

# Distal fibula fractures in professional athletes: carbon plate fixation and accelerated rehabilitation protocol can improve return to play

Fabio Marzilli<sup>1</sup>, Andrea Fidanza<sup>1</sup>, Tommaso Scuccimarra<sup>1</sup>,  
Pierluigi Matri<sup>2</sup>, Edoardo Viglietta<sup>3</sup>, Rocco Erasmo<sup>1</sup>

<sup>1</sup> Santo Spirito Hospital, Pescara, Italy; <sup>2</sup> Department of Life, Health & Environmental Sciences, University of L'Aquila, L'Aquila, Italy; <sup>3</sup> Department of Orthopaedics, Sant'Andrea Hospital, Sapienza University of Rome, Rome, Italy

## SUMMARY

**Objective.** The purpose of this preliminary study is to investigate whether the use of a carbon plate fixation system for distal fibula fracture, applied to an intensive rehabilitation protocol, is a good method to accelerate the return to play of professional athletes.

**Methods.** This is a longitudinal case series with 6 months of total follow-up. Athletes of various sports, each with a minimum Tegner's activity score of 7, who underwent fibular ORIF with carbon fiber plates in our institute for Weber B fracture were considered. The primary outcomes were: return to play (RTP) at the previous level, radiological union, and the complication rate (nonunion, hardware failure, and infection). Secondary outcomes were the AOFAS score, VAS on everyday activities and VAS after sport tested at 1, 2, 3, and 6 months.

**Results.** Considering primary outcomes, the mean RTP measured was 75.64 days  $\pm$  10.96; for the union rate 3 patients satisfied union criteria at 1 month follow-up, 7 at 2 months, and 4 at 3 months. No complication occurred during follow-up.

**Conclusions.** The improved elastic compatibility of the carbon plate, with respect to the bone, allows for an "extended" safety zone to accelerate the patient's rehabilitation and return to a pre-injury athletic level.

**Key words:** carbon plate, elastic fixation, trauma, fibula fracture

## Introduction

Fractures of the distal fibula are particularly common, with an incidence of 100.8 per 100,000 people per year, accounting for an estimated 9% of all fractures <sup>1</sup>. In a recent epidemiological study of athletes who sustained a traumatic lower limb fracture between 2000 and 2016 in the 5 major European soccer leagues (English Premier League, Bundesliga, La Liga, Ligue 1, and Serie A), distal fibula fractures were shown to account for 36% of all lower limb fractures <sup>2</sup>.

Although the incidence of this type of trauma in active athletes is not particularly high, the loss of about  $77 \pm 60$  <sup>3</sup> days from the specific sport affects the career of a high performance athlete. For this reason, it is essential to accelerate the recovery time of athletes as much as possible while maintaining a margin of safety.

Received: April 25, 2022  
Accepted: September 12, 2022

## Correspondence

Fabio Marzilli

Santo Spirito Hospital, Pescara, II piano ala sud, via Fonte Romana 8, 65124 Pescara. Tel. +39 085 425 2779. E-mail: marzillifab@gmail.com

**How to cite this article:** Marzilli F, Fidanza A, Scuccimarra T, et al. Distal fibula fractures in professional athletes: carbon plate fixation and accelerated rehabilitation protocol can improve return to play. Lo Scalpello Journal 2022;36:78-82. <https://doi.org/10.36149/0390-5276-256>

© Ortopedici Traumatologi Ospedalieri d'Italia (O.T.O.D.I.) 2022



OPEN ACCESS

This is an open access article distributed in accordance with the CC-BY-NC-ND (Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International) license. The article can be used by giving appropriate credit and mentioning the license, but only for non-commercial purposes and only in the original version. For further information: <https://creativecommons.org/licenses/by-nc-nd/4.0/deed.en>

Carbon plates for the synthesis of distal fibula fractures have been shown to be as effective as other fixation systems in the treatment with several advantages, especially for the surgeon<sup>4,5</sup>. Based on the assumption that the modulus of elasticity of carbon plates is more similar to that of bone<sup>6-8</sup>, we designed this study to evaluate the extent to which this parameter can be associated with faster patient recovery.

The purpose of this preliminary study is to investigate whether the use of this innovative fixation device, applied to an intensive rehabilitation protocol, is a good method to accelerate the return to play of a professional athlete.

## Materials and methods

This longitudinal study followed all athletes of various sports, each with a minimum Tegner's activity score of 7, who underwent fibular ORIF with carbon fiber plates from January 2019 to January 2021 (during Covid-19 Outbreak<sup>9,10</sup>). All fibula fractures were Weber B. The presence of a syndesmosis lesion was evaluated intra-operatively and treated if present. The presence of other fractures and vascular or nerve lesions were all considered an exclusion criterion. Considering these stringent selection criteria, 14 patients were included in the study (demographic data in Table I). The primary outcomes were: return to play (RTP), even if only at the full level of training, at the previous level (considering Tegner activity score), and radiological union and complication rates (nonunion, hardware failure, and infection). Union was defined as a radiographic sign of linking bone on at least 3 of 4 cortices (medial/ lateral

cortex on anteroposterior view and anterior/posterior cortex on lateral view)<sup>11</sup>. Each fibula was fixated, practicing a direct lateral approach to the fibula, with the CarboFix distal fibula plate (Carbofix Orthopedic Ltd, Herzeliya, Israel). The same trauma team performed all surgical procedures. Secondary outcomes were the AOFAS score, VAS on everyday activities, and VAS after sport (this score was taken at the first follow-up after the RTP). We evaluated all outcomes at 1, 2, 3, and 6 months.

## Post-operative care

All patients followed the same rehab protocol at the same physio kinetic center as follows:

- 0-2 weeks: Walker brace immobilization, antidecline position of the treated lower extremity, and tolerance weight bearing using canes;
- 2-4 weeks: free or tolerance weight bearing on the treated lower limb with walker brace. Daily removal of the brace for progressive recovery of ankle articulation;
- 4-6 weeks: recovery of gait pattern and progressive resumption of non-contact cardiovascular activity, such as cycling and running, and resistance and proprioceptive training. Test and recovery of the specific sport action pattern in water;
- 6-8 weeks: Progressive return to specific sport pattern.

## Results

The mean RTP, measured in days starting from the surgical procedure and calculated until the return to previous fracture activity level, was  $75.64 \pm 10.96$ . Considering the union rate, 3 patients satisfied the union criteria at 1 month follow-up, 7 at 2 months, and 4 at 3 months.

No complications were present in this case series. The continuous variable outcomes are shown in Table II.

## Discussion

The most important finding of this paper is the mean RTP was 75.64 days  $\pm$  10.96, which is acceptable for a young athlete. The radiological results also show rapid healing due, in our opinion, to two factors: one intrinsic and the other extrinsic. The first factor is probably due to the fixation device itself. The potential theoretical advantages of carbon fiber plates over titanium plates have been highlighted in recent studies and reports<sup>4,5,12</sup>. Carbon fibers have a lower Young's modulus of elasticity than metal and therefore provide more uniform loading at the plate-bone interface. Consequently, previous research has suggested that internal fixation of fractures with carbon fiber plates stimulates better healing than metal plates<sup>13</sup>. Metal implants have a high modulus of elasticity (between 110 GPa and 220 GPa) compared to bone (17-20 GPa)<sup>14</sup>. The difference in modulus leads to a stress-shielding effect according to Wolff's

**Table I. Characteristics of patients.**

| Demographic data                          | Athletes |       |
|-------------------------------------------|----------|-------|
| N                                         | 14       |       |
| Gender                                    |          |       |
| Male                                      | 11       | 78.5% |
| Female                                    | 3        | 21.5% |
| Age*                                      | 26       | 4.1   |
| BMI*                                      | 18.8     | 6.2   |
| Side                                      |          |       |
| Right                                     | 9        | 64.2% |
| Left                                      | 5        | 35.8% |
| Sports                                    |          |       |
| Soccer                                    | 7        | 50%   |
| Volleyball                                | 1        | 7.2%  |
| Basketball                                | 4        | 28.5% |
| Martial arts                              | 2        | 14.3% |
| *expressed as mean and standard deviation |          |       |

Table II. Secondary outcomes.

|                   | AOFAS* |      | VAS* |     | VAS after RTP* |
|-------------------|--------|------|------|-----|----------------|
| 1-month follow-up | 75.2   | ± 11 | 3.2  | ± 3 | Not recorded   |
| 2-month follow-up | 88.1   | ± 9  | 2.1  | ± 2 | Not recorded   |
| 3-month follow-up | 92.9   | ± 11 | 1.4  | ± 1 | 2.4 ± 3        |
| 6-month follow-up | 94.4   | ± 9  | 1    | ± 1 | 1 ± 2          |

\*expressed as mean and standard deviation



Figure 1. Ankle of a martial arts fighter before surgery (A,B) and at 1 month follow-up (C,D).

law, describing a biological mechanism in which bone remodels in response to the mechanical stress applied to it so that it is better able to withstand subsequent applied forces. With metal plates, the fractured bone can be shielded from the applied forces, resulting in irregular healing and weaker bones<sup>7,15</sup>. To minimize all these complications, carbon fiber composites have been considered as an alternative material and have been shown to reduce stress shielding<sup>7,13,14</sup>.

A previous study of tibial fractures in a rat model<sup>16</sup> found that carbon fiber plates are a more reliable bone implant material than those made of metal because their density is comparable to that of bone, resulting in better stress transfer, and their electrical properties promote tissue formation. In this study, researchers showed that rats which received carbon fiber rods achieved a greater percentage of bone area (PBA) after 14 days than rats that those receiving titanium alloy implants. For the carbon fiber implant, the PBA was  $77.7 \pm 7.0$  at 0.1 mm from the implant, while the titanium composite implant yielded a PBA of only  $19.3 \pm 12.3$  at 0.1 mm from the implant ( $p < .00000001$ ). These results were also confirmed by image characterization of histologic slides, which showed osteoinductive responses for the carbon fiber implants that were superior to the titanium alloy implants. Large bone formation occurred along the entire surface of the carbon fiber implant, whereas the titanium alloy had only small bone fragments that integrated along the surface of the implant.

Previous studies have shown that carbon fiber implants have better osteointegration compared to metal implants due to their intrinsic biocompatible conductivity<sup>16</sup>.

Considering the fastest recovery and RTP of athletes herein, this is slightly better than that reported by Larsson, Ekstrand and Karlsson<sup>3</sup>.

However, these two values are difficult to compare for several reasons: firstly, the size of the sample; secondly, and in our opinion mainly, the level of the athletes being compared. In Larsson's study, these were all patients from the major soccer leagues, which have an athletic level that is very different from that of the athletes analyzed in this study, which have a much lower Tegner score, although all professionals.

This study has several critical issues: the sample is relatively small and the significant heterogeneity of the sports analyzed does not allow us to make an effective comparison within the group itself. There is no control group with the same fixation device and a standard rehabilitation protocol versus an accelerated one, nor between different plates and the same accelerated RTP protocol.

## Conclusions

In conclusion, the improved elastic compatibility of the carbon plate allows us to achieve an "extended" safety zone to accelerate rehabilitation and return to a pre-injury athletic level.

## Acknowledgements

None.

## Conflict of interest statement

The Authors declare no conflict of interest.

## Funding

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

## Authors' contributions

FM, RE: conceptualization; FM, PM, EV: data curation; FM, TS, AF: writing-original draft preparation; FM, AF: writing-review and editing; RE: supervision. All Authors have read and agreed to the published version of the manuscript.

## Ethical consideration

All patients were treated according to the ethical standards of the Helsinki Declaration, and were invited to read, understand, and sign the informed consent form.

## References

- 1 Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. *Injury* 2006;37:691-697. <https://doi.org/10.1016/j.injury.2006.04.130>
- 2 Lavoie-Gagne O, Gong MF, Patel S, et al. Traumatic leg fractures in UEFA football athletes: a matched-cohort analysis of return to play, reinjury, player retention, and performance outcomes. *Orthop J Sport Med* 2021;9:232596712110242. <https://doi.org/10.1177/23259671211024218>
- 3 Larsson D, Ekstrand J, Karlsson MK. Fracture epidemiology in male elite football players from 2001 to 2013: 'How long will this fracture keep me out?' *Br J Sports Med* 2016;50:759-763. <https://doi.org/10.1136/bjsports-2015-095838>
- 4 Marzilli F, Scuccimarra T, Michelucci F, et al. Longitudinal follow-up of 101 distal fibula fracture treated with carbon plate. *J Orthop Res Ther* 2021;6. <https://doi.org/10.29011/2575-8241.001196>
- 5 Guzzini M, Lanzetti RM, Lupariello D, et al. Comparison between carbon-peek plate and conventional stainless steel plate in ankle fractures. A prospective study of two years follow-up. *Injury* 2017;48:1249-1252. <https://doi.org/10.1016/j.injury.2017.03.035>
- 6 Behrendt P, Kruse E, Klüter T, et al. Winkelstabile karbonverstärkte Polymerkompositplatte zur Versorgung einer distalen Radiusfraktur: Pilotstudie zur klinischen Anwendung. *Unfallchirurg* 2017;120:139-146. <https://doi.org/10.1007/s00113-015-0088-6>
- 7 Bagheri ZS, Tavakkoli Avval P, Bougherara H, et al. Biomechanical analysis of a new carbon fiber/flax/epoxy bone fracture plate shows less stress shielding compared to a standard clinical metal plate. *J Biomech Eng* 2014;136. <https://doi.org/10.1115/1.4027669>
- 8 Wilson WK, Morris RP, Ward AJ, et al. Torsional failure of carbon fiber composite plates versus stainless steel plates for comminuted distal fibula fractures. *Foot Ankle Int* 2016;37:548-553. <https://doi.org/10.1177/1071100715625291>

- <sup>9</sup> Andreozzi V, Marzilli F, Muselli M, et al. The impact of COVID-19 on orthopaedic trauma: a retrospective comparative study from a single university hospital in Italy. *Orthop Rev (Pavia)* 2020;12:210-213. <https://doi.org/10.4081/or.2020.8941>
- <sup>10</sup> Andreozzi V, Marzilli F, Muselli M, et al. Effect of shelter-in-place on orthopedic trauma volumes in Italy during the COVID-19 pandemic. *Acta Biomed* 2021;92:1-7. <https://doi.org/10.23750/abm.v92i2.10827>
- <sup>11</sup> Fidanza A, Rossi C, Iarussi S, et al. Proximal humeral fractures treated with a low-profile plate with enhanced fixation properties. *J Orthop Sci* Published online October 2021. <https://doi.org/10.1016/j.jos.2021.08.008>
- <sup>12</sup> Caforio M, Perugia D, Colombo M, et al. Preliminary experience with Piccolo Composite™, a radiolucent distal fibula plate, in ankle fractures. *Injury* 2014;45:S36-S38. <https://doi.org/10.1016/j.injury.2014.10.020>
- <sup>13</sup> Tarallo L, Mugnai R, Adani R, et al. A new volar plate made of carbon-fiber-reinforced polyetheretherketon for distal radius fracture: analysis of 40 cases. *J Orthop Traumatol* 2014;15:277-283. <https://doi.org/10.1007/s10195-014-0311-1>
- <sup>14</sup> Huang ZM, Fujihara K. Stiffness and strength design of composite bone plates. *Compos Sci Technol* 2005;65:73-85. <https://doi.org/10.1016/j.compscitech.2004.06.006>
- <sup>15</sup> Pinter ZW, Smith KS, Hudson PW, et al. A retrospective case series of carbon fiber plate fixation of ankle fractures. *Foot Ankle Spec* 2018;11:223-229. <https://doi.org/10.1177/1938640017718343>
- <sup>16</sup> Petersen R. Carbon fiber biocompatibility for implants. *Fibers* 2016;4:1. <https://doi.org/10.3390/fib4010001>