Salud Integral y Comunitaria. 2026; 4:298
doi: 10.62486/sic2026298

SYSTEMATIC REVIEW

Surgical trends in the treatment of type IIIB Gustilo fractures: a systematic review

Tendencias quirúrgicas de cobertura en fracturas Gustilo tipo IIIB: una revisión sistemática

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Cite as: Arana Alvarado ZN, Bueno Ordoñez S, Castro Guerra DI, Bazualdo Fiorini E, Cecilia Elizabeth FC. Surgical trends in the treatment of type IIIB Gustilo fractures: a systematic review. Salud Integral y Comunitaria. 2026; 4:298. https://doi.org/10.62486/sic2026298

Submitted: 19-05-2025 **Revised:** 11-10-2025 **Accepted:** 01-01-2026 **Published:** 02-01-2026

Editor: Dr. Telmo Raúl Aveiro-Róbalo

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ABSTRACT

Introduction: the objective of this review was to identify the most commonly used methods of coverage in Gustilo type IIIB fractures, as well as those that offer the greatest benefits with the fewest risks and complications.
Method: a systematic descriptive literature review was conducted, following the PRISMA statement guidelines and adopting the scientific quality recommendations necessary to ensure the adequate systematization of the information. The search was performed in the PubMed, ProQuest, ResearchGate, and Web of Science databases, selected for their relevance and accessibility.
Results: after the selection, analysis, and refinement of the records obtained, a total of 20 studies were included in the review.
Conclusions: in the management of Gustilo type IIIB fractures, the choice of coverage technique is a decisive factor in preventing complications and promoting optimal patient recovery. The debate continues regarding the use of free or locoregional flaps, given that both options have comparable results in terms of efficacy, survival rate, and complications.

Keywords: Gustilo III-B Fractures; Flaps; Complications.

RESUMEN

Introducción: el objetivo de esta revisión fue identificar cuáles son los métodos de cobertura más utilizados en fracturas Gustilo tipo IIIB, así como aquellos que ofrecen mayores beneficios con menores riesgos y complicaciones.
Método: se llevó a cabo una revisión sistemática de la literatura de carácter descriptivo, siguiendo los lineamientos de la declaración PRISMA y adoptando las recomendaciones de calidad científica necesarias para garantizar la adecuada sistematización de la información. La búsqueda se realizó en las bases de datos PubMed, ProQuest, ResearchGate y Web of Science, seleccionadas por su relevancia y accesibilidad.
Resultados: tras el proceso de selección, análisis y depuración de los registros obtenidos, se incluyeron en la revisión un total de 20 estudios.
Conclusiones: en el manejo de fracturas Gustilo tipo IIIB, la elección de la técnica de cobertura resulta un factor decisivo para prevenir complicaciones y favorecer una recuperación óptima del paciente. La discusión persiste en torno al uso de colgajos libres o locorregionales, dado que ambas opciones presentan resultados comparables en términos de eficacia, tasa de supervivencia y complicaciones.

Palabras clave: Fracturas Gustilo III-B; Colgajos; Complicaciones.

INTRODUCTION

Open fractures are pathologies that are unique because the overlying skin is modified and the fractured bone is connected to the external environment through a wound in the skin.[1,2,3,4] Their medical importance lies in the high morbidity and mortality rate, being predominant in men and young adults; they are usually caused mostly by direct trauma, the most common being traffic accidents.[2] Their high morbidity and mortality rate is due to the fact that multiple complications can occur in the treatment of these fractures, such as compartment syndrome, partial or total loss of function, neurovascular injuries, infections such as osteomyelitis, or even amputations. Furthermore, unlike closed fractures, these require more surgical interventions to achieve complete closure of the soft tissues.[3,5,6,7] One of the classifications of open fractures is the Gustilo classification, created in 1976 by Gustilo and Anderson. Type III fractures are extensive wounds greater than 10 cm with intense bone comminution and h . Subtype A affects soft tissues but does not require skin coverage, unlike subtype B, which does require flaps, and subtype C, which requires revascularization surgery.[4,8,9,10] The treatment of these fractures is a constant challenge for physicians, and their management guidelines have varied over time with the aim of avoiding complications and reducing the economic burden on patients and the healthcare system. It is clear that these fractures require immediate and appropriate surgical treatment.[5,11,12,13,14] Management includes early vascular repair and serial debridement. Primary reconstructive options include locoregional flaps, which are transplanted from tissue adjacent to the wound with a blood supply; on the other hand, free flaps are transplanted from distant tissues with vessel anastomosis.[5,15,16,17] However, there are high rates of complications from microvascular thrombosis, infection, and partial or total loss of the flap.[6,18,19,20,21] Likewise, the V.A.C. (vacuum-assisted closure) technique is a negative pressure treatment that attempts to optimize wound healing by reducing inflammatory exudate and promoting granulation tissue. This technique is used for the healing of complex wounds, such as open fractures in this case.[7,22,23,24,25] There is also the Masquelet technique, also known as the membrane induction technique, developed in 1986, which consists of two phases: the first, where the creation of integuments is stimulated, and the second, where an autologous bone graft is placed.[8,26,27,28] Currently, among the innovative biological techniques, we find the use of acellular dermal matrix, which is a synthetic skin substitute made up of bovine collagen and chondroitin sulfate. This stimulates fibroblastic and endothelial growth through processes of neovascularization and remodeling.[9] On the other hand, platelet-rich plasma (PRP) is also being studied for the treatment of these injuries because autologous platelet concentrations contribute to obtaining growth factors that aid in regenerative processes.[10,29,30,31]

The main objectives of surgical treatment are to prevent infection, stabilize the fracture early, and cover soft tissues in order to achieve proper union and restoration of function.[2] In addition, postoperative care and outcomes vary depending on the technique used and the nature of the patient's injury, with associated injuries and comorbidities being relevant, with infection rates ranging from 5 to 50 % (IIIA – IIIC respectively).[11,32] It is therefore important to be familiar with the different surgical techniques available in order to assess and understand their effectiveness and postoperative results, so that decisions can be made and long-term complications avoided.

The objective of this review is to identify the most commonly used methods of coverage in Gustillo type IIIB fractures, as well as those that offer the most benefits with the fewest risks and complications.

METHOD

A systematic review of descriptive literature was conducted, following the guidelines established in the PRISMA statement and adopting the scientific quality recommendations required to ensure the necessary quality for the systematization of information, including: a) formulation of objectives, b) definition of search equations, c) determination of inclusion and exclusion criteria, d) systematic process flow diagram, e) review of selected bibliography, f) analysis of secondary sources, and g) structure and discussion of results.[12]

Multiple search engines were used, utilizing the data sources PUBMED, PROQUEST, RESEARCHGATE, and WOS due to their importance and easy access to the documents to be reviewed by the general public. Subsequently, the following inclusion criteria were determined: 1) publication period 2019-2024, 2) studies with free full-text availability, 3) studies in Spanish, English, and Portuguese, 4) studies addressing the surgical treatment of open fractures, and 5) studies with additional contributions related to the central theme. The following criteria were also excluded: 1) duplicate studies, 2) studies that do not focus on the main topic, 3) studies not found in the selected databases. The search was carried out continuously thanks to the delimitation of keywords that constructed search equations, which were formulated by combining these terms with Boolean operators such as "AND," generating expressions such as "coverage surgical treatment" AND "open fractures type Gustillo IIIB" AND "effectiveness." The bibliography was selected systematically, taking into account a) date of publication, b) author, c) title, d) country of origin of the study, e) abstract, and f) DOI. Figure 1 shows in detail the document exclusion process, first excluding studies conducted outside the desired period, then those studies that are not freely accessible, followed by those documents that were duplicated on the

different platforms, and finally those studies that did not have a precise focus on the central theme of the research. As a result of this process, the research was reduced to a total of 20 studies.

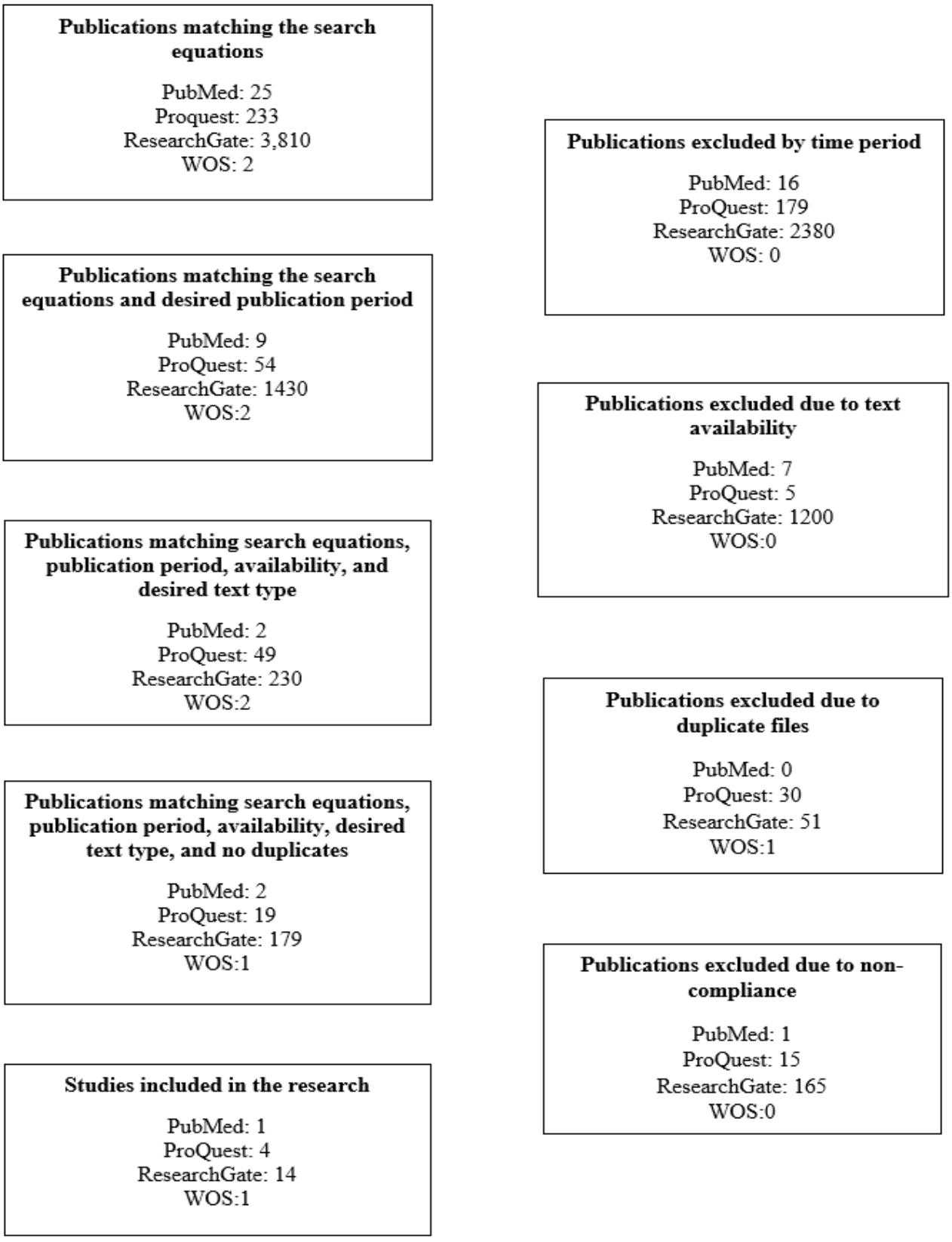

Figure 1. PRISMA flow diagram of the systematization process

DEVELOPMENT

After the systematic selection of the bibliography, a synthesis matrix was created (table 1).

Table 1. Selected bibliography

No.	Year	Authors	Title of the research	Country of origin	DOI	Abstract
1	2022	Luo J et al.[14]	Clinical effectiveness of early internal fixation combined with free flap technique in the treatment of Gustilo IIIB open forearm fracture	China	10.1016/j.otsr.2022.103346	Skin coverage with skin flap combined with early debridement and early internal fixation achieves satisfactory functional results, shortening treatment time and maximizing outcomes in IIIB open forearm fractures.
2	2020	Jitprapaikulsarn S et al.[31]	Combined medial gastrocnemius and hemisoleus flaps are a reliable and effective alternative for open tibial fractures complicated with large or double soft tissue defects. However, if the posterior calf muscle is severely traumatized, free tissue transfer would be an inevitable option.	Germany	10.1007/s00590-020-02772-6	Combined locoregional medial gastrocnemius and hemisoleus flaps are reliable and effective in 83 % of patients with open tibial fractures IIB.
3	2024	Mitsutoshi O et al.[15]	Clinical outcomes of perforator-based propeller flaps versus free flaps in soft tissue reconstruction for lower leg and foot trauma: a retrospective single-center comparative study	England	https://doi.org/10.1186/s12891-024-07433-x	In fractures of the lower leg and foot, free flaps have better results, efficacy, and fewer complications (10 %) compared to propeller flaps, whose most challenging complication is venous congestion (72 %).
4	2023	Jae Lee Y et al.[16]	Anterolateral Thigh Chimeric Flap: An Alternative Reconstructive Option to Free Flaps for Large Soft Tissue Defects	Switzerland	10.3390/jcm12216723	The anterolateral thigh chimeric free flap is 100 % effective and has few complications in extensive and wide defects.
5	2021	Chun Yu C et al.[29]	Immediate application of negative pressure wound therapy following lower extremity flap reconstruction in sixteen patients	England	10.1038/s41598-021-00369-5	The use of negative pressure after flap reconstruction in lower extremities is an effective (60 %) but recent and little-studied option.
6	2024	Gusti Agung D et al.	Free flap versus local flap on managing Grade III open tibial fractures: Meta Analysis Study	Indonesia	https://doi.org/10.33472/AFJBS.6.4.2024.351-362	The study shows superiority in the success rate of free flaps (48 %) compared to local flaps (18 %).
7	2024	Shuming Y et al.	Delayed Perforator Pedicle Propeller Flap Reconstruction Using the Induced Membrane Technique for Open Gustilo IIIB Distal Tibia Fracture	China	10.1055/a-2151-5175	Locoregional perforator pedicle propeller flap transfer is considered for delayed reconstruction of exposed IIIB tibial fractures with a 100 % success rate and no significant complications.

8	2024	Azad Ali et al.[17]	Soft tissue coverage for IIIB fractures: from timing to coverage options	Jamaica	10.1097/OI9.0000000000000317	Although local flaps are commonly used for tibial defects, a study of complications indicates that free flaps are now preferred, as they are more than 90 % effective.
9	2021	Nicolaides M et al.[33]	Open tibial fractures: An overview	England	https://doi.org/10.1016/j.jcot.2021.101483	Locoregional muscle flaps are used in open tibial fractures with large defects; however, with the new use of free flaps, this is being debated.
10	2023	Rupp M et al.[30]	The antibiotic bead pouch – a useful technique for temporary soft tissue coverage, infection prevention, and therapy in trauma surgery	Germany	https://doi.org/10.5194/jbji-8-165-2023	In Gustilo IIIB fractures, a relatively new technique is temporary soft tissue coverage with antibiotic bead pouches.
11	2022	Rysselberghe V et al.[28]	Negative Pressure Wound Therapy for Extremity Open Wound Management: A Review of the Literature	USA	10.1097/BOT.0000000000002430	Negative pressure therapy is useful for treating open fractures and may even reduce the need for flaps, with over 50 % effectiveness in patients with IIIB fractures; however, these results are not entirely reliable.
12	2021	Zeiderman M et al.[34]	Contemporary approach to soft-tissue reconstruction of the lower extremity after trauma	USA	https://doi.org/10.1093/burnst/tkab024	Although free flaps have favorable aesthetic results and success rates (90 %), they should be reserved as a backup when local flaps are not available in open tibial fractures.
13	2021	Nazri M et al.[35]	Revisiting the Pedicled Gastrocnemius Flap for Orthoplastic Limb Reconstruction	Malaysia	https://doi.org/10.31436/imjm.v20i2.174	In open tibial fractures, the locoregional gastrocnemius flap has an 85 % success rate and is an e that could save the leg from amputation.
14	2024	Gupta R et al.[36]	Utilization of the gastrocnemius flap for post-traumatic knee reconstruction: a systematic review	USA	https://doi.org/10.1007/s00590-024-03938-2	In fractures of the knee and proximal third of the leg, the locoregional gastrocnemius flap has a 100 % survival rate without significant complications.
15	2022	MacKechnie MC et al.[19]	Management of soft tissue coverage for open tibial fractures in Latin America: techniques, timing, and resources	USA		In this study, surgeons used the free flap technique in lower limb fractures, with an effectiveness of approximately 55 %.

16	2019	Shaun D et al.[22]	A Review on the Orthoplastic Approach to Lower Limb Reconstruction	USA	10.1055/s-0039-1688095	Although this study addressed various points, it mentions two commonly used types of flaps: the free fibular osteocutaneous flap, with a success rate of approximately 90 %, and the free medial femoral condyle flap, used in large fractures.
17	2019	Mahajan R et al.[23]	Management of Post-Traumatic Composite Bone and Soft Tissue Defect of Leg	India	10.1055/s-0039-1688097	The free vascularized osteocutaneous or osteomusculocutaneous fibula flap is used when the defect is not very large with insignificant complications (<5 %); if it is, the free fibula flap is applied with a 100 % survival rate.
18	2020	Azadgoli B et al.[18]	Review of soft tissue coverage options in distraction osteogenesis of the extremity	USA	10.20517/2347-9264.2019.028	Free flaps, either latissimus dorsi or rectus abdominis, were used in most cases (90 %), with a satisfactory success rate.
19	2019	Van Boerum S et al.[24]	Cross-Leg Flaps for Lower Extremity Salvage: A Scoping Review	USA	10.1055/s-0039-1679955	It was found that free cross-leg fasciocutaneous flaps are commonly used in approximately 90 % of cases, with 100 % effectiveness, making them a reliable option.
20	2019	Bolletta A et al.[37]	Advances in microsurgery for upper and lower limb reconstruction and limb preservation.	Italy	http://dx.doi.org/10.20517/2347-9264.2019.22	Local perforator flaps are ideal for medium-sized defects, unlike free flaps, which are better in areas where greater coverage is needed, with a survival rate of 90 % and complications of less than 10 %.

DISCUSSION

The objective of this review was to identify which types of soft tissue coverage in Gustilo IIIB fractures are most effective and involve fewer complications. The table above summarizes studies that had relevant information for understanding these points. The selection of the type of coverage to be used in traumatic defects will depend on multiple factors, such as the needs, the location and size of the defect, the technique and experience of the staff, the patient's comorbidities, the preoperative cost, and medical care, among others.[13,14] Thus, in China, Luo et al. indicate that the flap technique is effective as long as it is accompanied by early debridement and fixation.

Among the studies, Mitsutoshi et al.[15] in England, Jae Lee et al.[16] in Switzerland, Azad et al.[17] in Jamaica, Azadgoli et al.[18] in the US, and MacKechnie et al.[19] in the US agree that free flaps are the most commonly used, in addition to showing a very good rate of effectiveness and survival. It is important to emphasize that free or microsurgical flaps are those that come from an area far from the defect or complex wound and consist of skin, fat, and even muscle and bone, interrupting their circulation and then being anastomosed at the recipient site.[20]

Similarly, in Colombia, another study conducted by Jimenez et al.[21] in high-complexity centers mentioned that this type of coverage is the first option for defects in the lower extremities, with a success rate of 80 % and

major complications below 10 %. All studies agree that the free flap technique requires thorough preparation of healthcare personnel, as well as an adequate learning curve and high pre- and post-operative costs for both the patient and the corresponding healthcare sector.

Shaun et al.[22] in the US and Mahajan et al.[23] in India report that the free flaps commonly used are free fibular osteocutaneous flaps for smaller defects and free medial femoral condyle flaps for larger defects, both with a high survival rate and more than 90 % efficacy.

In 2019, Vann Boerum et al.[24] in the US mention that the cross-leg flap, a technique in which the vessels from the flap are anastomosed to the healthy leg,[25] is another option for large defects where vessels, nerves, and/or tendons are exposed and serious complications such as osteomyelitis are to be avoided. It is used effectively when the free flap is not accessible in the health context in which the research is being conducted. It should be emphasized that this technique is used in complex situations but requires teamwork due to the need for extensive knowledge of external fixation.[26]

Contrary to this trend, in Cuba, Tabares Saenz et al.[27] report that microsurgery has declined considerably and that this free flap technique is being relegated and replaced by techniques such as negative pressure, as does Rysselberghe et al.[28], who indicates that this could completely close a relatively large defect without the need for flaps, agreeing with Chun Yu et al.[29] in England that it is a technique that has not yet been studied extensively, similar in this respect to the use of antibiotic microsphere bags described in the study by Rupp et al.[30] in Germany.

On the other hand, Jitprapaikulsarn et al.[31] in Germany, Shumming et al.[32] in China, Azad et al.[17] in Jamaica, Nicolaides et al.[33] in England, Zeiderman et al.[34] in the USA, Nazri et al.[35] in Malaysia, Gupta et al.[36] in the US and Bolletta et al.[37] in Italy agree that locoregional flaps, which are vascularized blocks of tissue with skin, fat, and muscle mobilized to the recipient site while maintaining their vascular connection to the donor site,[20] have a good success rate and insignificant complications. They agree with Beltran et al.[38] in Uruguay that these flaps should be used in preference to free flaps due to the shortage of healthcare personnel, infrastructure, or material resources, in addition to the fact that recovery requires patient commitment, which is not always adequate.

Among the most commonly used locoregional flaps, the authors agreed that sural fasciocutaneous flaps are effective and have minor or no complications, coinciding with the work of Vergara et al.[39] and Marrero et al.[40] in Cuba, who mention that it is a technique that does not require specialization or knowledge of microsurgery, in addition to not being very expensive, giving very favorable results in the patient.

CONCLUSIONS

In the management of Gustilo type IIIB fractures, the choice of coverage technique is crucial to avoid complications in the patient and ensure optimal recovery.

The choice between free flaps and locoregional flaps is still a matter of debate due to the similarity in efficacy, survival rate, and complications observed in both techniques.

On the one hand, free flaps have greater aesthetic benefits and are commonly and necessarily used in settings with sustainable economic resources, advanced equipment, and highly specialized health personnel. On the other hand, in the public health sector, locoregional flaps are more frequently used, being a viable and highly effective option in contexts where the aforementioned resources are not available. This highlights the importance of individualizing each patient in order to provide treatment that is appropriate for them and the resources available.

Despite advances in reconstructive techniques, it is clear that more research is needed on coverage strategies so that, in the future, we can work in different scenarios and provide adequate care with functional results and improve the quality of life of each patient.

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FINANCING

None.

CONFLICT OF INTEREST

None.

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