The Foot 41 (2019) 30–33

Contents lists available at ScienceDirect

The Foot

journal homepage: www.elsevier.com/locate/foot

Original Article

Comparing the efficacy of Cartiva synthetic cartilage implant hemiarthroplasty vs osteotomy for the treatment of conditions affecting the second metatarsal head

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ARTICLE INFO

Keywords:
Cartiva Synthetic Cartilage Implant
Osteotomy
PROMs
Second Metatarsal

ABSTRACT

Background: Cartiva synthetic cartilage implants (SCI) have been designed for treatment of conditions affecting the second metatarsal head. Osteotomies are regularly performed for the treatment of conditions affecting the second metatarsal head such as Freiburg's disease. A comparative study between these two procedures has not yet been performed.

Methods: Patients at a single centre with symptomatic conditions affecting the second metatarsal head who received Cartiva SCI or a primary Osteotomy were identified, and patient-reported outcomes were evaluated using MOXFQ and the FAAM questionnaires.

Results: Six Cartiva SCI and 7 Osteotomy patients were identified and included in this study. All patients were female and were followed up for an average of 19 months (SD +/- 5.6) and 27 months (SD +/- 10.9) respectively.

Cartiva SCI MOXFQ Index scores improved by 13 points from 57 to 44 (33%). Walking/and Pain domain scores improved, however, Social interaction deteriorated. Mean FAAM scores improved by 10% from 65% to 75%, and subjective FAAM scores improved by 7% from 48% to 55%. Four of the six Cartiva patients (3 Freiberg's disease and 1 Osteochondral defect) had revisions to Weil osteotomies at a mean of 15 months post-operatively.

The Osteotomy group had improved MOXFQ Index and 3 Domain scores. FAAM scores improved by 26% from 66% to 92% and subjective FAAM scores improved by 28% from 60% to 88%.

Conclusions: Second metatarsal head osteotomies result in high functional outcomes and should be the mainstay of treatment, especially when there is avascular necrosis of the metatarsal head.

1. Introduction

The second metatarsal plays an important role in load distribution and gait mechanics of the foot [1]. Arthritis of the second metatarsal can be caused by traumatic and non-traumatic conditions. Non-traumatic conditions include osteoarthritis, inflammatory arthritis, Freiberg's disease and osteochondral lesions [2,3]. These lead to pain, reduced range of motion and poor mobility.

First-line management with non-operative treatment such as insole modifications, orthosis and steroid injections are able to relieve symptoms and patients have been known to achieve high functionality with the disease [4]. However, for patients who remain symptomatic, operative treatment can be considered. Osteotomies are regularly performed for the treatment of such conditions as they can effectively reduce metatarsalgia and reduce pain [4].

A Gauthier rotational osteotomy can be performed to relieve pressure from the dorsal metatarsal head which is commonly affected in the early stages of degenerative or vascular diseases of the metatarsal head [4]. This has been shown to result in good clinical scores with high patient satisfaction rates, however, bone shortening, pain from dorsal screws or staples and non-union are recognisable complications [4].

A new 6 mm polyvinyl alcohol implant manufactured by Cartiva has been created for use in the second metatarsal head. It acts to provide a cushion within the metatarsophalangeal joint (MTPJ) and relieve symptoms. A similar implant has been used in the management of hallux rigidus with excellent post-operative results [5]. No data exists as of yet regarding the efficacy of this Cartiva synthetic cartilage implant (SCI) for treatment of 2nd MTPJ disease.

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https://doi.org/10.1016/j.foot.2019.06.003
Received 16 March 2019; Received in revised form 24 June 2019; Accepted 25 June 2019

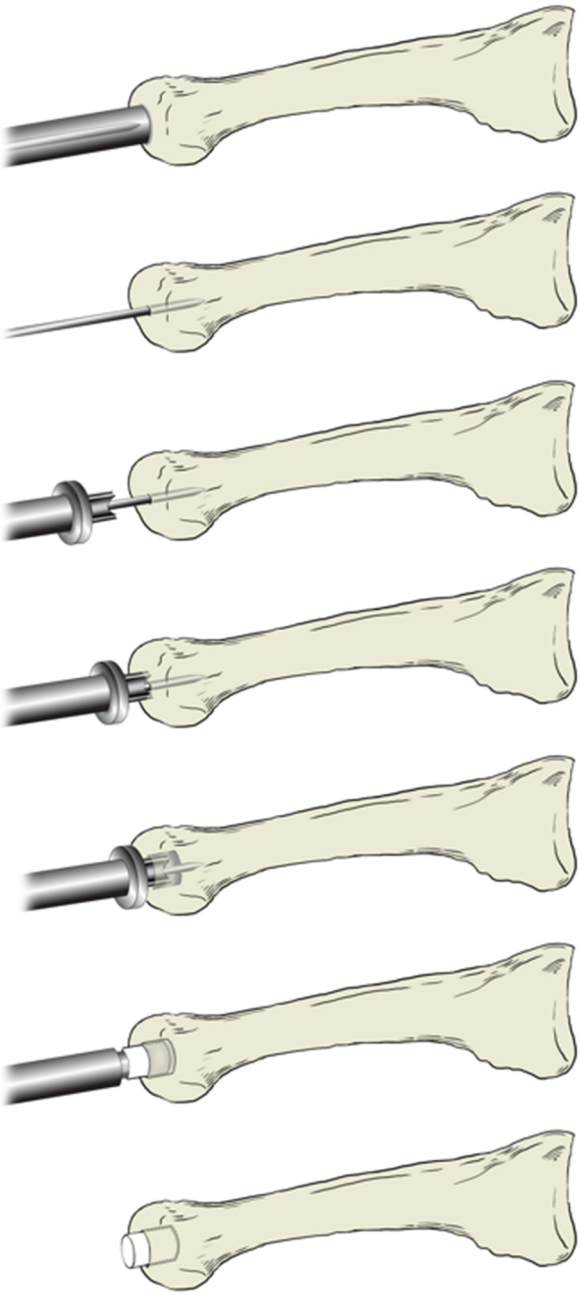

Fig. 1. Illustrations demonstrating the press-fit technique of Cartiva SCI implantation.

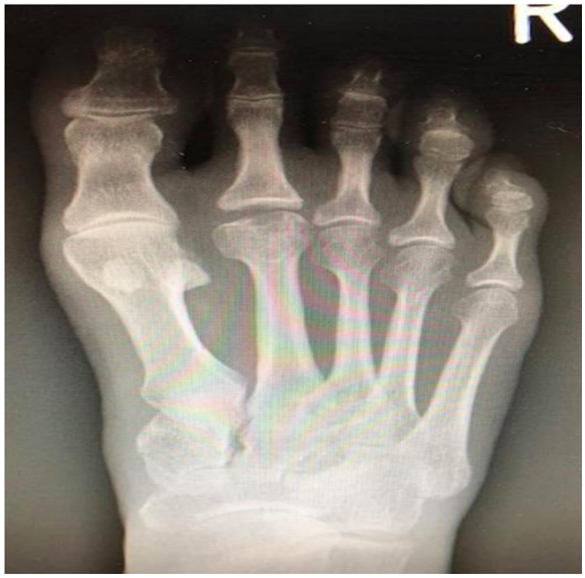

Fig. 2. X-ray showing a second metatarsal head Cartiva SCI.

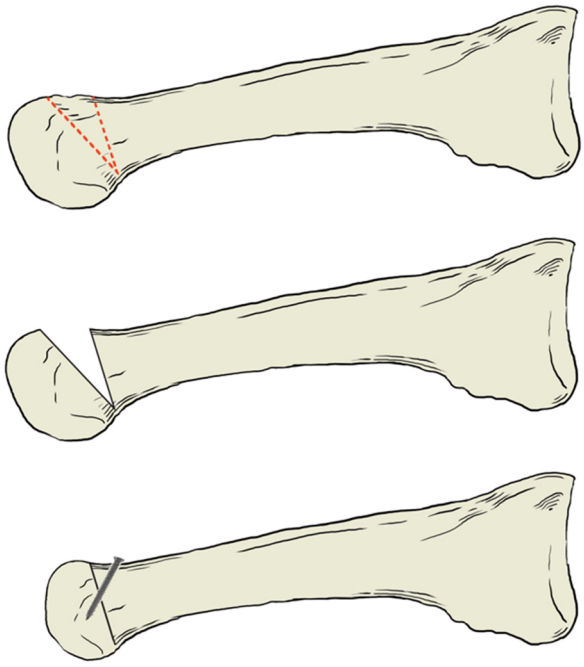

Fig. 3. Illustration demonstrating 2nd MTP osteotomy surgical technique.

This study aims to assess the efficacy of the two procedures on the treatment of conditions affecting the second metatarsal head, utilising patient reported outcome measures (PROMs).

2. Methods

Adult patients over 18 years of age at a single centre with symptomatic conditions affecting the second metatarsal head who received Cartiva SCI (Figs. 1 and 2) or a primary osteotomy (Figs. 3–5) were included. Post-traumatic 2nd MTPJ arthritis and patients who had previous surgery on the second metatarsal were excluded.

Pre-operative and post-operative patient-reported outcomes were evaluated using the Foot and Ankle Ability Measure activities of daily living [6] (FAAM ADL) subscale and the Manchester-Oxford Foot Questionnaire [7] (MOXFQ).

FAAM ADL consists of 21 questions relating to daily activities and the difficulty encountered within the past week is scored by the patients between “No difficulty” and “Extremely difficult” or “Unable to do”, where “No difficulty” is given a score of 4, “Unable to do” a score of 0 and the remaining answers a score in between. The total score is divided by 84, however, for every question the patient marks as “Unable to do” are not scored in the final tally, and this score is then multiplied by 100 to express as a percentage. Finally, a subjective score is taken from the patient between 0–100 regarding their current level of function compared to their prior level of function.

MOXFQ is a 16 question questionnaire which evaluates a person’s

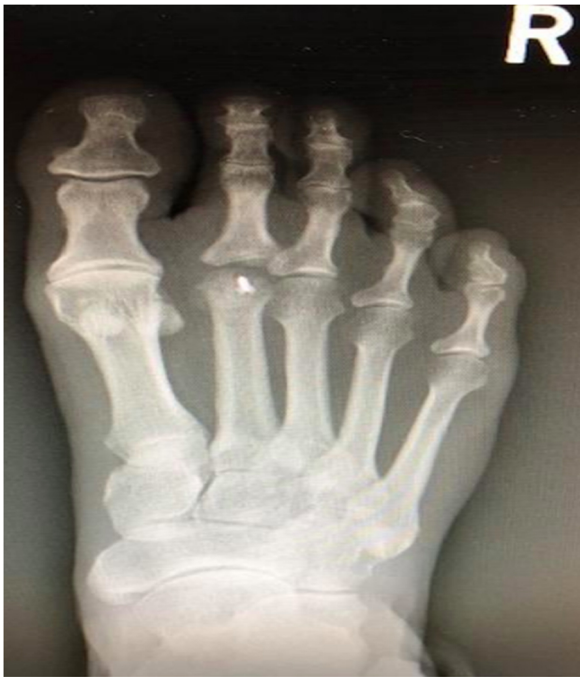

Fig. 4. X-ray showing a second metatarsal head rotational osteotomy.

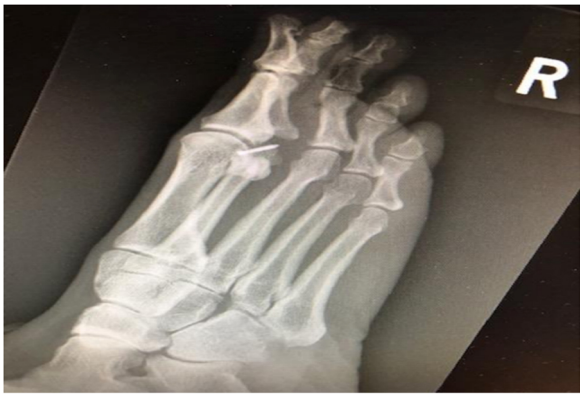

Fig. 5. X-ray showing a second metatarsal head rotational osteotomy.

foot and ankle functionality across three domains: Walking/Standing (7 questions), Pain (5 questions) and Social Interaction (4 questions). Five responses are allowed between "None of the time" and "All of the time", which are scored between 0 and 4 respectively. The total is divided by the maximum score per domain. A combined score can be calculated as an overall score of functionality and is known as the Index score.

Pre-operative scores were taken on the day of surgery and post-operative data was collected from patients as convenient from clinic visits.

Surgical technique involved a dorsal approach to the metatarsal head. Nerve and tendon were protected. Preparation of the metatarsal head including removal of dorsal osteophytes and implant inserted utilising press fit technique. Implant left at least 3 mm proud on all occasions. Intra-operatively, the aim was to achieve 90 degrees of dorsiflexion in every case.

3. Results

Six Cartiva SCI (3 Freiburg's disease, 2 osteoarthritis (OA), 1 osteochondral defect (OCD)) and 7 Osteotomy (3 OA, 2 Freiburg's, 2 Rheumatoid arthritis (RA)) patients were identified and included in this study. All patients were female. Cartiva SCI patients had an average age of 51 and were followed up for an average of 19 months (SD +/−5.6). Osteotomy patients had an average age of 64 and were followed up for an average of 27 months (SD+/−10.9) (Table 1).

Cartiva SCI MOXFQ Index scores improved by 13 points from 57 to 44 (33%). Three Domain scores, Walking/Standing improved by 2 points from 46 to 44 (4.4%), Pain improved by 4 points from 63 to 59 (6.3%), however, Social interaction deteriorated by 4 points from 41 to 45 (1.1%). Mean FAAM scores by 10% from 65% to 75%, and subjective FAAM scores improved by 7% from 48% to 55% (Table 2).

Four of the six Cartiva patients (3 Freiberg's disease and 1 Osteochondral defect) failed and subsequently had revisions to Weil osteotomies at a mean of 15 months post-operatively. (Fig. 6) Cartiva SCI did not impede revision to osteotomy due to the small amount of bone loss during primary surgery.

The Osteotomy group had improved MOXFQ Index and 3 Domain scores. Index score improved by 45 points from 59 to 14 (76.3%), Walking/Standing score improved by 54 points from 65 to 11 (83.1%), Pain score improved by 44 points from 55 to 11 (80%) and Social Interaction score also improved, by 21 points from 35 to 14 (60%). FAAM scores improved by 26% from 66% to 92% and subjective FAAM scores improved by 28% from 60% to 88%. All seven patients were satisfied with the procedure and when asked directly, stated they would recommend it to their friends and family members and would have the same operation again (Table 2).

4. Discussion

Osteotomy outperformed Cartiva SCI across every domain of the MOXFQ and FAAM ADL and received much higher patient satisfaction rates from the patients. Osteotomy was also effective at a longer follow-up with no failures in any of the patients. These results are comparable to previous studies on osteotomies resulting in high functional outcomes and pain reduction with low complication and failure rates [8].

The rational for using Cartiva was to provide an interpositional arthroplasty for the 2nd MTPJ to alliviate pain and improve range of movement. It also reduces impingement pain from the altered joint mechanics due to articular collapse and secondary OA of the second MTP. Pain in burnt out Freiburg's disease could be due to a combination of altered mechanics of the damaged joint, boney and soft tissue impingement and secondary OA.

Cartiva SCI resulted in high failure rates. Four of the six patients (67%) required a revision surgery to a Weil osteotomy at a mean 15

Table 1
Patient demographics.

Surgery	Number of patients/per condition	Average follow up/months	Gender	Average age/years
Cartiva	6 (3 Freiburg's, 2 OA, 1 OCD)	15 (SD +/−5.6).	All female	51
Osteotomy	7 (3 OA, 2 Freiburg's, 2 RA)	27 (SD +/−10.9).	All female	64

Table 2
Comparative table showing foot and ankle ability measure activities of daily living scores for cartiva synthetic cartilage implant and osteotomy patients.

Domain		Cartiva SCI	Osteotomy
Number of patients		6	7
Follow up months		19	27
MOXFQ index score		44	14
MOXFQ domain scores	Walking/standing	44	11
	Pain	59	11
	Social interaction	45	14
FAAM ADL		75	92

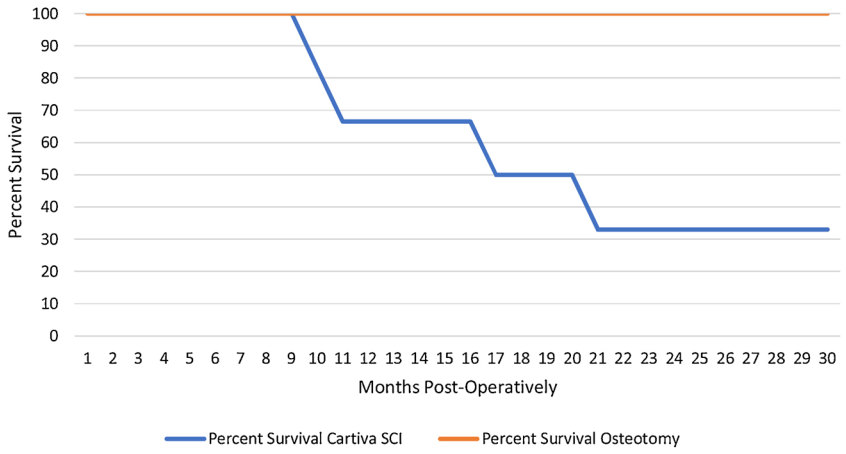

Fig. 6. Kaplan–Meier survival plot.

months post-operatively. Failures were most likely due to avascular necrosis of the metatarsal head leading to loosening and subsidence of the implant. Specifically, in conditions such as Freiburg's disease and osteochondral defects where the blood supply to the head is compromised, we postulate that the implant would not hold in the metatarsal head. The implant is press fit into the metatarsal head but requires good quality bone. Revision surgery was possible due to the small amount of bone resected during the primary Cartiva hemiarthroplasty procedure. Additional imaging such as CT and MRI should be utilised to analyse the quality of the bone within the metatarsal during the pre-operative planning stage. At our centre, Cartiva for the second toe is no longer on offer. As opposed to the larger 10 mm^2 Cartiva SCI which is used in the management of hallux rigidus, there is a lack of data regarding the efficacy of this implant for use in the second metatarsal head and further studies or implant modifications are required. Patients also need to be warned about the uncertain efficacy of this procedure and made aware of the potential high failure rate and alternative options.

5. Limitations

The lack of patients included in this study does limit the reliability of the conclusions drawn from this study. The low patient numbers were due to the fact that it was a prospective study and that Cartiva SCI is a new technique for second metatarsal conditions, which only one surgeon is currently performing at our site. Two Cartiva patients now live abroad and therefore only telephone follow up was feasible. Due to the small cohort of patients it was not possible to perform any comparative statistical analysis.

6. Conclusion

Second metatarsal head osteotomies result in high functional outcomes and should be the mainstay of treatment, especially when there is avascular necrosis of the metatarsal head. Cartiva SCI should only be used in patients who have good quality subchondral bone. At our centre, Cartiva for the 2nd toe is no longer on offer. These patients will continue to be followed up and durability of the implant studied.

Funding received

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

There are no conflicts of interest to declare.

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