Can polyaryletherketone cage be used to achieve union and maintain correction in anterior calcaneal lengthening osteotomy for treatment of flexible flatfoot?

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Can polyaryletherketone cage be used to achieve union and maintain correction in anterior calcaneal lengthening osteotomy for treatment of flexible flatfoot?

Khaled M. Zaghloul, Ahmed Mostafa Saied, Bassam A. Abouelnas and Wael Ali M. Al Adl

A structural graft is often used to maintain correction and achieve union after anterior calcaneal lengthening osteotomy for treatment of flexible flatfoot. Autograft, the current gold standard, is limited in availability and configuration and is associated with donor site morbidity in as much as 48%, whereas the alternative allograft carries risks of disease transmission and collapse. Polyaryletherketone cage, with a healing rate similar to that of autograft, high stability, and no donor-site morbidity, has been used in spine surgery. However, its use has not been documented in foot and ankle surgery. We reviewed 15 patients with painful flatfeet after failure of conservative treatment who were treated by anterior calcaneal lengthening osteotomy using polyaryletherketone cage instead of bone graft. Minimum follow-up was 1 year (average, 1.27 years; range, 1–1.5years). The male–female ratio was 1:1.5 (six males, nine females). Mean age at time of surgery was 10.8 ± 1.7 years (range, 8–13.5 years). Minimum follow-up was 1 year (average, 1.27 years; range, 1–1.5 years). Nine patients had a unilateral procedure and three had a simultaneous bilateral procedure, for a total of 15 operated feet (seven right and eight left). The paired t-test result was statistically significant in comparison of radiographic measurements at presurgery and postsurgery with P value <0.001. All cases showed full union clinically and radiographically at last follow-ups and no complications occurred. Our data suggest that polyaryletherketone cage may be used as a structural graft option for anterior calcaneal lengthening osteotomy.

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Introduction

To achieve and maintain a desired correction, a structural graft often is needed to fill the gap after anterior calcaneal lengthening osteotomy (ACLO) [1,2]. Autograft, allograft, and xenograft bone, each has some disadvantages. Autograft has high healing potential, but it usually increases operative timing and could be associated with donor site morbidity in 15–48% [3–8], postoperative complications (hematoma, hypoeesthesia, and wound dehiscence) in 3–39% [5–7], limited quantity, and risk of graft collapse [5]. Allograft and xenograft may increase the risk of infectious disease transmission, lower stability resulting from preparation and graft may fail to unite, which can also result in its collapse [5,9–11].

Polyaryletherketone (PEEK) materials were first commercialized in the 1980s as a biomaterial in prosthetic implants, it belong to the family of PEEK polymers [12]. PEEK strength exceeds many metals and it can resist high temperatures (up to 300°C), chemicals and radiation [13,14]. PEEK had great success in interbody fusion devices, two attributes of PEEK that make it beneficial as a biomaterial for spinal fusion are radiolucent and low elastic modulus. The minimal radiographic signature of PEEK allows an unobstructed evaluation of fusions by radiographs and computed tomography [15].

Our pilot study had two purposes: (1) to evaluate the clinical outcome and complications after using PEEK cage for anterior calcaneal lengthening osteotomy after a short trial period and (2) to evaluate the osteocompatibility of the radiolucent PEEK polymeric device and usefulness of PEEK cage as a substitute for bone graft in ACLO for painful flatfeet after failure of conservative treatment.

Methods

We retrospectively reviewed 15 feet in 12 patients with painful flatfeet after failure of conservative treatment who were treated by ACLO as described by Mosca [1] using PEEK cage instead of bone graft from June 2016 to March 2018. All patients did percutaneous Achilles tendon lengthening and medial soft tissue plication with tibialis posterior tendon distal advancement (Figs. 1 and 2).

Inclusion criteria were:

1. Skeletally immature patients with open growth plate in preoperative foot radiographs.

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Fig. 1

Preoperative clinical photographs and radiographs showing bilateral idiopathic planovalgus foot deformity in a 10-year-old boy (a)–(f).

Fig. 2

Intraoperative photographs showing the PEEK cage filling the osteotomy gap after its opening by laminar spreader (a) and (b), radiographs, and clinical photograph at the last follow-up visit showed deformity correction and satisfactory result according to Mosca’s criteria (c)–(f). PEEK, polyaryletherketone.

(2) Symptomatic flexible pes planovalgus with no response to conservative treatment.

The male–female ratio was 1:1.5 (six males, nine females). Mean age at time of surgery was 10.8 ± 1.7 years (range, 8–13.5 years). Minimum follow-up was 1 year (average, 1.27 years; range, 1–1.5 years). Nine patients had a unilateral procedure and three had a simultaneous bilateral procedure, for a total of 15 operated feet (seven right and eight left).
In order to assess clinical and functional outcome, all patients were evaluated according to Mosca [1] clinical criteria before surgery and at the last follow-up visit. According to Mosca [1] clinical criteria, outcome is satisfactory when hindfoot valgus deformity has been corrected, longitudinal arch has been created, prominence of the talar head has been eliminated, pain and callus have been eradicated, ulcerations do not recur, and brace and toes tolerance has improved.

Radiographic evaluation
All patients underwent anteroposterior (AP) and lateral weight-bearing foot radiographs preoperatively, at 3- to 4-month postsurgery and at the last follow-up visit. Foot deformity was assessed by measuring talo-first metatarsal angle, calcaneal pitch, and talo-horizontal angle on the lateral radiograph and talo-first metatarsal angle on the AP radiograph as suggested by Mosca [1].

Normal average radiograph angle values are as follows: AP talo-first metatarsal angle 10 (2 SD range, 10–20), lateral talo-first metatarsal angle 5 (2 SD range, 7–20), lateral calcaneal pitch 25 (2 SD range, 15–30), lateral talo-horizontal angle 27 (2 SD range, 15–37) [16].

Radiographic outcome was rated as satisfactory or unsatisfactory according to the Mosca radiographic criteria, where radiographic outcome is satisfactory when at least two of lateral talo-first metatarsal angle, calcaneal pitch, talo-horizontal angle, and talo-first metatarsal angle on the AP radiograph are in the normal range [1].

Patients provided informed consent and the study was approved by the authors' University Ethical Review Board.

Statistical analysis
Continuous data are presented as means and SDs as appropriate. The paired t-test was used to compare radiographic measurements at presurgery and postsurgery. Windows SPSS 12.0 was used for the statistical analysis and significance was set at $P <0.05$.

Results
Clinical and functional outcome
Mosca clinical criteria: all 15 (100%) feet had satisfactory outcome.

Radiographic outcome
The paired t-test result was statistically significant in all parameters with $P <0.001$ (Table 1). Correction was maintained at the last follow-up visit. According to the Mosca radiographic criteria, outcome was satisfactory in all 15 feet. Final AP and lateral foot radiographs showed complete bone union and good remodeling.

Discussion
ACLO for the treatment of flatfoot deformity was first described by Evans [17] and later modified by Mosca [1]. This technique was used in several publications which reported good short- and long-term clinical outcomes [18–23].

PEEK has good established mechanical and wear characteristics, also has good biocompatibility in bulk and particulate form [28–32]. Rivard et al. [33] found that there was no necrosis or swelling when PEEK particles were injected in tissues adjacent to the spinal cord and nerve roots of 12 New Zealand white rabbits. In 2002, Sénégas [34] evaluated PEEK interspinous system for nonrigid stabilization and showed that it is efficacious for low back pain due to degenerative instability. Cho et al. [35] showed that the PEEK devices were able to facilitate stability and space maintenance during cervical fusions, increase cervical lordosis, and increase foraminal height [35].

In order to achieve a complete reduction, different PEEK cages were prepared before operation and the choice of proper size and shape was done. Major complications after PEEK cage are infection, bony absorption, and non-union [35].

In this study, ACLO using PEEK cage instead of graft showed improved radiological indices and all the cases had bony union and satisfactory results at the final follow-up. However, further evaluation of ACLO with and without reconstruction of medial column of the foot is necessary.

Our study has certain limitations. First, we included a limited number of patients who would be reviewed after a trial period before exposing more patients to the procedure, despite the fact that PEEK already was used in spinal surgery. Second, we do not know the long-term outcome of these procedures and whether long-term complications would develop, or the difficulties in revising these procedures (e.g., in the case of secondary infection). Third, there was no control group of patients treated with different techniques.

All osteotomies united and we observed no complications. These observations are consistent with those reported with the use of PEEK cage in spinal fusion [31,33,35]. PEEK cage has the advantage that it avoids donor site morbidity of harvesting the iliac crest graft and the possibility of disease transmission with allograft. Harvesting autograft at the iliac crest has a reported donor-site morbidity rate of 15–48% (postoperative hematoma, infection, hypoesthesia, increased postoperative pain, wound

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<td>Talo-first metatarsal (anteroposterior view)</td>
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Values are mean ±SD.
dehiscence, cosmetic defect, prolonged pain in the long term, and impairment in ambulation, work, and activities of daily living) [3]. The cost of PEEK cage (approximately $100 per block in the Egypt) is cheaper compared with allograft ($850, plus approximately 5 minutes of preparation time in the operating theater) or harvesting iliac crest autograft (estimated at $600–$700, as it involves approximately 20 minutes of operating time, suture material, sponges, and dressing). Also, availability of allograft is limited in Egypt.

Conclusion
Our data suggest that PEEK cage can be used as a structural graft to maintain correction after ACLO. All patients achieved union without any complications, corresponding to the findings reported when PEEK cage has been used in spine.

Acknowledgements
Ethical approval is obtained from institutional review board of Mansoura faculty of medicine with code number RP /18.01.2

Conflicts of interest
There are no conflicts of interest.

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