INTRODUCTION

Coverage defects in the lower limb, especially in the leg, are a difficult problem to confront due to the specific characteristics of the anatomical region. For this reason, different reconstruction strategies have been developed, being the fasciocutaneous perforator flaps the most frequently used. The aim of this manuscript is to present the therapeutic alternative, to describe the surgical technique, the results and the complications of the posterior tibial artery perforator flap (PTAPF) for the treatment of coverage defects. We performed a retrospective review of patients treated with a fasciocutaneous flap at the level of the leg operated at our center. We analyzed preoperative demographic variables. The surgical technique and the indications in each patient are described. Finally, the postoperative variables such as complications and the survival of the flap were analyzed. Twelve patients treated with CPATP were included. All male. The average age at the time of surgery was 52 years (range 29–77 years). The maximum follow-up of 55 months, with a minimum of 5 months (average 18 months). There were two flaps with suffering that reverted spontaneously, a partial failure and a total failure. The posterior tibial artery perforator flap should be considered a valid option in the treatment of wounds of small and medium size of the leg. They provide similar tissue in thickness, texture and color in the recipient site with good clinical and aesthetic results.

Materials and Methods

For the purpose of this retrospective study, we reviewed medical records of patients whose leg had been treated with a PTAPF at a large tertiary academic hospital. All operations were performed by an orthopaedic surgeon specialized in lower limb surgery and microsurgery (GC). We included twelve patients with coverage defect on the anterior face of the leg, with bone or tendon exposure or skin defect in whom the surgical reconstruction had been specifically performed with a PTAPF.
We followed the PROCESS guideline to report this case series [1]. Every patient gave their informed consent to be treated, understanding the risk and the objectives of the treatment.

We analysed preoperative, intraoperative and postoperative variables.

The pre-operative variables analyzed were: body mass index, comorbidities, number of previous surgeries, cause, type of defect and indication for this flap. The intraoperative variables were: pedicle location, size of the skin paddle, rotation degrees of the flap, intraoperative complications as well as the need of a second surgical time. Furthermore we recorded complications defined as venous congestion, partial or total necrosis and the flap survival as postoperative variables.

The patients were preoperatively evaluated to determine the presence of perforators by Doppler sonography.

**Surgical Technique**

The procedure starts with the patient in supine position, with a slight external rotation of the limb that is being operated on. A cutaneous mapping is performed to identify the presence of perforators in the influence site of the posterior tibial artery and close to the defect to be covered.

We define the proximal or distal orientation of the flap to be rotated (from 45 to 180 degrees) depending on the location of the defect, the presence of previous scars and the location of the perforator vessels.

Subsequently, we define the skin to be elevated including the perforator/s in one of the extremes (Figure 1). The length of the skin paddle will be consistent with the distance between the distal edge of the defect and the perforator, adding 1–2 centimeters according to the perforator theoretical location at a skin level.

Afterwards the flap is elevated (Figure 2) under limb ischemia. It can be totally performed either far from the perforator territory or on its posterior face. Then we identify the perforator vessels. (Figure 3)

After having identified the perforator vessel/s (usually no more than 2) and depending on the necessary rotation to reach the defect area, one of those perforators may be sacrificed to obtain the desired rotation.

It is worth noting that, when a rotation higher to 90 degrees is needed, it is mandatory to free the perforator from the fascia until the posterior tibial artery in order to diminish the possibility of kinking the vessel and complications associated to the venous congestion.

Once the flap is raised, the ischemia is released to assess its adequate capillary filling and to perform the corresponding hemostasis. The flap rotation is performed reaching and covering the soft-tissue defect suturing with separate stitches in two layers and without tunneling (Figure 4). The primary closure is performed at the donor site level.

Depending on the bone underlying pathology and the procedure performed, the use of a half cast may be considered.

**Results**

From March 2008 to 2018, we performed twelve PTAPF, all of them on male patients. The average age was 52 years old (range 29 to 77 years).

The average body mass index (BMI) was 31.4, more than half of the patients having an over-30-BMI. Five patients were cigarette smokers, three were diabetics Type II and one was hypothyroid. Four out of the twelve patients had no comorbidities.

The patients diagnosis was:

– Six patients undergoing chronic osteomyelitis as a result of open fractures, three of which were tibia
shaft fractures and three tibial pilon fractures.
- Two patients had a sequel of infection in a total knee arthroplasty (Figure 5).
- Two patients with an open shaft tibial and pilon fracture.
- A patient with a gunfire wound in the leg.
- A patient with a dehiscence wound after distal tibial fracture treatment.

The type of soft-tissue defect suffered by the patients was:

- Seven patients underwent wound necrosis
- Three patients underwent an active fistula
- Two patients had a soft tissue defect

There were no patients showing vascular soft tissue defects.

Regarding the specific medical indication in each patient, we took into account if they had undergone previous surgeries, the soft-tissue defect, the indemnity of the nourishing vascular bed and the topography of the defect to be covered (Table 1).

In the proximal defects and in the third half defects in which it is usual to perform muscle flaps we chose to preserve the muscle, performing the PTAPF. Furthermore the aesthetic result was mostly satisfactory (Figure 6).

On the other hand, the choice of this flap in six patients with defects in the distal leg was due to therapeutic limitations regarding the vascular aspect. Two patients had already had a previous sural flap, while another patient had had an injury in the peroneal artery. The remaining three patients didn’t show good perforators at the pulsed Doppler sonography. The fasciocutaneous sural flap depends on vascular pedicles from the peroneal artery, thus the PTAPF was the most viable option in view of this limitation.

Summarizing, the flap influence area was: two flaps for the proximal third of the leg, four flaps for the middle third and six flaps for the distal third.

The surgery was performed in one surgical time in three cases, two of which had an active fistula. The third patient with an active fistula required a second surgical time in which we performed an additional gastrocnemius muscle flap due to a partial failure of the PTAPF. The second surgical time in six patients was to complete the flap closure and in one of them to add a skin graft.

In two patients a venous congestion was observed, requiring the flap to be released. After the event was

**Figure 4:** Flap presentation in the defect area (A). Final closure of the donor and recipient site (B). Assessment after four months from the surgery (C).

**Figure 5:** Coverage defect in the proximal third of the leg as a sequel of the infection of the knee total arthroplasty (A). Immediate postoperative image (B). Assessment after one year from the surgery (C).
overcome, the wound was closed. Only one patient presented a complete failure. There were no intraoperative complications.

Two perforators were included in six flaps. In the remaining six flaps, just one perforator was included. The rotation degree was different according to each case (Table 2). The average size of the skin paddle was 12 × 5 cm. The average follow-up was 18 months (range 5 to 55 months) excluding the failed case. As already mentioned, there were two flaps with distress due to congestion which resolved in a brief period, a partial failure and a total failure.

Table 1: Features of recipient area.

| Case | Number of previous surgeries | Topography of the defect | Nourishing vascular bed | Type of soft-tissue defect |
|------|-----------------------------|--------------------------|-------------------------|---------------------------|
| 1    | yes                         | middle third anterior    | undamaged               | Fistula of 1 cm           |
| 2    | yes                         | anteromedial             | previous sural flap     | Necrosis of 10 cm         |
| 3    | yes                         | middle third anterior    | undamaged               | Necrosis of 4 cm          |
| 4    | yes                         | distal third medial      | undamaged               | Necrosis of 3 cm          |
| 5    | yes                         | anteromedial             | previous sural flap     | Defect of 3 cm            |
| 6    | No                          | anteromedial             | injured                 | Defect of 5 cm            |
| 7    | yes                         | anteromedial             | perforators             | Fistula of 1 cm           |
| 8    | yes                         | anteromedial             | undamaged               | Necrosis of 4 cm          |
| 9    | yes                         | anterior                 | undamaged               | Fistula of 3 cm           |
| 10   | yes                         | anteromedial             | No peroneal artery      | Necrosis of 4 cm          |
| 11   | yes                         | anterior                 | undamaged               | Necrosis of 5 cm          |
| 12   | No                          | middle third anterior    | undamaged               | Necrosis of 4 cm          |

Figure 6: Wound necrosis in the middle third of the leg (A). Immediate postoperative image (B). Assessment after seven months from the surgery (C).
Discussion
The lack of knowledge of the local tissue vascularization pattern has been the main cause of disappointment with local fasciocutaneous flaps [6]. The situation is even more complicated when the blood flow is affected by the limb trauma or the peripheral vascular pathology [5].

Reliable perforator arteries have been known thanks to several anatomic studies, such as those from the posterior tibial artery [13, 14] which are easily identified by Doppler sonography. Most of them are septocutaneous and they have a higher diameter on the proximal third of the leg [13, 16]. The inclusion of the deep fascia allows the design of larger size flaps nourished by just one perforator, due to the extensive axial communication with the flap [12].

The PTAPF is nowadays an alternative that meets the conditions to be considered as a first-line choice for orthopedic surgeons. It was described by Pontén in 1981 [11], who suggests it as the first viable alternative in distal defects in lower limbs due to their versatility, aesthetics and little morbidity of the donor site.

Its versatility lies in the possibility of being carried or rotated up to 180° over its pedicle, being possible its pivot point to be proximal or distal, so widening the range of coverage to all the anterior face of the leg [4, 8, 12]. By using the PTAPF, the principal arteries that nourish the foot are preserved as the primary closure is feasible to be performed. The surgical time is short as it does not require microvascular anastomosis. The PTAPF advantages include the aesthetics, as the skin texture, its thickness and its pigmentation are homogeneous to the recipient site, so avoiding the interfaces [9, 10, 13, 18].

It is emphasized its usefulness as a rescue flap in case of a failed sural flap as well as in those cases in which the use of a reverse flow sural flap is impossible to perform because the pedicle that nourishes it has become compromised during a lower limb trauma or previous procedures on the area.

Conclusion
The posterior tibial artery perforator flap is considered a relevant option to treat small to medium size defects from the proximal third to the distal third of the leg. It provides similar tissue to the recipient area regarding thickness, texture and pigmentation, with little morbidity in the donor site resulting in good clinical and aesthetic outcomes. At the same time, it is a good option when it is not possible to use a reverse flow sural flap or as a rescue in case of flap failure.

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The authors have no competing interests to declare.

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References
1. Agha, RA, Borrelli, MR, Farwana, R, Koshy, K, Fowler, A and Orgill, DP, For the PROCESS Group. The PROCESS 2018 Statement: Updating Consensus Preferred Reporting of Case Series in Surgery (PROCESS) Guidelines. International Journal of Surgery. 2018; 60: 279–282. DOI: https://doi.org/10.1016/j. ijsu.2018.10.031
2. Baumeister, SP, Spierer, R, Erdmann, D, Sweis, R, Levin, LS and Germann, GC. A realistic complication analysis of 70 sural artery flaps in a
multimorbid patient group. Plast Reconstr Surg. 2003 Jul; 112(1): 129–40; discussion 141. DOI: https://doi.org/10.1097/01.PRS.0000661617.68966.66

3. Carabelli, G, Barla, JD, Taype, DR and Sancineto, CF. Colgajo fasciocutáneo sural para la cobertura del tercio distal de pierna y pie. Rev Asoc Argent Ortop Traumatol. 2017 Jun; 82(2): 136–40. DOI: https://doi.org/10.15417/602

4. Carrquirry, C, Aparecida Costa, M and Vasconez, LO. An anatomic study of the septocutaneous vessels of the leg. Plast Reconstr Surg. 1985 Sep; 76(3): 354–63. DOI: https://doi.org/10.1097/00006534-198509000-00003

5. El-Sabbagh, AH. Non-microsurgical skin flaps for reconstruction of difficult wounds in distal leg and foot. Chin J Traumatol. 2018 Aug; 21(4): 197–205. DOI: https://doi.org/10.1016/j.cjtee.2017.08.009

6. Erdmann, MW, Court-Brown, CM and Quaba, AA. A five year review of islanded distally based fasciocutaneous flaps on the lower limb. Br J Plast Surg. 1997 Sep; 50(6): 421–7. DOI: https://doi.org/10.1016/S0007-1226(97)90329-5

7. Hamdi, MF, Kalti, O and Khelifi, A. Experience with the distally based sural flap: a review of 25 cases. J Foot Ankle Surg. 2012 Oct; 51(5): 627–31. DOI: https://doi.org/10.1053/j.jfas.2012.05.029

8. Hyakusoku, H, Yamamoto, T and Fumiiri, M. The propeller flap method. Br J Plast Surg. 1991 Jan; 44(1): 53–4. DOI: https://doi.org/10.1016/0007-1226(91)90179-N

9. Mendiesta, M, Cabrera, R, Siu, A, Altamirano, R and Gutierrez, S. Perforator Propeller Flaps for the Coverage of Middle and Distal Leg Soft-tissue Defects. Plast Reconstr Surg Glob Open. 2018 May 2; 6(5): e1759. DOI: https://doi.org/10.1097/GOX.0000000000001759

10. Özalp, B and Aydinol, M. Perforator-based propeller flaps for leg reconstruction in pediatric patients. J Plast Reconstr Aesthet Surg. 2016 Oct; 69(10): e205–11. DOI: https://doi.org/10.1016/j.bjps.2016.07.015

11. Pontén, B. The fasciocutaneous flap: its use in soft tissue defects of the lower leg. Br J Plast Surg. 1981 Apr; 34(2): 215–20. DOI: https://doi.org/10.1016/S0007-1226(81)80097-5

12. Schaverien, MV, Hamilton, SA, Fairburn, N, Rao, P and Quaba, AA. Lower limb reconstruction using the islanded posterior tibial artery perforator flap. Plast Reconstr Surg. 2010 Jun; 125(6): 1735–43. DOI: https://doi.org/10.1097/PRS.0b013e3181ccdc08

13. Schaverien, M and Saint-Cyr, M. Perforators of the lower leg: analysis of perforator locations and clinical application for pedicled perforator flaps. Plast Reconstr Surg. 2008 Jul; 122(1): 161–70. DOI: https://doi.org/10.1097/PRS.0b013e3181774386

14. Sur, YJ, Morsy, M, Mohan, AT, Zhu, L, Michalak, GJ, Lachman, N, et al. Three-Dimensional Computed Tomographic Angiography Study of the Inter perforator Flow of the Lower Leg. Plast Reconstr Surg. 2016 May; 137(5): 1615–28. DOI: https://doi.org/10.1097/PR.0000000000002111

15. Vaienti, L, Calori, GM, Leone, F, Brioschi, M, Parodi, PC and Marchesi, A. Posterior tibial artery perforator flaps for coverage of Achilles region defects. Injury. 2014 Dec; 45(Suppl 6): S133–7. DOI: https://doi.org/10.1016/j.injury.2014.10.037

16. Wu, WC, Chang, YP, So, YC, Yip, SF and Lam, YL. The anatomic basis and clinical applications of flaps based on the posterior tibial vessels. Br J Plast Surg. 1993 Sep; 46(6): 470–9. DOI: https://doi.org/10.1016/0007-1226(93)90220-6

17. Yasir, M, Wani, AH and Zargar, HR. Perforator flaps for reconstruction of lower limb defects. World J Plast Surg. 2017 Jan; 6(1): 74–81.

18. Yu, D, Hou, Q, Liu, A, Tang, H, Fang, G, Zhai, X, et al. Delineation the anatomy of posterior tibial artery perforator flaps using human cadavers with a modified technique. Surg Radiol Anat. 2016 Nov; 38(9): 1075–81. DOI: https://doi.org/10.1007/s00276-016-1671-4

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