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Original Article

Preliminary results of acute Achilles tendon rupture treated with platelet-rich plasma and immobilization

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Abstract

Objective: Evaluate preliminary functional results, return to sport, re-rupture rate of acute Achilles rupture treated with one application of platelet-rich plasma (PRP), and immobilization.

Methods: A prospective analytical study was performed in patients with acute Achilles tendon rupture treated conservatively, associated with a single local application of PRP within 10 days of injury. The sample comprised 28 patients diagnosed and monitored by the same team for a minimum of 12 months. The American Foot and Ankle Society Functional Rating Scale (AOFAS), Achilles tendon total rupture score (ATRS), visual analog scale (VAS), and Achilles tendon resting angle (ATRA) were evaluated, the time of return to sports activities and isokinetic strength were evaluated at the different follow-up times and injury site using magnetic resonance imaging.

Results: The variance analysis of the AOFAS, ATRA, and VAS scores showed a significant difference at six and 12 months regarding the initial score and according to the injury site. The mean time to return to sports activities was 197 days, 85.7% had homogeneous tendons, and heel-rise type 2 was achieved in 28.6% at six months and 60.7% at 12 months.

Conclusion: The protocol proposed by our study for Achilles tendon rupture significantly improved all the scores evaluated compared to the initial condition and the isokinetic evaluations, obtaining even better results in proximal injuries.

Level of Evidence IV; Therapeutic studies investigating the results of treatment; Case series.

Keywords: Platelet-rich plasma; Achilles tendon; Bloodless medical and surgical procedures; Therapeutic treatment.

Introduction

The Achilles tendon is the strongest in the human body; however, ruptures are frequent in both elite and recreational athletes[1,2]. The exact cause of Achilles tendon ruptures is unknown because most patients who suffer a spontaneous rupture never had any symptoms before the rupture, although, studies on Achilles tendon ruptures show that almost all of these subjects have clear degenerative changes, such as hypoxia and mucoid degeneration, poor vascular supply, tissue and cell necrosis, calcification and lipomatosis, and irregular and degenerated collagen fibers[3].

Multiple studies have evaluated the efficiency and complications of treatments for Achilles ruptures. Over time, the "gold standard" for managing this injury has evolved from conservative approaches involving immobilization and functional rehabilitation to various surgical techniques developed over the years. Given the frequency of this injury, controversies remain as to whether its treatment should be surgical or nonsurgical[4].

Scientific evidence indicates a lower rate of re-rupture in surgical treatment, but with similar long-term functional results, with the advantage of nonsurgical treatment of not presenting the complications associated with surgery[3,4,5].

Study performed at the Centro Artroscopico Jorge Batista, CABA, Buenos Aires, Argentina.

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Achilles tendon ruptures are noted for their slow healing process, sometimes preventing an optimal restoration of strength and function to pre-injury levels and delaying the return to sports activity at acceptable times[6]. This issue could be due to the tendon's anatomy, as the proximal and the distal regions are well-supplied by the posterior tibial and peroneal arteries, while the medial portion has the least blood supply and is, therefore, the most challenging to regenerate[7].

When choosing the right treatment, it is important to consider the tendon healing process. Tendon healing usually involves the contribution of cells from multiple sources, primarily in the acute phase of rupture (first 2 weeks of injury), including infiltrating inflammatory cells, tendon surface resident fibroblasts, and tendon- or marrow-derived mesenchymal stem cells. Recent evidence suggests that modulating inflammation early after tendon repair may lead to better healing. It is important to recognize that while inflammation largely benefits tissue repair, excessive or persistent inflammation can be harmful. Inflammatory cytokines attract fibroblasts to the repair site, but excessive inflammation can lead to poor clinical outcomes[7].

Based on the published results, we understand that new techniques are necessary to accelerate these processes, improve healing speed, and return to sports activities.

Platelet-rich plasma (PRP) is used in multiple fields of medicine, particularly in numerous pathologies within orthopedics and traumatology, with its best results in muscle-tendon injuries (Figure 1)[8].

The objective of this study is to evaluate the preliminary functional results, return to sports activities, re-rupture rate of acute Achilles rupture treated with one application of PRP, and immobilization.

Methods

A prospective analytical study was performed in patients with acute complete and partial Achilles tendon ruptures submitted to nonsurgical treatment with walker boot immobilization for six weeks with 2 cm heel enhancement (2 heel pads of 10 mm each), one week without weight-bearing, then partial weight-bearing with crutches, at third week the removal of one heel pad and at fifth week removal of the last heel pad and total weight-bearing, associated with a single local application of PRP within 10 days of injury. A dose of 5 ml of PRP was applied to the injury site visualized under ultrasound guidance (RegenKit®A-PRP, Regenlab SA, Le Mont-sur-Lausanne, Switzerland) (Figure 2).

The sample comprised 28 patients diagnosed and monitored by the same team for a minimum of 12 months. Baseline characteristics such as age, injury mechanism, risk factors for tendon rupture (use of statins, smoking, sedentary lifestyle, etc.), time from the injury to the start of treatment (application of PRP and immobilizer boot), return to sports activities and level of physical activity were recorded.

Magnetic resonance imaging (MRI) of the affected ankle was performed to verify the rupture site (proximal, medial, or distal) and at six and 12 months after the treatment to evaluate the tendon characteristics (Figure 3).

Figure 1. Autologous platelet-rich plasma kit, closed system (RegenKit®A-PRP, Regenlab SA, Le Mont-sur-Lausanne, Switzerland).

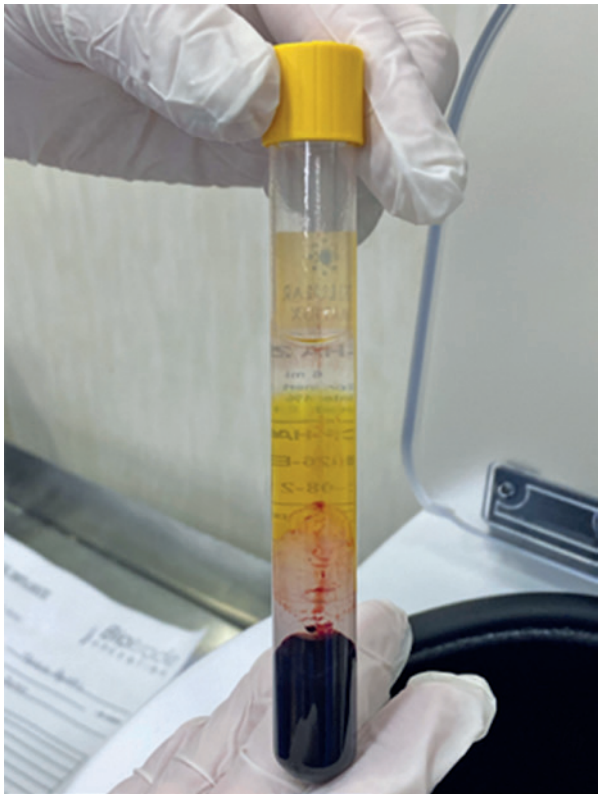

Figure 2. Application under aseptic conditions of 5ml of autologous PRP in the injury site under ultrasound vision.

The functional outcomes of the treated ankle were evaluated by validated scores: The American Foot and Ankle Society Functional Rating Scale (AOFAS), Achilles tendon total rupture score (ATRS), visual analog scale (VAS), and Achilles tendon resting angle (ATRA) (Figure 4).

The strength of the treated ankle compared to the healthy one was measured through an isokinetic evaluation. The heel-rise test was used to compare both sides and classify functionality as weak, mild positive (less than the healthy side), and normal (equal to the healthy side).

In the follow-up period, the tendon healing was evaluated with MRI (Figure 5). Before treatment, the injury site (proximal, medial, or distal) was classified according to the Chang classification[9], and at six and 12 months, the tendon condition was evaluated by assessing the presence of any gap, in addition to the homogeneity and heterogeneity of the tendon.

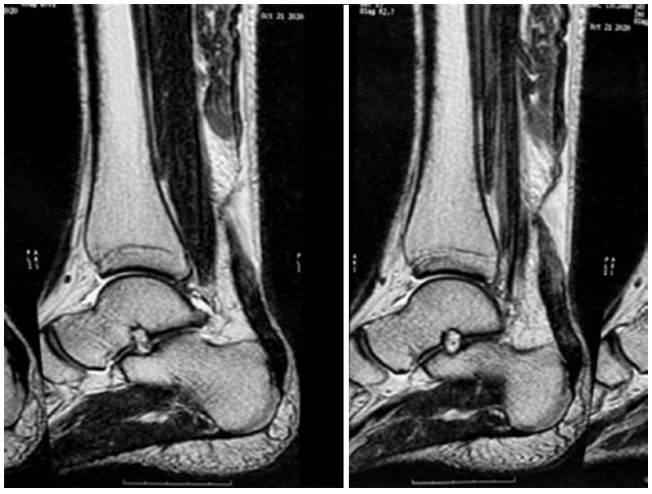

Figure 3. Magnetic resonance imaging (sagittal section) where a complete Achilles tendon rupture in its medial area is visualized.

The score differences, the time to return to sports activities, and isokinetic strength were evaluated at the different follow-up times and injury site (MRI) through variance analysis with mixed models (design of repeated measures) and the t-student test for paired samples. The time of evolution (initial, six, and 12 months) and injury site were defined as predictor variables. Homoscedasticity and normality were verified by graphical methods and with the Shapiro-Wilks test. Post-hoc comparisons between groups were obtained by Tukey's method.

The association between paired categorical variables with more than three categories was evaluated by Stuart Maxwell's marginal homogeneity test and Fisher's test in those not paired.

The tests with $p < 0.05$ and 95% confidence level were considered significant. Data analysis was conducted with R Studio statistical software (R core team, 2022).

Results

Table 1 summarizes the demographic, clinical characteristics, risk factors, times until the procedure, and return to sports activity.

Functional scales according to follow-up time

The variance analysis of the AOFAS, ATRA, and VAS scores showed a significant difference at six and 12 months compared to the initial score. As for the ATRS, the means increased significantly and progressively over the follow-up time. The data are shown in Tables 2 and 3. Comparisons between the different Tukey follow-up times revealed at what times these scales differ during follow-up. The p-values and magnitude of the effect are shown in Figure 6.

The isokinetic strength of the affected ankles compared to the healthy side at six months was contrasted with the strength at 12 months through a t-student test, revealing a statistically significant difference ($p < 0.001$). This comparison showed that the mean strength at six months was 7.1% to 13.2% lower than that recorded at 12 months (Figure 7).

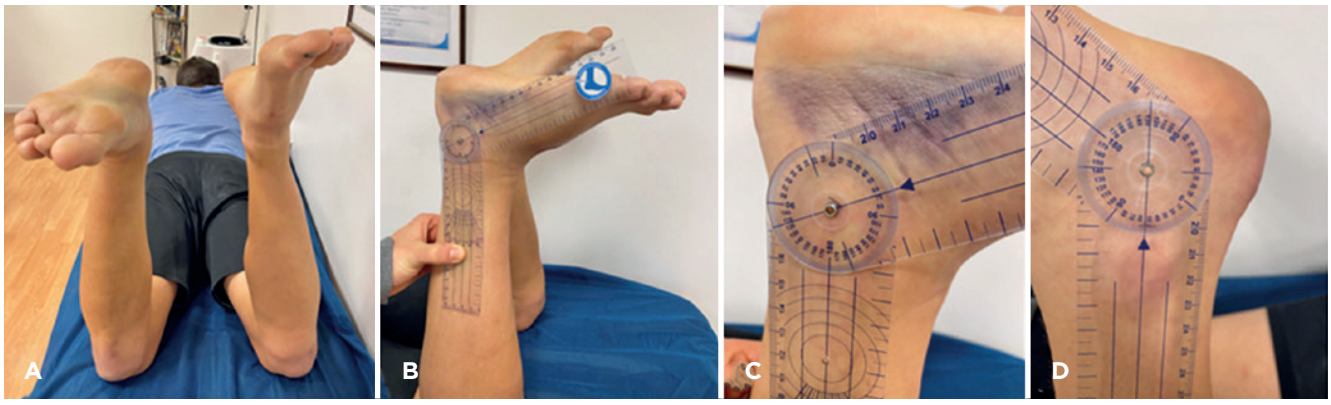

Figure 4. Achilles tendon rupture angle (ATRA) measurement images in patients with left Achilles tendon rupture.

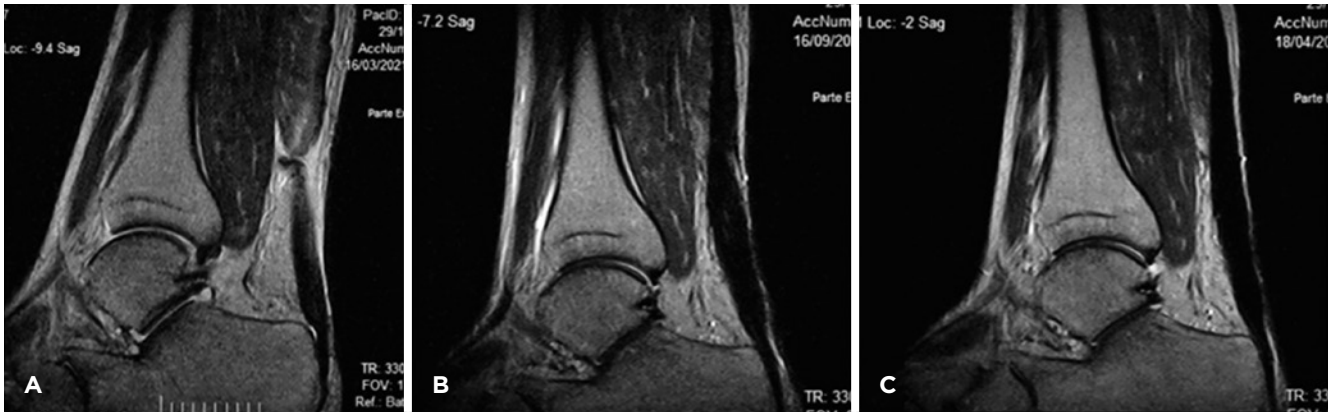

Figure 5. (A) Magnetic resonance imaging (sagittal section) where the Achilles tendon rupture in its medial area is visualized. (B) Image of the same patient six months after conservative treatment and PRP. (C) Image of the same patient at 12 months postoperative.

Table 1. General characteristics of the sample

	Overall (n = 28)
Age	
Mean (SD)	46.7 (11.6)
Median [Min, Max]	44.5 [26.0, 73.0]
Days from injury to infiltration	
Mean (SD)	4.21 (3.07)
Median [Min, Max]	3.50 [0, 10.0]
Return to sports activity in days	
Mean (SD)	197 (57.7)
Median [Min, Max]	177 [148, 439]
Risk Factors	
0	15 (53.6%)
1	8 (28.6%)
2	1 (3.6%)
3	4 (14.3%)
Level of physical activity	
Active	26 (92.9%)
Inactive	2 (7.1%)
Sex	
Male	25 (89.3%)
Female	3 (10.7%)
Laterality	
Right	16 (57.1%)
Left	12 (42.9%)

*Risk factors: smoking, overweight, hypothyroidism, use of statins drugs.

Table 2. Functional scales and Achilles tendon resting angle

	AOFAS	VAS	ATRS	ATRA	Isokinetic strength
Statistic F	566.72	118.37	861.13	70.63	47,997
p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

AOFAS: The American Foot and Ankle Society Functional Rating Scale; VAS: Visual analog scale; ATRS: Achilles tendon total rupture score; ATRA: Achilles tendon resting angle.

Table 3. Functional scores and isokinetic results

	AOFAS	ATRA	ATRS	Isokinetic strength
Preoperative	52.7 (7.68)	55.5 (8.02)	17.7 (5.16)	
6 months	91 (7.51)	46 (6.78)	86.5 (12.1)	-0.205 (0.105)
12 months	94 (7.09)	45.2 (7.1)	93.7 (8.07)	-0.104 (0.09)

AOFAS: The American Foot and Ankle Society Functional Rating Scale; ATRA: Achilles tendon resting angle; ATRS: Achilles tendon total rupture score.

Functional scales according to injury site and risk factors

The analysis of the marginal effects revealed a significant difference according to the injury site for AOFAS, VAS, and ATRS, showing better results in the group with proximal Achilles tendon rupture. No differences were found between patients with and without risk factors (Table 4). In the ATRA score, there was no significance for either variable. The p-values and effect magnitudes are shown in Figure 8.

Return to sports activities

The mean of return to sports activities was 197 days, with no significant difference in time according to the injury site (p = 0.59) and risk factors (p = 0.48).

Relationship between heel-rise and MRI findings

Differences in MRI findings of the injured ankle were evaluated at six and 12 months. At six months, only one patient did not present homogeneity (GAP), and 85.7% presented homogeneous tendons with some areas of heterogeneity, without clinical relevance (scores altered or pain). At 12 months, 89.2% had homogeneous and continuous tendons. The proportion of tendon functionality equivalent to the healthy side (Heel-rise type 2) was achieved at 28.6% at six months and 60.7% at 12 months. This difference was statistically significant in the Stewart-Maxwell test (p = 0.024).

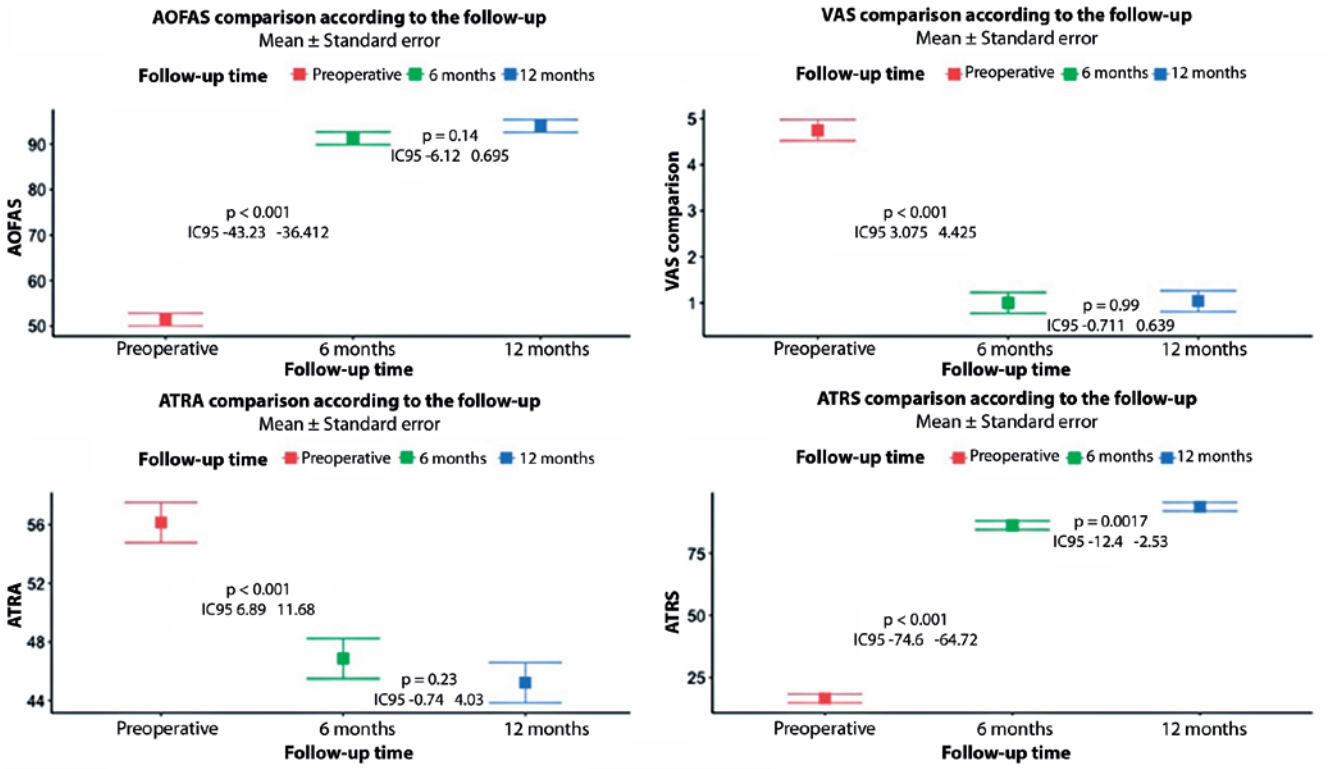

Figure 6. Scales comparisons according to follow-up time.

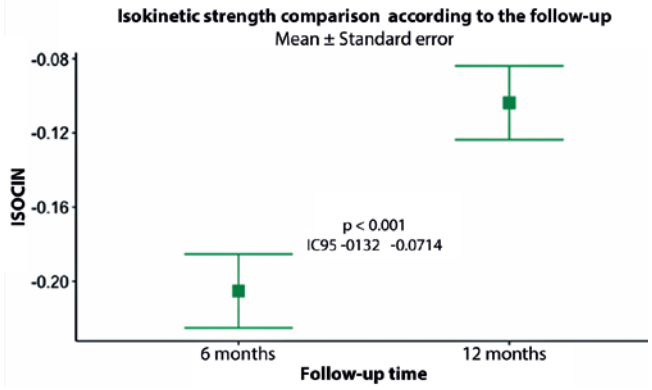

Figure 7. Isokinetic strength at six and 12 months.

Table 4. Association of risk factors with re-rupture

	OR	p-value
Sedentary lifestyles	0 (0 - 99.9)	0.99
Dyslipidaemia	3 (0.03 - 257)	0.45
High blood pressure	0 (0 - 29.7)	0.99
Overweight	7 (0.08 - 700)	0.24
Smoking	7 (0.08 - 700)	0.24
Hypothyroidism	0 (0 - 99.9)	0.99

Re-rupeture incidence = 0.06.
OR: Odds ration.

Regarding the re-rupture incidence, there were two patients with type 2 injuries, without clinical relevance (Figure 9).

Although the functional and MRI studies were conducted at the initial, six and 12 months have been to date 39 months of evolution, and none presented relapses.

Discussion

The results of our study show that conservative treatment for proximal Achilles tendon ruptures improves functional scores compared to preoperative. In addition, strength and heel-rise improved significantly at six and 12 months.

Surgical treatment of Achilles ruptures allows the re-rupture rate to decrease, but without differences in clinical scores or return to sport compared to conservative treatment[10].

Kauwe states that functional rehabilitation has reduced the risk of re-rupture in conservative treatment compared to the surgical approach. Because of this and the relatively high risk of complications associated with surgery, recent studies recommend conservative treatment. Kauwe also emphasizes that the rehabilitation protocol should be carefully managed in both treatment approaches to achieve a low re-rupture rate[11]. In our study, the same rehabilitation protocol was instructed to all patients, with a period of immobilization

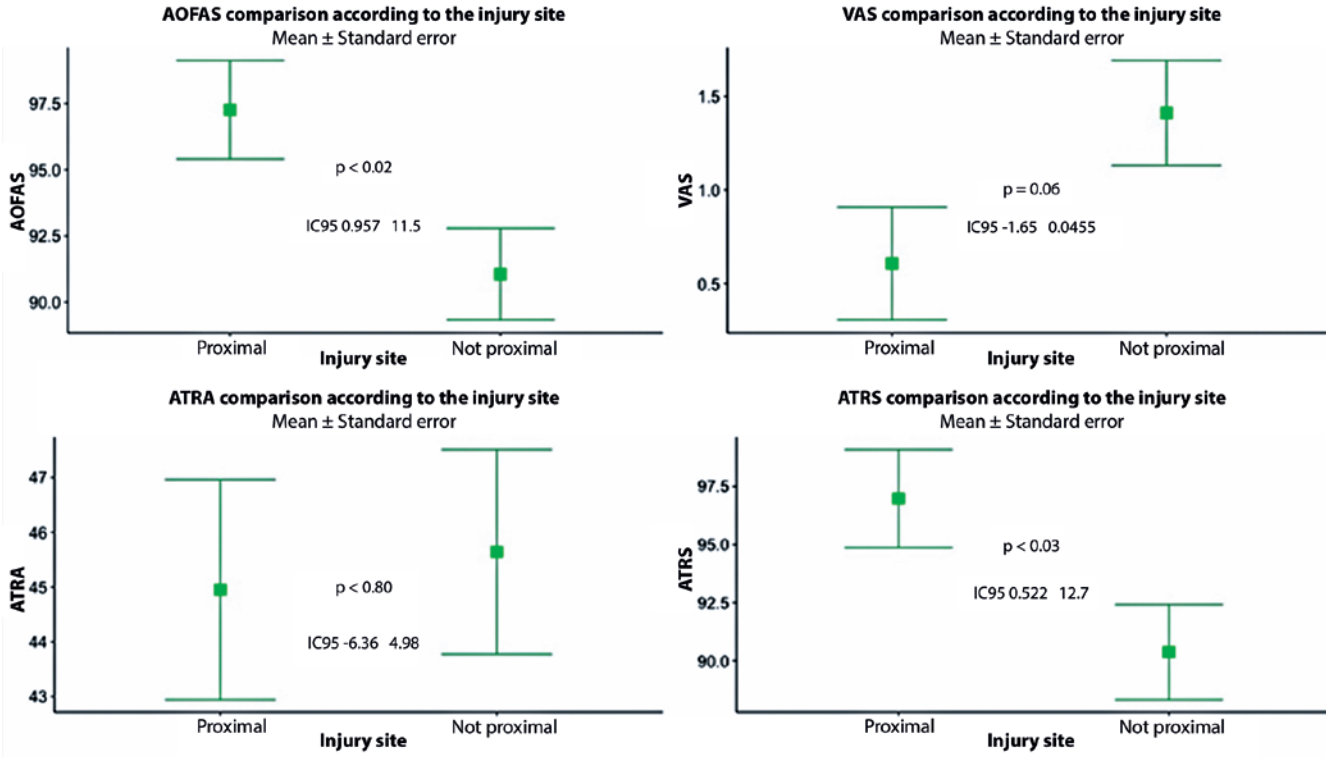

Figure 8. Scales at 12 months according to the injury site.

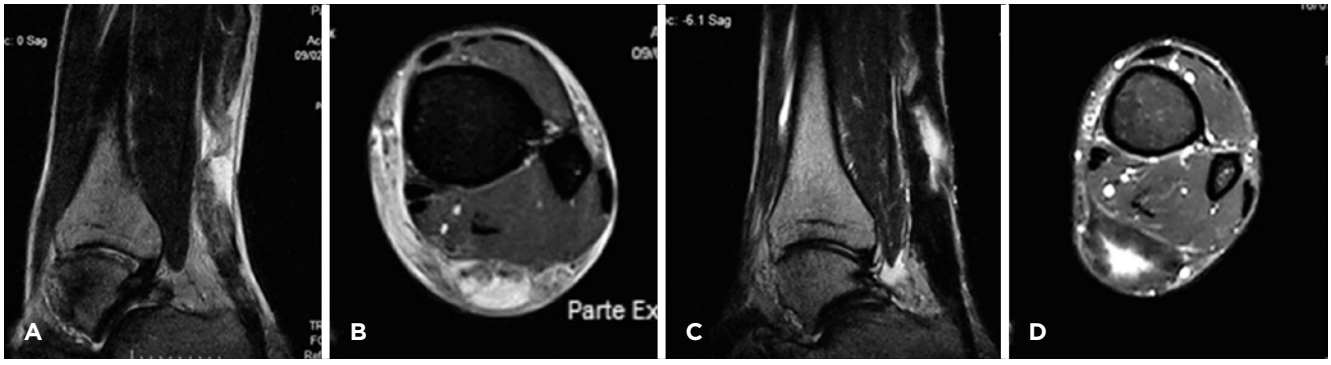

Figure 9. (A and B) Sagittal and axial sections of Achilles tendon rupture. (C and D) Focal images at the six months postoperative with no clinical relevance.

before functional rehabilitation, thus facilitating tendon healing.

A recent study analyzed the functional outcomes of conservative treatment for high Achilles tendon ruptures, reporting good functional results and a successful return to activity. However, the study also noted a statistically significant reduction in calf circumference in the injured leg compared to the healthy one, along with atrophy of the soleus muscle in the affected limbs. The strength tests improved significantly in our series at six and 12 months compared to the preoperative period. At six months, 28.6% of patients achieved muscle strength equal to the contralateral leg, and by 12 months, this increased to 60.7%, indicating an acceptable outcome within a relatively short period. This rapid improvement raises the possibility that the use of PRP may have contributed to the accelerated recovery, warranting further study.

There is little current evidence in the literature concerning PRP as a biological adjuvant and anti-inflammatory therapy. A recent study compared surgical and conservative treatment

in groups with and without PRP and analyzed results, concluding that no clear data emerged regarding whether PRP would provide a benefit in treatment[12].

A recent meta-analysis, including six studies involving PRP therapy in Achilles ruptures, gathered 256 patients with PRP application, compared the results with 254 patients without PRP, and concluded no differences in the medium and long term. However, it does not clarify whether the injuries are proximal to the mid-third or insertional[13]. The data of the injury site is of utmost importance since proximal injuries, as described above, have better vascularization, and therefore, the effect of PRP could be more beneficial, unlike pure or more distal tendon injuries.

Despite the above, *in vitro* studies verify the effects of cell migration and expression of growth factors that would favor the regeneration of tendon tissue, as is the case of the Imai et al study[14].

This study has limitations, such as no randomization and the absence of a control group. However, due to no consensus on the treatment of these injury types, this study was considered appropriate as an attempt to reduce the re-rupture rates and elongations often associated with functional rehabilitation while reducing complications related to open or percutaneous treatment of acute Achilles tendon ruptures.

In addition, the procedure is technically simple, does not require a certain learning curve, and has a low cost in terms of Achilles tendon surgeries and their complications. Despite all the above, and to the best of our knowledge, this study is the first to describe the use of biological devices (PRP) in the treatment of acute Achilles tendon rupture with a minimum follow-up of 12 months.

Conclusion

The treatment protocol proposed by our study for Achilles tendon ruptures significantly improved all the scores evaluated compared to the previous condition, in addition to the isokinetic evaluations, obtaining even better results in proximal injuries. The results showed 89.2% homogeneous tendons at 12 months in the MRI evaluation, and only two patients had focal heterogeneous images, which had no clinical relevance. At 39 months of evolution, no patient presented re-ruptures. The analysis of these results allows us to continue investigating these injuries and their treatment with PRP as adjuvant biological therapy, with promising long-term results.

Authors' contributions: Each author contributed individually and significantly to the development of this article: JB *(https://orcid.org/0000-0003-0910-4140), and AQ *(https://orcid.org/0000-0001-5036-074X), and HMDP*, and LC *(https://orcid.org/0000-0003-1187-0864), Conceived and planned the activity that led to the study, wrote the article, participated in the review process. GMJ *(https://orcid.org/0000-0001-9998-190X), and GA *(https://orcid.org/0000-0003-4767-5489) Data collection, bibliographic review. All authors read and approved the final manuscript.*ORCID (Open Researcher and Contributor ID).

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