

The prevalence of symptomatic venous thromboembolism in patients requiring total contact casting for neuropathic foot complications

Declan Doherty, Andy Bridgen, Aaron Barber and Frank Webb

Citation: Doherty D, Bridgen A, Barber A, Webb F (2022) The prevalence of symptomatic venous thromboembolism in patients requiring total contact casting for neuropathic foot complications. *The Diabetic Foot Journal* 25(4): 50–6

Key words

- Bohler walker
- Charcot neuroarthropathy
- Total contact cast
- Ulceration
- Venous thromboembolism

Article points

1. There is little evidence on the risk of venous thromboembolism (VTE) associated with a total contact cast (TCC).
2. This study aimed to investigate the rate of symptomatic VTE in neuropathic patients with a TCC.
3. The use of TCC did not increase the prevalence of VTE in this patient cohort.

Authors

Declan Doherty is Trainee in Podiatric Surgery, Buxton Hospital, Buxton, Derbyshire, UK; Andy Bridgen is Senior Lecturer in Podiatry and Postgraduate Course Leader, University of Huddersfield, Huddersfield, UK; Aaron Barber is Lead Podiatrist in Diabetes, Diabetes Centre, Barnsley Hospital, Barnsley, UK; Frank Webb is Consultant Podiatric Surgeon, Buxton Hospital, Buxton, UK.

The total contact cast (TCC) is considered the gold-standard treatment for plantar neuropathic ulceration and acute Charcot neuroarthropathy. There is little evidence on the risk of venous thromboembolism (VTE) associated with TCC treatment. It is widely accepted that routine VTE chemoprophylaxis is not required for neuropathic patients treated with a TCC. Aims: This study aimed to investigate the rate of symptomatic VTE in neuropathic patients with a TCC and to provide up-to-date information to guide future practice. Methods: A retrospective service evaluation was undertaken. The PASCOM-10 online database was utilised for data collection within a community-based podiatric surgery unit. Patients treated with a TCC or TCC with Bohler walker for plantar ulceration or Charcot neuroarthropathy between 2019 and 2021 were identified. Data were reviewed to ascertain if any evidence of symptomatic VTE had been recorded during casting. Results: A total of 53 casting episodes in 40 patients were included. All patients had a diagnosis of peripheral neuropathy. The mean length of time in a cast was 51 days (range 14–161 days). No episodes of total contact casting resulted in a symptomatic VTE. Conclusion: The use of TCC did not increase the prevalence of VTE in this patient cohort. Larger, prospective studies are warranted to further investigate VTE risk in neuropathic patients treated with a TCC and the theorised VTE protective mechanisms in this patient population.

The International Working Group for the Diabetic Foot recommends use of a total contact cast (TCC) as the primary choice of treatment to offload a neuropathic diabetic foot ulceration (Bus et al, 2020). In patients with Charcot neuroarthropathy (CN), a TCC is commonly used to immobilise the foot and prevent further destruction in the inflammatory phase (Griffiths and Kaminski, 2021). This involves the patient being placed in a below-knee cast, often for a prolonged period of time.

Lower-limb immobilisation is associated with a markedly increased risk of venous thromboembolism (VTE), a major cause of

morbidity and mortality. It is the most commonly potentially preventable cause of VTE in the 18–65 age group (Braithwaite et al, 2017). The risk is due to the immobilisation of the calf and lack of ankle mobility, creating potential for venous stasis (Aufwerber et al, 2019). The National Institute for Health and Care Excellence (2018) recommends VTE chemoprophylaxis for people undergoing lower-limb immobilisation whose risk of VTE outweighs their risk of bleeding.

However, it is widely accepted that routine VTE chemoprophylaxis is not required for neuropathic patients treated with a TCC. Tonge et al (2019) theorised that weightbearing through the cast



Figure 1: A total contact cast.

could keep the calf muscle pump active and prevent venous stasis. King et al (2017) proposed that the arteriovenous shunting associated with CN may be protective in those who are kept non-weightbearing in a cast. These factors are theoretical and have yet to be proved. There is also no available local or national protocol on the need for VTE chemoprophylaxis in patients treated with a TCC for neuropathic foot complications.

Despite the paucity of evidence, we do not routinely use VTE chemoprophylaxis in neuropathic patients being treated with a TCC within our service. This has created a dilemma as to whether it is justifiable to omit VTE chemoprophylaxis in this patient cohort. There is a clear need for investigation and research into this area in order to inform clinical practice, both locally and nationally. This service evaluation aims to investigate the prevalence of symptomatic VTE in neuropathic patients who undergo an episode of total contact casting.

Materials and methods

A retrospective service evaluation was performed for any patient with peripheral neuropathy who had been placed in a TCC or a TCC with Bohler walker for the treatment of plantar ulceration or CN.

TCCs act in the treatment of neuropathic ulceration and CN by providing protection from further trauma and deformity, reducing oedema, immobilisation to help bone and soft tissue healing, redistribution of pressure and by provided protected weightbearing (Griffiths and Kaminski, 2021, Sahu et al, 2018). A TCC is a rigid or semi-rigid anatomically moulded cast which extends from the patient's foot to below the knee (Figure 1).



Figure 2: A Bohler walker.

A Bohler walker frame is a non-invasive frame with a curved platform on the sole that is fitted onto a standard below-knee cast (Figure 2). The frame is applied so that a space is created beneath the plantar surface of the cast and the walking surface (Berwin et al, 2015). This allows the foot to be completely raised off the ground during ambulation (Venkatakrishnan et al, 2019).

It was decided to differentiate between those treated with TCC alone and TCC with Bohler, due to the difference in weightbearing through the cast.

All data was collected from data in the PASCUM-10 database from a single NHS podiatric surgery unit. PASCUM-10 is a web-based, anonymised audit and service evaluation instrument owned by the College of Podiatry (Maher, 2016). The unit started collecting data for this patient cohort in September 2019. The data collected included: age, gender, BMI, cause of neuropathy, comorbidities, reason for casting, type of cast, length of time in a cast, casting episode outcome, if the patient was taking anti-coagulation medication, whether VTE chemoprophylaxis was used and if a symptomatic VTE was recorded.

A "casting episode" was defined as any period that a patient was placed in a TCC. The episode was defined as complete when the cast was removed. A

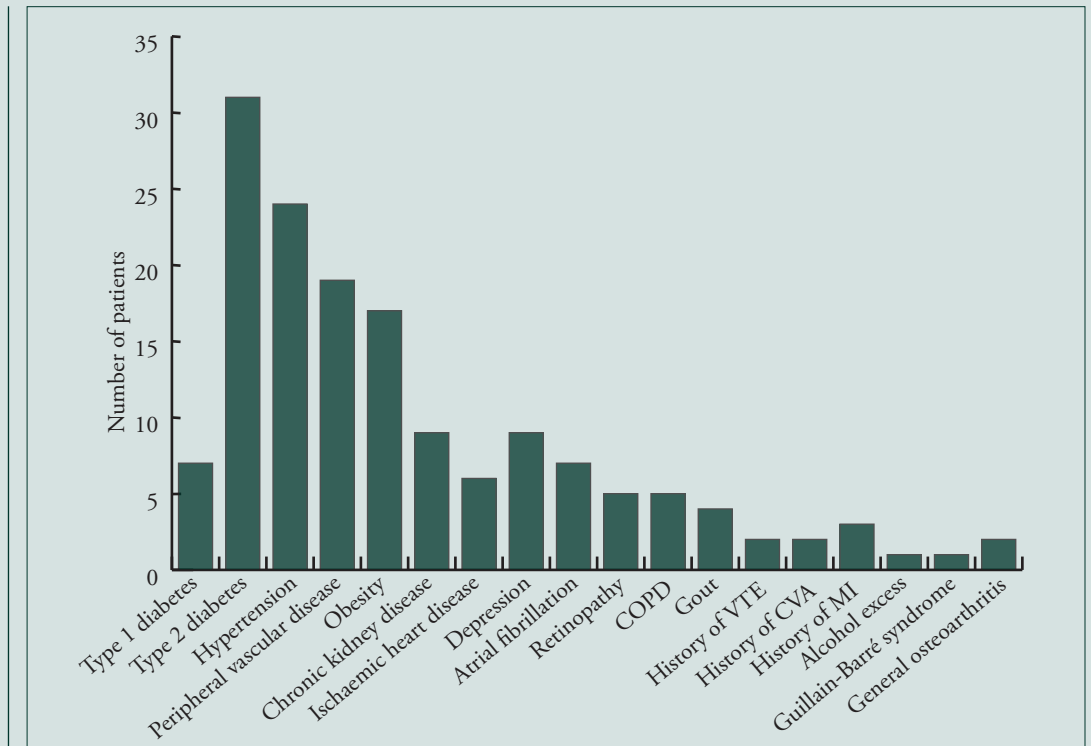


Figure 3: Co-morbidities in the study sample.

separate casting episode was recorded if the patient had at least 2 weeks out of the cast prior to cast reapplication, similar to the protocol applied by Tonge et al (2019). Peripheral neuropathy was diagnosed using the 10g monofilament test.

Wound assessment was carried out at each change for those treated for ulceration. Treatment monitoring for those treated for CN was carried out at each cast change. The resolution of active CN was determined based on the resolution of acute swelling, redness and warmth, and a dermal temperature differential $<2^{\circ}\text{C}$ across the previously mentioned anatomical sites when compared to the unaffected limb (Griffiths and Kaminski, 2021).

Data analysis was completed using PASCOM-10 and Microsoft Excel. Descriptive statistics were used to analysis patient demographics and relevant outcome measures. To further analyse the data, the sample was split into two groups: those on long term anticoagulation therapy and those on no anticoagulation therapy.

Ethics committee approval

Ethical approval was gained from the local NHS trust to allow access to the PASCOM-10 database.

Ethical approval was also gained from the University of Huddersfield Course Ethics Panel upon submission of a research proposal for this study. Informed consent was given for the use of the photographs.

Results

A total of 53 casting episodes in 40 patients were identified. Thirty-six patients (90%) were men, and four patients (10%) were women. The mean age at the time of casting was 60.2 years (range 41–79 years). All patients had peripheral neuropathy diagnosed prior to initiating the casting episode. Thirty-eight patients (95%) had peripheral neuropathy secondary to diabetes, one patient (2.5%) due to alcohol excess and one patient (2.5%) due to a complication from spinal surgery. The comorbidities are shown in Figure 3. The mean length of time of time in a cast was 51 days (14–161 days, median 42 days). Figure 4 shows the spread of casting episode lengths in the patient cohort. The cohort was split into the Anticoagulation group ($n=20$) and No Anticoagulation group ($n=33$). These groups were further divided based on whether casting treatment was being used to treat Charcot or Ulceration: Anticoagulation Ulceration Subgroup ($n=12$), Anticoagulation Charcot Subgroup ($n=8$),

Anticoagulation Ulceration Subgroup ($n=22$) and No Anticoagulation Charcot Subgroup ($n=11$).

Anticoagulation group

In the anticoagulation group, 18 patients underwent 20 casting episodes. No episodes of symptomatic VTE were identified. The mean BMI in this group was 28.9. Nine patients were on long-term antiplatelet therapy: clopidogrel ($n=5$) and aspirin ($n=4$). Nine patients were on long-term anticoagulation therapy: warfarin ($n=2$), edoxaban ($n=3$), rivaroxaban ($n=2$) and apixaban ($n=2$). Twelve casting episodes were used to treat ulceration and eight casting episodes were used to treat CN.

In the ulceration subgroup, TCC alone was applied in 9 episodes, and TCC and Bohler walker in 3 episodes. Table 1 summarises the outcomes of the casting episodes in this subgroup.

In the Charcot subgroup, TCC alone was applied in seven episodes, and TCC and Bohler in one episode. Table 2 summarises the outcomes of the casting episodes in the Charcot subgroup.

No anticoagulation group

Twenty-two patients underwent 33 casting episodes in this group. No episodes of symptomatic VTE were identified. The mean BMI in this group was 29.5. Twenty-two casting episodes were used to treat ulceration and 11 casting episodes were used to treat CN.

Table 3 summarises the outcomes of the casting episodes in the ulceration subgroup, and Table 4 summarises the outcomes in the Charcot subgroup. In the ulceration subgroup, TCC alone was applied in 14 episodes, and TCC and Bohler Walker in eight episodes. Table 3 summarises the outcomes of the casting episodes in the ulceration subgroup.

In the Charcot subgroup, TCC alone was applied in five episodes, and TCC and Bohler in six episodes. Table 4 summarises the outcomes of the casting episodes in the Charcot group.

Discussion

In this retrospective service evaluation, no episodes of TCC casting resulted in symptomatic VTE. Notably, 33 casting episodes involved patients who did not receive VTE chemoprophylaxis or who were not on long-term anticoagulation. There is no consensus within the literature as to why this might be the case

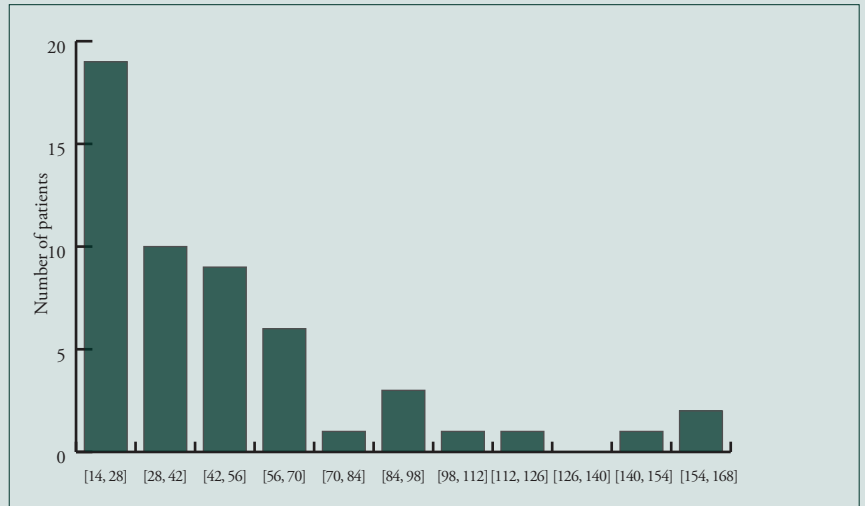


Figure 4: Casting episode length. This histogram shows the spread of casting episode lengths in the patient cohort; e.g. (14,28) = (14–28 days).

Table 1. Outcomes of the casting episodes in the ulceration subgroup of the anticoagulation group.

Treatment	Episode length	Episode outcome
TCC	35 days	Ulcer healed
TCC	21 days	Ulcer healed
TCC	91 days	Ulcer healed
TCC	28 days	Ulcer healed
TCC	56 days	Ulcer healed
TCC	119 days	Ulcer healed
TCC	91 days	Decision to operate (osteomyelitis)
TCC	14 days	Decision to operate (osteomyelitis)
TCC	56 days	Patient requested cast holiday
TCC and Bohler	84 days	Removed in hospital (heart failure)
TCC and Bohler	21 days	Removed in hospital (hypo)
TCC and Bohler	32 days	Decision to operate (no improvement)

Table 2. Outcomes of the casting episodes in the Charcot subgroup of the anticoagulation group.

Treatment	Episode length	Episode outcome
TCC	161 days	Active stage resolved
TCC	147 days	Active stage resolved
TCC	161 days	Active stage resolved
TCC	56 days	Active stage resolved
TCC	28 days	Active stage resolved
TCC	21 days	Active stage resolved
TCC	28 days	Patient requested cast holiday
TCC and Bohler	42 days	Active stage resolved

Table 3. Outcomes of the casting episodes in the ulceration subgroup of the no coagulation group.

Treatment	Episode length	Episode outcome
TCC	42 days	Ulcer healed
TCC	21 days	Ulcer healed
TCC	112 days	Ulcer healed
TCC	63 days	Ulcer healed
TCC	70 days	Ulcer healed
TCC	14 days	Ulcer healed
TCC	49 days	Ulcer healed
TCC	38 days	Ulcer healed
TCC	14 days	Removed due to infection
TCC	14 days	Removed due to infection
TCC	70 days	Patient requested cast holiday
TCC	14 days	Patient requested cast holiday
TCC	21 days	Patient requested cast holiday
TCC	35 days	Patient requested cast holiday
TCC and Bohler	21 days	Ulcer healed
TCC and Bohler	42 days	Ulcer healed
TCC and Bohler	56 days	Ulcer healed
TCC and Bohler	42 days	Ulcer healed
TCC and Bohler	28 days	Patient requested cast holiday
TCC and Bohler	56 days	To allow more dressing changes
TCC and Bohler	49 days	To allow more dressing changes
TCC and Bohler	21 days	To allow more dressing changes

Table 4. Outcomes of the casting episodes in the Charcot subgroup of the no coagulation group.

Treatment	Episode length	Episode outcome
TCC	56 days	Active stage resolved
TCC	40 days	Active stage resolved
TCC	14 days	Active stage resolved
TCC	70 days	Active stage resolved
TCC	49 days	Ulceration and infection
TCC and Bohler	28 days	Active stage resolved
TCC and Bohler	91 days	Active stage resolved
TCC and Bohler	28 days	Active stage resolved
TCC and Bohler	63 days	Active stage resolved
TCC and Bohler	35 days	Patient requested cast holiday
TCC and Bohler	70 days	Patient requested cast holiday

and why neuropathic patients do not require VTE chemoprophylaxis when undergoing casting.

Tonge et al. (2019) hypothesised that weightbearing through a TCC may keep the calf muscle pump active and thus prevent a deep vein thrombosis (DVT). This theory was based on a study by Hickey et al (2014), who assessed calf muscle pump, via Doppler scanning of the popliteal vein, following a simple exercise programme in healthy volunteers treated with a lower-limb cast. They found that toe and ankle extension and flexion exercises did significantly increase mean systolic velocity in the popliteal vein. However, they did not perform any measurements while the participants were weightbearing or during gait.

King et al. (2017) suggested that the arteriovenous shunting associated with CN may be acting as protection against VTE while in a TCC. In CN, sympathetic vascular denervation increases local arteriovenous shunt flow and unregulated shunts increase venous pressure (Kaynak et al, 2013).

These two theories do not explain why patients without CN who are non-weightbearing in a cast did not develop a DVT.

In this study, 10 patients were treated with TCC and Bohler walker for ulceration and did not receive any VTE chemoprophylaxis or were not on long-term anticoagulation. The addition of the Bohler walker leads to the casted limb being suspended above the ground; thus the limb is effectively non-weightbearing. None of these patients suffered a symptomatic VTE while undergoing casting.

Further investigation is required to evaluate the risk of VTE in patients treated with TCC and Bohler specifically, as there is paucity in the literature about the use of Bohler walkers.

In this study, 20 casting episodes were used for the treatment of ulceration. Piaggese et al (2016) found a mean healing time of 37 days in 19 patients treated with TCC for neuropathic diabetic foot ulceration. In a similar study, Lavery et al (2015) found a mean healing time of 5.4 weeks (approximately 38 days). The mean time to healing was 54 days in TCC alone. This shows a longer healing time when compared to the studies by Lavery et al (2015) and Piaggese et al (2016). However, factors such as ulceration site, ulceration size and infection history were not considered which could affect healing time. Four TCC and Bohler casting episodes resulted in full ulceration healing.

Across the whole sample, 19 casting episodes were used for the treatment of active CN. Fifteen

episodes (79%) resulted in resolution of active CN. Ten episodes of TCC alone led to a resolution of active CN. The mean length of time leading to resolution was 75.4 days. The median episode length was 56 days.

In a retrospective review of 27 patients, Griffiths and Kaminski (2021) found a median TCC duration of 4.3 months (approximately 130 days) for resolution of acute Charcot foot. The shorter episode length in our study may be due to a smaller sample. It does show that within our service, TCC is effective in the treatment of active CN. Five TCC and Bohler casting episodes resulted in resolution of active CN.

In total, 20 casting episodes ended without achieved the desired outcome of ulceration healing or resolution of active CN. Two patients were admitted to hospital while in a TCC and Bohler and the casts were removed upon admission. No evidence of DVT or pulmonary embolism was found. Sadly, one patient subsequently died in hospital from heart failure. It was noted that the cast immobilisation was not a factor in the death.

Nine casting episodes ended due to the patient requesting a break from being in a cast. The cast holidays usually last for 1–2 weeks and then casting is recommenced. Five episodes ended due to the presence of active infection, two of which required surgery for osteomyelitis. One episode resulted in surgical intervention because casting had failed to sufficiently improve the wound. Three episodes ended due to the need for more regular dressing changes.

Limitations

Limitations of this study include small sample size, short study period and flaws due to the methodology. A much larger sample size and longer study period is required to provide better recommendations on VTE risk with TCC use. Being a service evaluation, the study is limited to only provide information which is useful to the service being evaluated and it cannot be extrapolated for the general population.

Conclusion

In this service evaluation, there were no occurrences of VTE recorded as a result of the use of TCC in neuropathic patients treated for ulceration or CN. Therefore, it could be claimed that the incidence of VTE in this cohort is probably no higher than the

general population. Nevertheless, studies with a much larger population are required before any lack of association can be proved.

It is recommended that a full VTE risk assessment is carried out for each patient prior to casting and if required, then VTE chemoprophylaxis should be considered. Further studies are required to fill the gaps in the evidence regarding this aspect of TCC treatment, notably a large-scale, prospective study to specifically examine the prevalence of VTE in patients treated with TCC. Additionally, further study is required into the protective mechanisms that have been hypothesised in previous studies, such as activation of the calf pump during weightbearing in a TCC and arteriovenous shunting in CN. Ultimately, guidelines produced for clinicians involved in TCC treatment would be extremely useful. ■

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1. When using a Bohler walker to offload the foot, the weight of the limb is suspended from which anatomical site? Select ONE option only.
 - A. Fibular head
 - B. Ischial tuberosity
 - C. Lateral malleolus
 - D. Medial femoral condyle
 - E. Tibial plateau
2. In which of the following situations is it appropriate to treat a deep diabetic foot ulcer with casting? Select ONE option only.
 - A. Critical limb ischaemia
 - B. Deep tissue cellulitis
 - C. Ulcer duration <6 weeks
 - D. Foot abscess
 - E. Osteomyelitis
3. Which long-term complication of diabetes is the most costly for healthcare systems? Select ONE option only.
 - A. Cerebrovascular disease
 - B. Foot ulceration
 - C. Ischaemic heart disease
 - D. Peripheral neuropathy
 - E. Visual impairment
4. When walking, which mechanical force is most likely to cause diabetic foot ulceration? Select ONE option only.
 - A. Compressive
 - B. Frictional
 - C. Rotational
 - D. Vertical
 - E. No single force more likely
5. How much does total contact casting reduce plantar pressure, according to Lavery et al (1996)? Select ONE option only.
 - A. 10%
 - B. 30%
 - C. 50%
 - D. 70%
 - E. 90%
6. When the proximal cast wall carries loading during ambulation, where is the force transferred to? Select ONE option only.
 - A. Calcaneum
 - B. Fibula
 - C. Hallux
 - D. Talus
 - E. Tibia
7. Instability at which one of the following joints in a person with Charcot neuroarthropathy has the highest risk of amputation? Select ONE option only.
 - A. Calcaneocuboid
 - B. Interphalangeal
 - C. Metatarsophalangeal
 - D. Navicular-cuneiform
 - E. Subtalar
8. According to Lavery et al (2015), what approximate percentage of diabetic foot ulcers heal using total contact casting? Select ONE option only.
 - A. 1–25%
 - B. 26–50%
 - C. 51–75%
 - D. 76–100%
9. A 73-year-old man has developed acute Charcot neuroarthropathy of his right foot with no ulceration. X-rays show marked involvement of the 2nd–4th metatarsophalangeal joints. Select ONE option only.
 - A. Achilles tendon lengthening
 - B. Decompressive exostectomy
 - C. External fixation arthrodesis
 - D. Internal fixation arthrodesis
 - E. Offloading with Total Contact Cast
10. A 69-year-old man with type 2 diabetes, diabetic neuropathy and obesity has developed a progressively deformed foot over the past 3 months with a noticeable bony plantar prominence. He has had two plantar ulcers around this area despite appropriate footwear, although his skin is currently intact and non-infected. Which is the single most appropriate treatment? Select ONE option only.
 - A. Achilles tendon lengthening
 - B. Exostectomy
 - C. Intramedullary midfoot fusion
 - D. Total contact cast
 - E. Transtibial amputation