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Correction of ankle and hind foot deformity in Charcot neuroarthropathy using a retrograde hind foot nail—The Kings' Experience

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ABSTRACT

Background: Corrective fusion for the unstable deformed hind foot and mid foot in Charcot Neuroarthropathy (CN) is quite challenging and is best done in tertiary centres under the supervision of multidisciplinary teams.
Methods: We present a follow up to our initial report with a series of 42 hind foot corrections in 40 patients from a tertiary level teaching hospital in the United Kingdom. The mean patient age was 59 (33-82). 17 patients had type1diabetes mellitus, 23 had type 2. 23 feet in 22 patients had chronic ulceration despite offloading. 17 patients were ASA 2 and 23 were ASA grade 3. All patients had hind foot nail fusion performed through a standard technique by the senior author and managed perioperatively by the multidisciplinary team.
Results: At a mean follow up of 42 months (12-99) we achieved 100% limb salvage initially and a 97% fusion rate. One patient with persisting non-union of ankle and subtalar joint with difficulty in bracing has been offered below-knee amputation. We achieved deformity correction in 100% and ulcer healing in 83%. 83% patients are able to mobilize and manage independent activities of daily living. There were 11 patients with one or more complications including metal work failure, infection and ulcer reactivation. There have been nine repeat procedures including one revision fixation and one vascular procedure.
Conclusion: Single stage corrective fusion for hind foot deformity in CN is an effective procedure when delivered by a skilled multidisciplinary team.

1. Introduction

Charcot neuroarthopathy (CN) of the foot is a dreaded complication of diabetes mellitus and continues to be a challenge for the foot and ankle surgeon. Although the neurotraumatic and the neurovascular theories have been postulated the exact pathology still remains unclear [1]. Mid foot and hind foot deformities can lead to ulceration, osteomyelitis and eventually amputation. Even in those that do not progress rapidly, chronic ulceration, difficulty with foot wear, and reduced mobility leads to significant morbidity.

The aim of any reconstructive procedure therefore is to achieve a stable plantigrade foot, to enable ulcer healing and allow weight bearing which lets the patient carry out activities of daily living independently.

Reconstruction modalities include internal fixation using an intramedullary hindfoot nail or plate fixation and external fixation [2–6]. Although good union rates have been reported with the hind foot nails, complications like infection, non-union, implant breakage and amputation continue to cause concerns to the patient and the treating team [2–5]. Most of these patients have concurrent renal, cardiac and other co-morbidities making them high risk surgical candidates. Therefore these patients are better managed in a tertiary setting under a multidisciplinary team.

We report the outcomes of hind foot fusion from a busy tertiary referral diabetic foot unit that manages more than 13,000 patient episodes a year. This is a follow up to our earlier report published with a smaller cohort and shorter follow up [7].

2. Patients and methods

Our multi disciplinary team includes orthopaedic surgeons, endocrinologists, vascular surgeons, podiatrists, physiotherapists, occupational therapists, orthotists and wound care specialist nurses. Our initial assessment involves taking a detailed history

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Fig. 1. Pre-operative X-rays for case 1.

followed by a thorough clinical examination including recording temperature difference, noting the swelling, redness, tenderness, sensation, ulceration, deformities, tendo achilles tightness and vascular status. Laboratory investigations include inflammatory markers, HbA1c and renal profile. Weight bearing plain X-rays are routinely performed (Figs. 1 and 3). CT scan is done to assess complex deformities and MRI scan helps confirm the diagnosis while ruling out any infective foci. Patients with unstable deformity not amenable to bracing are considered for corrective fusion. Those with ulcer are treated in staged manner with surgical debridement followed by VAC (vacuum assisted closure) therapy and deep tissue culture specific antibiotic administration to eradicate infection during the first stage before planning definitive deformity corrective fusion. Patients with peripheral vascular disease are initially managed by the vascular team and are re vascularised prior to fusion.

In this series we present 42 feet in 40 consecutive patients who underwent reconstruction of the ankle and hind foot between June 2008 and September 2015 (20 men and 20 women) and with a minimum of 1 year follow up period. Mean age was 59 (33–82). Two patients had bilateral reconstruction. 17 patients had type 1 DM 23 had type 2 DM and one patient had associated spina bifida. Mean HbA1c was 8.8. All patients had peripheral neuropathy, 6 had retinopathy and 18 had chronic renal disease. 17 patients were ASA grade 2 and 23 were ASA grade 3. 23 feet in 22 patients had ulceration at the time of surgery. This included patients who were advised to undergo below knee amputation from the referring hospital due to the degree of deformity and the presence of chronic non-healing ulcer.

The infected ulcers were debrided and culture specific intravenous antibiotics based on deep tissue specimens were administered until the infection was clinically and serologically eradicated. Detailed vascular assessments were performed on all patients and vascular optimisation by performing angioplasty and vascular bypass procedures prior to the deformity correction was done in 2 patients. All patients had hind foot fusion done using a hind foot arthrodesis nail (TRIGEN hind foot fusion nail, Smith & Nephew, Memphis Tennessee). The procedure was performed by the senior author (VK) using a standard surgical technique. Excision of a bony wedge on the convex side was performed to correct the deformity and tibiotalocalcaneal stabilization was done. A trans lateral malleolar extended lateral approach was used in a varus deformity to gain access to the ankle and subtalar joint. Two incisions were used in valgus deformities to enable anteromedial access to the ankle joint and a lateral approach to the subtalar joint.

Percutaneous tendoachilles lengthening to correct equinus was carried out where necessary. Multiple soft tissue and bone samples from areas of possible previous infections when present were harvested and sent for microbiological analysis. Bone graft substitutes (Chronos and DBX, Synthes UK) were used as required and a closed suction drain was used in all cases. The multidisciplinary team supervised the post-operative wound care and general medical management. A total contact cast was applied following healing of the surgical wounds. The patient was kept non-weight bearing for a minimum of three months and partial weight bearing for a further three months if clinical and radiological progress was satisfactory. Full weight bearing in a removable brace was allowed after at least 50% bony union was confirmed on a CT scan. The patient is then progressed to full weight bearing in custom-made lace up shoes.

Our main outcome measures were deformity correction, ulcer healing, clinical and radiological bony fusion, independent weight bearing, ability to wear lace up shoes and ability to carry out activities of daily living (ADL) independently. While correcting the deformity our main aim was to achieve a plantigrade foot that fits into a surgical shoe.

3. Results

All 40 patients underwent hind foot deformity correction and 18 feet had concurrent or staged mid foot deformity correction (midfoot fusion as a separate procedure). One patient had simultaneous 1st MTP joint correction. The mean follow up was 42 months (12–99). Five patients died during the follow up period, which meant that we have 37 feet in 35 patients available at final follow-up. Limb salvage and deformity correction was achieved in all patients (Fig. 5) except one for whom amputation is being discussed and awaiting review. For this patient the bone union was not achieved despite two revision procedures and resulted in breakage of the intramedullary nail. The ankle developed instability and pressure from the brace led to skin breakdown

Fig. 2. Post-operative X-rays for case 1.

and deep infection requiring removal of the metal work and extensive debridement to eradicate the infection. The ankle and subtalar joints remained mobile and unstable.

All the other patients had clinical and radiological evidence of satisfactory bony union, thus achieving a union rate of 97% (Figs. 2 and 4). Ulcer healing was achieved in 19 feet out of the 23 (83%) that had chronic ulceration. Twenty nine patients (83%) were able to fully weight bear in surgical shoes or custom orthoses at the time of final follow up and 6 patients were in a bivalved total contact cast three of them awaiting orthotics. These 29 patients were able to carry out ADLs with 3 requiring walking aids.

4. Complications

We had 11 patients (28%) who developed one or more complications. These included superficial or deep wound infection in five feet (12.5%), five cases of screw migration (12.5%), two with ulcer reactivation (9%) one metal breakage (2.5%) and one non-union (2.5%).

There were a total of nine repeat procedures (22.5%) undertaken. Of these four were removal of metal work for infection (2 cases) and loosening of locking screws (2 cases) two were dynamisation, one debridement for deep wound infection-one revision fusion and one vascular procedure.

5. Discussion

Outcome studies regarding management of hind foot Charcot neuroarthropathy are sparse compared to the larger body of literature on mid foot Charcot. Published research is limited to small retrospective case series. While most mid foot deformities tend to be more stable and can be treated with custom made shoes; even mild instability in the hind foot is poorly tolerated, more prone to ulceration and could lead to potential amputation [8]. If we follow Brodsky's or the Sander's/Frykberg classification systems, ankle involvement is seen in only 10% of cases and the triple joints are involved in 30% [8,9]. However Schon et al. in their series of 221 cases found that 2/3rd of patients with hind foot involvement required surgery while only half of those with transverse tarsal joint involvement and a third of those with tarso-metatarsal joint involvement needed operative intervention [10]. This underscores the importance of keeping these patients under close follow up and planning early intervention for a successful outcome.

Fig. 3. Pre-operative X-rays for case 2.

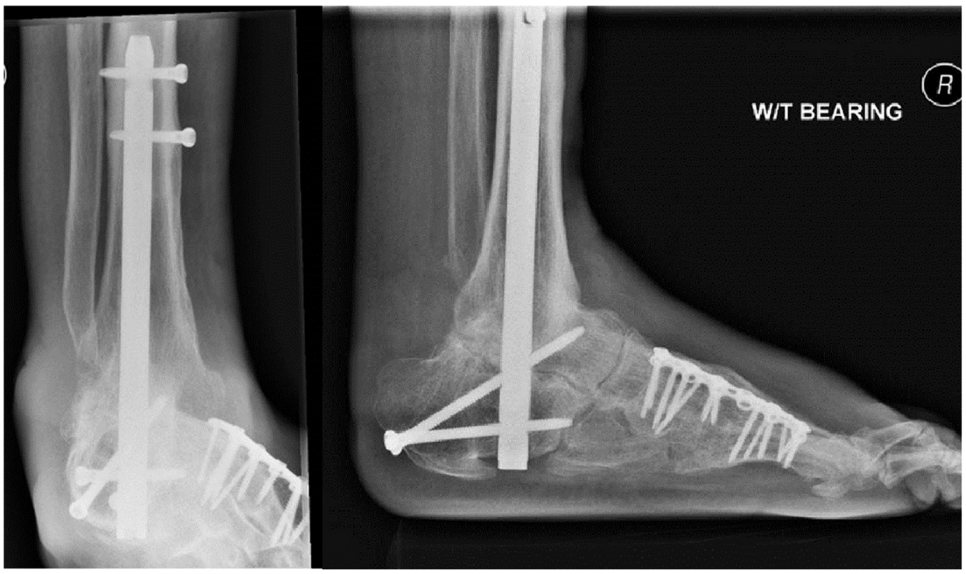

Fig. 4. Post-operative X-rays for case 2.

Fig. 5. Preoperative and post-operative clinical pictures of case 2 showing the correction of varus.

We have been following the classical teaching of intervening in Stage 3 of Eichenholtz [11]. Literature is still sparse regarding the appropriate stage of surgical intervention. Simon et al. have shown good results with early intervention in tarsometatarsal joints but it may be difficult to extrapolate this to the hind foot [12]. Lowery's systematic review shows that literature regarding acute surgical management is inconclusive at this time [9].

There is evidence that in cases where surgery is warranted, arthrodesis is the option with good functional outcomes and most supported in literature [13,14]. Regarding the mode of fixation, there are advantages and disadvantages to both internal and external fixation. Surgical decision-making should come down to the quality of bone and soft tissues and the surgeon's experience or preference [15]. Intramedullary nail serves as a rigid load-sharing device and can resist large forces across the ankle especially with the long lever arm that the foot exerts on this area [16].

Dalla Paola reports 100% limb salvage and 77.8% fusion in a series using hind foot nail but without ulceration [5]. Caravaggi's series of 45 patients had ulcers and the limb salvage rate was 86.7% [2]. A smaller series with 21 patients, 8 of which had chronic ulcers reported a limb salvage of 95.2% and fusion rate of 90.5% [16]. DuVries series of 45 feet included 12 with ulceration and they had an amputation rate of 22% [4].

Our series shows that single stage deformity correction and fusion with a hind foot nail is an effective technique in this difficult cohort of patients. With 55% of our patients having had chronic

ulcers, we achieved 100% limb salvage initially, 100% deformity correction and 83% ulcer healing. 83% of patients were able to mobilize in custom-made footwear and return to activities of daily living.

This is a very demanding treatment regime and should be under the supervision of a highly skilled multidisciplinary team especially as this cohort of patients often has multiple co morbidities and consequently are high risk for major surgery. The neuropathy, vasculopathy and poor tissue oxygenation consequent to the diabetes puts these patients at high risk for wound problems [17,18]. Correction of deformity and stabilization, meticulous wound management and the pressure-offloading regimes are crucial to ulcer healing. We had 2 patients with recurrent ulcers due to prominent metalwork, which healed after metal removal.

Subsequent to their use in trauma and deformity correction, the use of external fixation has become increasingly popular in the management of Charcot deformity. Pinzur and Kelikia report a series of 178 patients with a limb salvage rate of 95.7%. 62% of their patients achieved ulcer healing after surgery [19]. There have been other series with reported limb salvage rates of around 90%. DeVries compared the use of IM nail alone and in combination with a frame and concludes that the combination adds extra stability with the construct [4].

Our study shows that IM nail alone can produce good results while avoiding problems such as pin site complications and poor patient compliance associated with an external fixator [20,21].

In Charcot feet, the bone fusion times following surgical reconstruction are often prolonged, and as a result, the durability of fixation is crucial. The hind foot nail used in our series has threaded distal screw holes to reduce the risk of screw migration through telescoping mechanism. We initially used the standard non-HA coated screws for the first few cases in our series and subsequently used HA coated screws following a few incidences of screw migration [7]. Screw migration was observed 6 months post-operatively for the cases where non-HA coated screws were used. This phenomenon has been explained in mechanical engineering as rotational loosening in bolted joints due to cyclic transverse loading [22,23]. In HA coated screws the bone apposition increases the loosening threshold as well as increasing the torque of introduction and extraction [24].

The surgical procedure above forms only a link in the chain of events in the patients' journey to the final outcome. Following such complex reconstructive procedures, close monitoring and input from a multi-disciplinary team is crucial. This is most successful in specialized units in a tertiary care setting.

The main drawback of our study is that it is a case series without a comparative group. But a randomised trial for a condition such as this will be challenging and may raise ethical issues.

To conclude we report satisfactory outcome for corrective fusion of severe deformities of ankle and hind foot in CN treated with an intramedullary nail. We were able to achieve the goals that we set namely ulcer healing, limb salvage, deformity correction and return to independent activities of daily living.

Conflict of interest

No authors have any conflicts of interest related to this study.

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