

Prevention of avascular necrosis in displaced talar neck fractures by hyperbaric oxygenation therapy: A dual case report

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ABSTRACT

Talar neck fractures are a rare injury that account for less than 2% of all foot fractures. Displaced fractures are associated with an exceedingly high rate of avascular necrosis (AVN). The incidence of AVN following Hawkins Type 3 fractures of the talar neck may approach 100%, particularly if diagnosis and reduction are delayed. Severe cases may present as pain and disability of the ankle and the subtalar joints due to a talar dome collapse, resulting in degenerative changes that usually require hind foot arthrodesis. We present two cases of traumatic displaced talar neck fractures which were treated surgically more than 2 weeks following injury due to a delay in diagnosis. Both patients underwent hyperbaric oxygen therapy (HBOT) after the operation and neither resulted in AVN of the talus in a three-year follow-up. We suggest that this favorable result may be due to the beneficial effects of HBOT.

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Talar neck fractures are a rare injury,^[1-4] that account for less than 2% of all foot fractures.^[5] Displaced fractures are associated with an exceedingly high rate of avascular necrosis (AVN).^[6,7] The major causes of talar neck fractures associated with AVN are devastating motor vehicle accidents and falls from height.^[2,8]

The incidence of AVN following Hawkins Type 3 fractures of the talar neck (talar neck fracture with dislocations involving the subtalar and ankle joints) may approach 100%,^[9,10] particularly if diagnosis and reduction are delayed.^[1-3]

Severe cases may present as pain and disability of the ankle and the subtalar joints due to a talar dome collapse, resulting in degenerative changes that usually require hind foot arthrodesis.^[11]

We present two cases of traumatic displaced talar neck fractures which were treated with open reduction and internal fixation more than 2 weeks following injury due to a delay in diagnosis. Both patients underwent hyperbaric oxygen therapy (HBOT) after the operation and neither resulted in AVN of the talus in a three-year follow-up. We suggest that this favorable result, despite displacement of the fracture and a delay in diagnosis and treatment, may be due to the beneficial effects of HBOT.

Case History

Case 1

A 29-year-old professional endurance race athlete was injured when he struck a cliff during a parachute jump off Table Mountain in Cape Town, South Africa. The athlete was hanging from a cliff by his canopy strings, 50 m above the ground and was rescued a couple of hours later by a climbing team which took him to the local emergency room.

On examination, the right ankle was markedly inverted, swollen, tender and exhibited a lateral hematoma. He could not bear any weight on it because of the pain. On initial ankle radiography no fracture was seen and a diagnosis of ankle sprain was made for which he was treated with physical therapy.

Ultrasound did not show any major ligamentous injury. Ten days later, due to severe pain, swelling of the hind foot, difficulty in weight bearing and plantar hematoma, he was reevaluated in an orthopedic clinic.

Computerized tomography demonstrated Hawkins Type 3 fracture of the talar neck with the body of the talus dislocated posteriorly and engaged in the posterior facet. The tibial aspect of the tibio-talar joint was not damaged.

The patient went for open reduction and internal fixation 14 days after the injury, using dual medial and lateral approaches and two AO screws. Small bone fragments in the sinus tarsi were debrided. The athlete was treated by non-weight-bearing cast for 6 weeks. Hyperbaric oxygen therapy was initiated, 11 days post operation and 25 days post injury (protocol - five treatments a week, 35 sessions, 2 atmosphere absolute (ATA), 100% O₂, 90 min).

Six weeks post operation (8 weeks post injury) a plain radiograph showed a complete healing of the fracture with no signs of AVN. The cast was removed, physical therapy and swimming were initiated.

Nine weeks post operation the patient started full weight bearing and hydrotherapy was added (walking and running in the water with the "Aqua Jogger" floating belt). Fifteen weeks post operation he resumed full training, free of pain, performing up and downhill jogging, mountain biking, white water kayaking and parachuting. Only the last range of motion of plantar and dorsiflexion and subtalar joint were absent. A few weeks later he was back rock and ice climbing.

On three years follow-up there was full range of motion of the ankle and subtalar joints, free of pain even in strenuous activity. A series of plain radiograph films showed no sign of AVN.

Case 2

A 27-year-old female athlete fractured her talus after falling on her left ankle while rock climbing. The fracture was initially misdiagnosed at the local facility in Turkey and she did not present to our specialist outpatient clinic until Day 18 post injury. A Hawkins Type 2 displaced fracture of the neck of the talus was evident and she was operated on that same day with open reduction and internal fixation. The rehabilitation regimen was the same as the previous case, initiating HBOT 14 days post operation (32 days post injury) under the same protocol.

Six weeks post operation and 9 weeks post injury a plain X-ray showed the fracture to be healed with no sign of AVN.

On a three-year follow-up after the injury she is back to low-level

sport activity due to minor degree of subtalar joint arthrosis but with no signs of AVN on a series of radiograph films.

Discussion

During the administration of HBOT the patient is breathing 100% oxygen intermittently at a pressure greater than 1 ATA, [Figure 1A, B].

Hyperbaric oxygenation of plasma and tissue fluids is the primary aim of HBOT, during which oxygen tension can be increased up to 10-fold (1000%). The oxygen physically carried in the plasma under HBO conditions of 3 ATA is sufficient to keep mammalian organisms alive without hemoglobin-carried oxygen!^[12] With hemoglobin-carried oxygen plus the 10-fold increase in plasma-carried oxygen with HBOT, the blood oxygen content is increased by 125% and the distance oxygen diffuses through tissue fluids increased by a threefold (300%) factor.^[13,14] Optimal tissue oxygen tension enhances osteogenesis and neovascularization which fill the dead space with new bone and promotes soft tissues healing.^[15-17] In addition, HBOT enhances osteoclastic activity assisting removal of necrotic bone^[18] and has a major effect in reducing edema in traumatic crush injuries^[19,20] and compartment syndrome.^[21] These HBOT roles suggest its treatment will lower edema which accompany traumatic injuries^[22,23] and lead to a better fracture recovery.

Hyperbaric oxygen has been shown to be effective in the treatment of early AVN of the femoral head.^[18] Reis *et al.* claimed that the most rapid action of HBOT is the abolition of edema, thereby lowering the intra-osseous pressure, restoring venous drainage and rapidly improving the microcirculation.^[18,19] The elevated PO₂ gradient arising between arterial blood and hypoxic tissue during HBOT, produces an osmotic fluid pump in the desired direction for resolving edema.^[24]

To date, numerous professional athletic teams, including hockey (NHL), football (NFL), basketball (NBA) and soccer (MLS), utilize and rely on the use of hyperbaric oxygen as adjuvant therapy for numerous sports-related injuries acquired from playing competitive sports.^[25]



Figure 1: (A) and (B) Hyperbaric treatment chamber. Unlike early models, the chambers today enable an easy and comfortable treatment environment

There is no data in the literature concerning the prevention of post-traumatic AVN. It is possible that hyperbaric oxygen as a treatment modality which has been shown to restore function and eliminate radiographic evidence of an early AVN of the femur would play an equal role in the prevention of that same entity in displaced fractures of the talus. Many studies concluded that talar neck fractures can complicate to AVN in up to 100% of the cases, according to the degree of injury.^[1,10] The relatively favorable results in a few of these patients have been attributed to immediate operative therapy with open reduction and internal fixation.^[11-4,26,27]

Our cases suggest that with the application of HBOT it is possible that the process leading to AVN is reversible, even when reduction and fixation is delayed.

Both patients fractured their talus abroad and the fracture was misdiagnosed on a plain radiograph film, leading to a delay in the surgical intervention. Hyperbaric oxygen therapy in these two cases was delayed for 11 and 14 days postoperatively (about 1 month post-injury), but neither patient developed AVN [Figures 2 and 3].

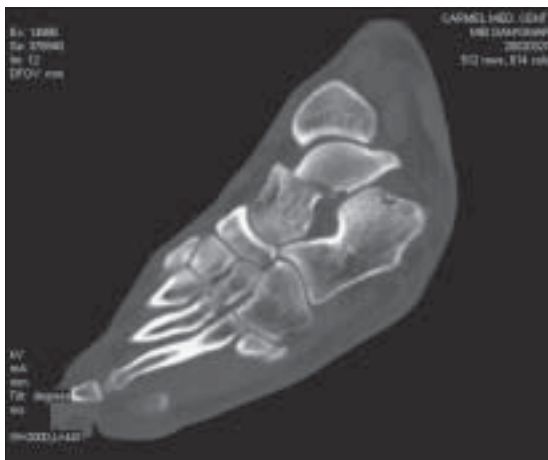


Figure 2: CT sagittal view of a talar neck fracture. A subtalar joint displacement is evident. Additional mild luxation of the tibio-talar joint was seen on CT reconstructions



Figure 3: The same fracture after HBOT. No sign of AVN is seen three years post injury

Further research is needed to confirm these results and verify the mechanisms involved in HBOT and the optimal protocols and timing for initiating such treatment.

In both cases presented the talar neck fracture was displaced for more than 2 weeks. Nevertheless AVN was not evident in a three-year follow-up, clinically and by radiographic examinations, contrary to what is generally expected from such cases, suggesting a beneficial effect of HBOT.

Our cases suggest that resolving bone and soft tissue edema can help in restoring oxygen supply to the bone after the injury, even when major blood vessels supplying the talus are damaged and may therefore decrease the risk of skin necrosis, wound dehiscence, infection and other complications seen in such cases.^[1,28]

The disadvantages of this mode of therapy are the long duration of treatment, its inconvenience (2 h of daily treatment) and its relatively high cost (\$100 to \$400 dollars per treatment^[18,29]) although, if appropriate candidates are carefully identified, this mode of treatment has been shown to significantly reduce the length of the patient's hospital stay, amputation rate and wound care expenses, making it a cost-effective modality.^[30]

Conclusion

Hyperbaric oxygen therapy as adjunct management for displaced talar neck fractures may improve fracture healing and lower the probability for AVN. Hyperbaric oxygen therapy may prevent AVN even after a delay in the surgical treatment and late intervention. We conclude that for compliant and well-motivated people, the addition of HBOT to both operative and rehabilitative therapy may be associated with significantly improved outcomes.

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