The average age was (58.54 ± 12.83) years old. Among them, 15 cases were mild deformities (28 feet), 135 cases were moderate deformities (248 feet), and 36 cases were severe deformities (52 feet). In this study, we excluded hallux valgus patients with other foot deformities or abnormal metatarsophalangeal range of motion, as well as patients with previous ankle surgery. (Table 1)
1.2 Inclusion Criteria

Measured by foot weight-bearing position X-ray film, HVA > 20° or IMA > 13°; Systemic conservative treatment was ineffective and needed surgical treatment; No contraindications; Agree to participate in this study and sign the informed consent form. Patients must meet all the terms of the inclusion criteria before they can be included in the study.

1.3 Exclusion Criteria

Gouty arthritis, rheumatoid arthritis and other connective tissue diseases; Foot deformity and trauma; Patients with a history of forefoot surgery (including joint fusion, arthroplasty, etc.); Morton syndrome, metatarsal neuroma, osteochondritis of metatarsal skull; Patients with other serious spinal, hip, knee and ankle diseases; Patients must be excluded from the study as long as they meet any of the exclusion criteria.

We intend to analyze the imaging changes and symptom scores of hallux valgus patients before and 12 months after operation, and comprehensively evaluate the clinical efficacy of DMMO in the treatment of hallux valgus. The imaging evaluation is to take the weight-bearing X-ray positive and lateral view of the foot, and measure and analyze the changes of HVA, IMA and DASA before and 12 months after the operation on the X-ray film. The imaging angle measurement in this research refers to the paper by DAI[9]. The symptom function score included comparing the VAS score of patients before and after
operation and evaluating the overall curative effect according to AOFAS score scale: 90–100 points were excellent, 75–89 points were good, 50–74 points were fair, 50 points were poor\textsuperscript{10}.

This clinical trial has been registered in China Clinical Trial Registration Center, registration number (ChiCTR2000038668). At the same time, it was approved by the Ethics Committee of Wangjing Hospital of China Academy of Chinese Medical Sciences, and the approval number of the Ethics Committee (WJEC-KT-2019-013-P003).

2 Surgical Techniques

2.1 Surgical approach and osteophyte removal

The patient was in supine position after anesthesia. A circular incision was made on the medial side of the proximal phalanx of the proximal phalanx of the great toe with knife, about 1cm(Fig. 1(a)). The skin and subcutaneous tissue were cut directly. The joint capsule was separated from the medial metatarsal head by a small periosteal dissector(Fig. 1(b)). The medial metatarsal head osteophyte can be removed by grinding with a grinding drill(Fig. 1(c)). Use a small bone file to smooth the inside of the metatarsal head(Fig. 1(d)).

2.2 Metatarsophalangeal Osteotomy

Using a sharpening drill to make an oblique osteotomy on the inside of the neck of the first metatarsal bone. The angle between the osteotomy line and the axis of the first metatarsal bone from the inside of the distal end to the outside of the proximal end in the horizontal plane is 10°~30°.

A longitudinal incision was made on the medial side of the great toe to expose the proximal phalanx of the great toe. After the osteotomy site was selected, a wedge-shaped osteotomy was performed with a high-speed grinding drill. The base was on the medial side, the tip was outward, and the lateral cortex was retained. (Fig. 1(e)).

2.3 Manipulative Reduction

The deformity and subluxation of metatarsophalangeal joint were corrected by hand touch, traction, pushing and end lifting. Standard of reduction: the distal metatarsal head was pushed out about a bone cortex from the inside to the outside, and the distal end of the osteotomy was not displaced to the dorsal side, and the thumb was placed in the inverted position 0°~ 5°(Fig. 1(f)).

2.4 Post-operative Rehabilitations
Two weeks, four weeks and six weeks after the operation, regular outpatient reexamination was carried out. The foot weight-bearing anteroposterior, lateral and axial X-rays were taken to check the stability of the osteotomy end and the deformity correction. The bandage was removed 6 weeks after the operation, and the patients could have normal daily activities.

3 Statistical Analysis

The statistical analysis of the data was performed by using the IBM SPSS version 20.0 for Windows software (IBM Corp, Armonk,NY,USA). The measurement data accord with the normal distribution and adopt the mean ± Standard deviation (x ± s) The HVA, IMA, DASA, VAS scores and AOFAS scores of preoperative and postoperative foot weight-bearing X-ray films were compared and analyzed. The difference was statistically significant (P < 0.05) by t-test.

Results

The operation was successfully completed in all cases. The operation time of hallux valgus was 15–20 minutes. 186 cases (328 feet) were followed up for 12 months. The osteotomy ends healed. At the last follow-up, HVA, IMA and DASA were significantly decreased compared with those before operation HVA (11.18 °± 2.04 °), IMA:(7.61°±1.46 °), DASA:(9.46°±1.88°). The differences of HVA, IMA and DASA before and after operation were (22.45°±8.70°, 5.34°±0.96°, 7.58°±0.73°)(Table 2).

<table>
<thead>
<tr>
<th>Index</th>
<th>Preoperative</th>
<th>Postoperative (12 months)</th>
<th>t value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAV (°)</td>
<td>23~50</td>
<td>7~14</td>
<td>45.03</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>(33.63 ± 8.74)</td>
<td>(11.18 ± 2.04)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMA (°)</td>
<td>9~16</td>
<td>4~13</td>
<td>34.22</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>(12.95 ± 2.42)</td>
<td>(7.61 ± 1.46)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMAA (°)</td>
<td>8~13</td>
<td>2~5</td>
<td>51.03</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>(9.46 ± 1.88)</td>
<td>(3.25 ± 1.15)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 Changes in average of radiological indices on weight bearing foot PA radiograph at preoperatively and 12 months post operatively

A female patient with hallux valgus preoperative(Fig. 2a-b) (HVA: left(L)45°, right(R) 39°; IMA: L 13°, R 11°; DASA: L 13°, R 14°); Only bandages were used for external fixation within 12 weeks after operation(Fig. 2(c-d)); 12 months after operation(Fig. 2(e-f)) (HVA: L 9°, R 10°; IMA:L 5°, R 6°; DASA: L 11°, R 5°).
The AOFAS and VAS scores of all patients were significantly improved (P < 0.001), and the postoperative AOFAS was 90.21 ± 7.65, VAS was 1.65 ± 0.48. The differences of AOFAS and VAS scores before and after operation were (49.65 ± 9.32, 5.61 ± 2.12). (Table 3)

<table>
<thead>
<tr>
<th>Index</th>
<th>Preoperative (12 months)</th>
<th>Postoperative (12 months)</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS</td>
<td>3~7 (5.61 ± 2.12)</td>
<td>1~3 (1.65 ± 0.48)</td>
<td>32.99</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>40~59</td>
<td>85~97</td>
<td>-60.92</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>AOFAS</td>
<td>(49.65 ± 9.32)</td>
<td>(90.21 ± 7.65)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

290 feet were excellent, 28 feet were good, and 10 feet were fair. The excellent and good rate of treatment was 95.14%. There were no complications such as thumb stiffness, hallux valgus recurrence, metastatic metatarsal pain and delayed union or nonunion of the osteotomy end. After the operation, 35 feet had numbness on the medial side of the big toe, and the symptoms disappeared 6 months later. At 3 months follow-up, there were 25 feet with limited range of motion of metatarsophalangeal joint, and they were given manipulative reduction. At 12 months follow-up, there was no limited range of motion of metatarsophalangeal joint.

Discussion

5.1 Development of MIS for hallux valgus

Since the 1970s, after several generations of foot scholars' exploration, the mainstream three generations of minimally invasive treatment of hallux valgus has been formed. The first generation of MIS is the reverse Isham percutaneous surgery proposed by Professor Isham[11]; The second generation of MIS was initiated by Professor Bösch[8,12]; Percutaneous transverse osteotomy of the metatarsal neck was performed and fixed with Kirschner wire along the medial cortex. This technique was later modified by Professor Magnan B[13,14]; The third generation of MIS belongs to the modified chevron osteotomy. There are two ways of osteotomy: intra-articular osteotomy and extraarticular osteotomy. However, there is still a lack of large sample, prospective and long-term clinical trials[15,18].

In the 1990s, the research group led by Professor Wen Jianmin, on the basis of inheriting the previous experience and integrating the advantages of foreign minimally invasive surgery, combined with the unique "manipulative reduction" technology of traditional Chinese medicine, finally established a
systematic "new method of minimally invasive treatment of hallux valgus and its related deformities" of integrated traditional Chinese and Western medicine\[^{19-20}\]. It has the advantages of simple operation, no need of internal fixation, satisfactory correction, less recurrence of deformity, quick recovery, less pain and fewer complications\[^{21-22}\]. Clinical practice found that more than 90% of patients with severe hallux valgus had rotational deformity of the thumb, and the deformity of hallux valgus was serious. This operation was only performed in the neck of the first metatarsal head, and the correction of thumb rotation and hallux valgus deformity was insufficient. Therefore, on the basis of inheriting "Wen's small incision on hallux valgus", we proposed a minimally invasive segmental osteotomy on hallux valgus supported by the concept of "segmental osteotomy, gradual correction".

### 5.2 Principle And Advantages Of Dmmo On Hallux Valgus

The traditional method of simple metatarsal osteotomy in the correction of HVA and IMA has significant clinical effect, but the correction effect of moderate and severe hallux valgus with pronation deformity is limited\[^{23-25}\]. If the displacement of the osteotomy end is excessively increased in order to correct the rotation, the contact of the osteotomy end may be too little and the stability will be poor. Because of the flexibility and practicability of akin operation, for patients with moderate to severe hallux valgus, the operators often combine the akin osteotomy of phalange with traditional operation to restore the matching degree of metatarsophalangeal joint and play a role in completely correcting hallux valgus deformity, with significant clinical effect\[^{26-27}\]. The advantages of minimally invasive treatment of hallux valgus combined with phalangeal akin osteotomy are as follows\[^{28}\]: (1) Correct the rotation deformity of the big toe and increase the postoperative beauty; (2) To further correct hallux valgus deformity and improve patient satisfaction; (3) Coordinate the balance of muscle and bone, alleviate the influence of tendon "bowstring", and prevent the recurrence of hallux valgus.

### 5.3 Clinical Analysis Of Dmmo On Hallux Valgus

Minimally invasive orthopedic surgery combined with akin osteotomy can restore the normal metatarsal measurement axis of HVA for the first time by first metatarsal osteotomy combined with manual lateral osteotomy. Akin osteotomy of phalange can improve the phalangeal measurement axis of HVA again. Both of them can reduce the HVA of hallux valgus patients and correct hallux valgus deformity. The results showed that the values of HVA and IMA were \((11.18 \pm 2.04)^\circ, (7.61 \pm 1.46)^\circ\) \(^*, which were lower than those before operation \((33.63 \pm 8.74)^\circ, (12.95 \pm 2.42)^\circ\) \(^*\) and the differences were statistically significant \((P < 0.05)\), which can effectively correct hallux valgus deformity; The DASA of patients with foot weight-bearing was \((3.25 \pm 1.15)^\circ\) \(^*, which was significantly less than \((9.46 \pm 1.88)^\circ\) \(^*\) before operation \((P < 0.05)\); This study proved that: wedge osteotomy at the base of phalanx effectively corrected the rotation deformity of thumb. In terms of VAS score and AOFAS score, the final review score \((1.65 \pm 0.48)\) and \((90.21 \pm 7.65)\) were significantly better than those before operation \((5.61 \pm 2.12)\) and \((49.65 \pm 9.32)\). Statistical analysis showed that there were significant statistical differences on hallux valgus with DMMO \((P < 0.05)\).
Conclusions

DMMO on hallux valgus can not only correct hallux valgus deformity, relieve the pain of forefoot, but also improve patient satisfaction, increase clinical efficacy and reduce complications. It has high safety and is worthy of clinical application.

Abbreviations

DMMO: Distal metatarsophalangeal mini-invasive osteotomy; HVA: Hallux valgus angle, IMA: Intermetatarsal angle; DASA: Distal articular set angle; AOFAS: American Orthopaedic Foot & Ankle Society; VAS: Visual analogue score; MIS: Minimally invasive surgery; L: Left; R: Right.

Declarations

Ethics approval and consent to participate

All patients were treated in accordance with the guidance of the Ethical Committee for Animal Experiments of Wangjing Hospital of China Academy of Chinese Medical Sciences. These patients were treated humanely throughout the experimental period.

Consent for publication

Not applicable.

Availability of data and materials: All data of this study can be obtained by contacting the corresponding author or the first author.

Competing interests

The authors declare that they have no competing interests.

Funding: This research was supported by the Beijing Municipal Science and Technology Project and the Beijing Municipal Natural Science Foundation of China. The project numbers are Z191100006619024 and 7172244 respectively.

Authors' contributions

The contributions of authors are ranked in order of the authors of the articles.

Acknowledgements

Not applicable.

References


Figures
Figure 1

Distal metatarsophalangeal mini-invasive osteotomy operation process

Note: The source of the image comes from our research team, and the author has the permission to use the line graph.

a: Incision of skin; b: Separation of joint capsule; c: Grinding osteophyte; d: File rough surface; e: Metatarsophalangeal osteotomy; f: Manual reduction
Figure 2

Twenty-five years old woman operated for hallux valgus deformity. Preoperative feet view (a,b). Postoperative feet view at second day (c,d). Postoperative feet view of 6 months(e,f)