REVIEW

acta orthopaedica belgica, 2025, 91, 419-428

doi.org/10.52628/91.4.14862

Masquelet Technique Combined with Platelet-Rich Plasma for Large Infectious Bone Defects: A Narrative Review

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Large segmental infected bone defects represent a serious complication frequently encountered following high-energy trauma, bone tumor resection, and osteomyelitis surgery, presenting substantial challenges in orthopedic management. Current clinical approaches such as autologous bone grafting, allogeneic bone grafting, the Ilizarov technique, and artificial bone substitutes each come with inherent limitations. In recent years, the Masquelet technique (induced membrane technique) has become increasingly refined in clinical practice. This method works by establishing a bioactive local microenvironment that serves as both a physical barrier and maintains a stable repair space, effectively enhancing the regenerative healing of bone defects. Concurrently, platelet-rich plasma (PRP), a biological therapeutic material abundant in various growth factors, has shown significant potential in stimulating angiogenesis and accelerating bone tissue repair, gaining widespread clinical adoption, particularly in orthopedic applications. This article presents a narrative review based on a structured literature search, aimed at synthesizing current evidence on the combined application of the Masquelet technique and platelet-rich plasma (PRP) in the treatment of large segmental infected bone defects.Through a narrative review of existing literature, it summarizes current evidence suggesting that the combination may offer synergistic benefits, highlights reported clinical observations and preclinical findings aims to inform clinical decision-making in orthopaedic practice, and identifies key areas for future investigation, providing a basis for further research into this combined approach.

Keywords: Masquelet technique, PRP, infection, bone defect, biofilm, antibacterial.

INTRODUCTION

The repair and reconstruction of large segmental infectious bone defects represent a significant challenge in orthopedic practice[42], marked by extended treatment periods, difficulties in managing infections, high costs of care, and substantial disability rates that can profoundly diminish patients' quality of life when these complications arise[37]. Infectious bone defect refers to bone loss accompanied by infection or occurring during the treatment of bone infection[45]. When a bone defect is too extensive to heal on its own, it is classified as either a large segmental bone defect or a critical-sized bone defect. This specifically refers to cases where the defect's length surpasses half the diameter of the affected long bone, indicating a significant challenge for natural repair processes[29,32]. The primary treatment options for large segmental infectious bone defects currently involve autologous bone grafting, allogeneic bone grafting, the Ilizarov technique, and the use of artificial bone substitute materials. Despite these available approaches, treating large segmental infectious bone defects remains challenging, often resulting in suboptimal outcomes and a high risk of complications.

In the context of resource-limited settings, the challenges of implementing complex techniques like the Masquelet procedure are further amplified. A cohort study by Nkuma et al. highlighted the difficulties in achieving consistent outcomes with the induced-membrane technique for traumatic tibial defects under constrained healthcare conditions, underscoring the need for optimized protocols and adjuvant therapies to improve reliability[28].

Furthermore, alternative established methods for managing massive post-traumatic bone defects in the lower limb have been extensively documented in the Acta Orthopaedica Belgica. The Ilizarov bone

transport technique, for instance, has proven effective for infected tibial nonunions, offering a valuable option, albeit with a prolonged treatment duration and potential for pin-site complications[7,44]. Similarly, vascularized fibular grafting represents a robust biological solution for longstanding and infected large bone defects, providing both structural support and a vascularized bed for healing[21].

The Masquelet technique, also known as the membrane induction technique, is a method used for repairing bone defects. French scholar Masquelet proposed the "induced membrane" theory in the 1980s. Through clinical practice verification, it has achieved good healing effects in the treatment of bone defects of varying lengths[27]. This technique involves a two-stage process designed to treat large segmental bone defects. The first stage focuses on forming an induced membrane: the bone and soft tissues in the defect area are carefully cleaned, after which biomaterial spacers are implanted alongside bone fixation. Over the next 6-8 weeks, these spacers stimulate the formation of a specialized biological membrane at the defect site. In the second stage, known as the induced membrane bone grafting phase, the spacers are removed while preserving the newly formed membrane, and the patient's own bone tissue is grafted into this membrane-enclosed space. The key innovation lies in the membrane's ability to create an optimal microenvironment for bone regeneration—acting not just as a physical barrier but also secreting growth factors and providing a rich vascular network that significantly enhances bone growth. This method has proven highly effective in clinical applications for large bone defects. Clinical studies have reported high success rates and relatively low complication recurrence rates with the Masquelet technique in treating large-segment infectious bone defects[48], although outcomes can vary.

Platelet-rich plasma (PRP), enriched with multiple growth factors such as PDGF, VEGF, and TGF-β, has gained increasing attention in orthopedic practice for its potential to enhance bone regeneration and angiogenesis. In the context of bone defect repair, PRP is increasingly explored as a biological adjuvant to augment the healing process, particularly when combined with established techniques like the Masquelet protocol. The use of PRP is intended to speed up the healing process and decrease recovery time. Some clinical studies suggest that PRP may reduce the healing period and could contribute to improved outcomes when combined with the Masquelet technique , though high-level comparative evidence is limited[18]. It is worth noting that the combined application of PRP and the Masquelet technique demonstrates excellent synergistic effects in treating infectious bone defects, as this approach not only enhances the success rate of treatment but also significantly lowers the risk of complications.

This paper systematically examines the clinical effectiveness of combining the Masquelet technique with PRP for treating large segmental infected bone defects through a comprehensive literature review. The study delves into how these two approaches work together synergistically, particularly highlighting their unique benefits in stimulating blood vessel growth within the bone defect area, effectively managing infection, and speeding up the bone healing process. By analyzing existing research, this work offers fresh perspectives and supporting evidence for clinical approaches to managing these challenging bone defects, ultimately aiming to improve treatment outcomes and advance medical practice in this specialized area. The findings could help surgeons make more informed decisions when dealing with complex cases of infected bone loss.

MASQUELET TECHNIQUE

History and development

The Masquelet technique has become a key method for reconstructing bone defects caused by trauma, infection, or tumor removal, offering a much faster healing process than conventional approaches[31]. By placing bone cement as a temporary scaffold in the damaged area, it stimulates the growth of a specialized membrane that blocks fibrous tissue invasion while releasing growth factors to support bone regeneration and blood vessel formation. Over time, improvements in biomaterials have broadened its use, making it effective for repairing challenging bone defects in areas like the pelvis, arms, and legs. This approach not only simplifies treatment but also enhances recovery outcomes for patients[20,34,46].

The formation mechanism of the induced membrane by Masquelet technique

The formation mechanism of the Masquelet technique-induced membrane is still not fully understood, though current research indicates that its development may be linked to foreign body reactions. The successful creation of this induced membrane plays a crucial role in the clinical effectiveness of the technique[15]. When bone cement is implanted into a bone defect, it immediately interacts with blood, leading to rapid

protein adsorption on its surface and the formation of a temporary matrix layer. This triggers an acute inflammatory response, marked by a significant influx of neutrophils at the implantation site. Over time, the inflammation shifts to a chronic phase, with increased numbers of monocytes and lymphocytes. Monocytes adhering to the material differentiate into macrophages, which attempt to degrade the implant by releasing cytokines and degradative enzymes. If the material proves resistant to degradation, macrophages may fuse to form multinucleated foreign body giant cells (FBGCs), which, despite their enhanced degradative capacity, may still fail to fully break down certain biomaterials. In the later stages of the foreign body reaction, fibroblasts migrate to the site and secrete extracellular matrix components like collagen, ultimately resulting in fibrous capsule formation[2,15,20]. Relevant literature shows that the thickness of the induced membrane can vary significantly, with measurements ranging from as thin as 45 micrometers to as thick as 2126 micrometers[16,30]. Research has demonstrated that the induced membrane develops a three-layered structure with distinct temporal and morphological characteristics. The cellular-rich inner layer forms first, appearing 3-6 weeks after bone cement placement, where it directly interfaces with the cement surface. Around the third week post-implantation, the middle fibrous layer begins developing as a loosely organized network with initially sparse cellularity that progressively increases in density, reflecting the membrane's maturation process during the 3-6 week period. The outermost layer, which interfaces with surrounding muscle tissue, shows markedly greater thickness compared to the inner layers and features a disorganized, loose architecture containing extensive vascular networks[38]. The hierarchical structural features observed in the induced membrane clearly demonstrate its distinct histological characteristics across various developmental stages, as well as its dynamic interactions with surrounding tissues, highlighting the complex and evolving nature of this biological structure.

Clinical application challenges of the Masquelet technique

The Masquelet technique, also known as the induced membrane technique, offers distinct advantages for repairing large infected bone defects, yet it presents several clinical challenges, the most significant being the elevated risk of infection. Research indicates that postoperative deep infection recurrence rates can reach 10% in cases of infected bone defects[33]. Open fractures or bone defects caused by osteomyelitis frequently involve infection, where insufficient initial debridement can lead to contamination of the bone cement spacer, ultimately disrupting the formation of the induced membrane and hindering bone healing. While PMMA bone cement can be impregnated with antibiotics like vancomycin or gentamicin, its rapid burst-release mechanism causes a steep drop in local drug concentration shortly after implantation, failing to sustain effective antibacterial levels and contributing to a high recurrence rate of resistant bacterial infections[8]. The second major challenge lies in the scarcity of bone graft sources and the limitations of substitute materials. During second-stage surgeries, substantial autologous bone grafting is typically required, yet this approach carries significant risks including donor site pain and postoperative infections. Additionally, when the harvested bone volume proves inadequate, patients often face the prospect of undergoing repeat surgical procedures to obtain sufficient graft material[35]. In current research, various alternative materials can be used alongside autologous bone to fill bone defects, helping to reduce the reliance on autologous bone grafts. However, most of these alternative materials come with certain limitations. For instance, while the new β-tricalcium phosphate composite material shows promise in partially replacing autologous bone, its compressive strength falls significantly short when compared to natural bone[25]. The formation and biological activity of induced membranes are shaped by multiple factors, such as variations among individual patients, the dimensions and anatomical positioning of the defect, and the quality of postoperative management[6]. Further research is needed to better understand the optimal timing and mechanical stability of the two-stage surgical approach. As biomaterials and tissue engineering continue to advance, integrating these innovations with the Masquelet technique presents a promising opportunity to enhance treatment efficacy, making this combination a key focus in current medical research. The clinical utility and practicality of the Masquelet technique have been validated in various real-world scenarios. A notable study by Khoshroo et al. reported favorable outcomes using a staged bone grafting protocol with the induced membrane for segmental long bone defects caused by trauma or infection, reinforcing its role as a reliable reconstructive strategy[13].

Antibiotic-Loaded Cement in Infection Control

The use of antibiotic-loaded polymethyl methacrylate (PMMA) cement as a spacer is a cornerstone of

infection management in the Masquelet technique. Commonly used antibiotics include vancomycin, gentamicin, tobramycin, and teicoplanin, selected based on preoperative culture results or local epidemiology of pathogens, particularly Staphylococcus aureus and coagulase-negative staphylococci. Vancomycin is frequently preferred for its broad coverage against Gram-positive organisms, including MRSA[14]. However, the release kinetics of antibiotics from PMMA cement is biphasic: an initial "burst release" within the first 24–72 hours delivers high local concentrations, followed by a rapid decline that often fails to maintain bactericidal levels beyond 2–4 weeks[19]. This pharmacokinetic limitation poses a significant challenge in eradicating biofilm-associated infections, which require prolonged antibiotic exposure. Consequently, while PMMA effectively reduces early infection recurrence, its inability to sustain therapeutic drug levels over the 6–8 week induction phase may contribute to late reinfection, especially in cases with persistent biofilm or multidrug-resistant organisms. To address this, recent strategies explore the use of bioresorbable carriers that allow complete resorption and sustained release, or the incorporation of novel antibiotic combinations and nanoparticle-based delivery systems to prolong antimicrobial activity[39].

PRP AS A BIOLOGICAL ADJUVANT IN THE MASQUELET PROTOCOL FOR INFECTED BONE DEFECTS

Stage-specific Roles of PRP in the Masquelet Protocol

In the two-stage process of the Masquelet technique, the timing of platelet-rich plasma (PRP) application determines its mode of action. In the first stage (the induction membrane formation period), local application of leukocyte-rich PRP (L-PRP) can significantly enhance local antibacterial activity through defensins, lysozymes, and neutrophil extracellular traps (NETs) released by leukocytes. It works in synergy with thorough debridement to effectively disrupt the residual biofilm and reduce the risk of infection recurrence[47]. Upon entering the second stage (the bone grafting period), PRP transforms into a "biological activator." The continuous release of high concentrations of growth factors such as platelet-derived growth factor (PDGF), vascular endothelial growth factor (VEGF), and transforming growth factor-beta (TGF-β) in PRP can recruit bone marrow mesenchymal stem cells, induce the migration of vascular endothelial cells, osteogenic differentiation, and collagen deposition, thereby accelerating bone integration. The latest research has further combined PRP with fibrin glue and nano-hydroxyapatite to construct a vascularized induction membrane that can replace polymethyl methacrylate (PMMA)[42]. This approach not only reduces the amount of autologous bone used but also significantly increases the vascular density within the membrane and the efficiency of osteogenesis.

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Synergistic Effects: PRP Growth Factors and Induced Membrane Biology

The integration of PRP into the Masquelet protocol strategically leverages its biological activity to enhance the induced membrane's functionality. Specifically, PRP amplifies the membrane's pro-angiogenic and immunomodulatory roles, which are critical for successful bone regeneration in compromised environments. The release of VEGF from PRP synergizes with endogenous factors in the

membrane, significantly increasing vascular density and establishing a robust blood supply essential for graft survival and integration[12]. Concurrently, TGF-β from PRP promotes a shift towards an anti-inflammatory (M2) macrophage phenotype, mitigating the detrimental effects of chronic inflammation and creating a more conducive microenvironment for bone healing. This dual enhancement of vascularization and immune regulation represents a key mechanism by which PRP augments the Masquelet technique[5].

Autologous PRP: Mitigating Infection-related Immune Risks

In the complex microenvironment of infectious bone defects, the autologous origin of platelet-rich plasma (PRP) endows it with unique advantages. There is no need to worry about the potential immune rejection triggered by allogeneic materials, and it also avoids the introduction of new antigens into the existing infected foci, thus reducing the risk of "second - hit"[1,47]. Studies have confirmed that PRP concentrate contains a large number of antimicrobial peptides and growth factors, which can directly inhibit common pathogenic bacteria such as Staphylococcus aureus and produce a synergistic effect with antibiotics[9,17]. In addition, anti - apoptotic proteins (such as Bcl - 2) released by PRP can neutralize the highly reactive oxygen species in the infected area, protecting osteoblasts and vascular endothelial cells from oxidative stress damage[36]. This helps maintain the coupling of osteogenesis and angiogenesis, providing a stable microenvironment for subsequent bone regeneration.

PRP-Composite Biomaterials for Enhanced Bone Defect Filling

In the second stage of the Masquelet technique, combining PRP with bone substitute materials such as calcium phosphate cement (CPC) or β-tricalcium phosphate (β-TCP) has shown promise in preclinical studies. These composites not only enhance the osteogenic potential of the graft but also provide a sustained release of growth factors, potentially reducing the required volume of autologous bone. Such strategies aim to optimize graft integration while minimizing donor-site morbidity.

PRP as a Biological Modulator in the Masquelet Protocol: Focus on Orthopedic Bone Regeneration

Within the context of large segmental infected bone defects, the role of platelet-rich plasma (PRP) should be understood not as a standalone therapy, but as a biologically active enhancer integrated strategically into the two-stage Masquelet protocol. Its value lies in its ability to modulate three key processes critical to successful reconstruction: angiogenesis, osteogenesis, and infection control.

The choice between leukocyte-rich PRP (L-PRP) and pure PRP (P-PRP) is clinically significant. L-PRP, with its neutrophils and monocytes releasing defensins and NETs, provides intrinsic antibacterial activity, making it advantageous for adjunctive use in Stage 1 to combat residual biofilm[22]. Conversely, P-PRP, with minimal leukocytes, reduces the risk of excessive pro-inflammatory signaling and is therefore better suited for Stage 2, where the focus is on fostering a pro-regenerative environment for graft integration[41].

Timing of application determines functional impact. Local application of L-PRP around the antibiotic-loaded spacer in Stage 1 complements debridement by disrupting residual microbial communities and reinforcing local immunity. In Stage 2, mixing P-PRP with autologous bone graft creates a "biological activator" effect: sustained release of PDGF, VEGF, and TGF-β enhances vascular ingrowth, accelerates mineralization, and supports coupled angiogenesis-osteogenesis[40].

Clinical evidence summarized in Table II supports this strategic use. For example, Li et al. (2019) demonstrated that combining PRP with bone grafting significantly shortened healing time (28.78 vs 36.17 weeks), reduced infection recurrence (5.6% vs 35.3%), and lowered complication rates. Similarly, Erdem et al. (2023) reported a 54% increase in induced membrane thickness and 68% higher vascular density in PRP-treated rats, underscoring its pro-angiogenic effect.

Thus, rather than viewing PRP as a generic regenerative tool, it should be optimized within the Masquelet framework based on patient-specific infection status, defect characteristics, and desired biological outcome.

MASQUELET COMBINED WITH PRP

The theoretical basis of combination therapy

The Masquelet technique is a surgical method used to treat large segmental bone defects, with its core mechanism relying on induced membrane formation to promote bone healing. When combined with PRP, this technique can produce significant synergistic effects. Building upon the described biological mechanisms, the combination of PRP with the Masquelet technique offers a multifaceted approach to overcoming the challenges of large infected bone defects. The strategic application of PRP, tailored to the specific phase of

the protocol (e.g., L-PRP in Stage 1, P-PRP in Stage 2), aims to simultaneously enhance infection control, accelerate vascularization of the induced membrane, and promote a favorable immune environment for bone regeneration. This integrated strategy seeks to optimize the biological performance of the induced membrane, thereby improving the overall success rate of bone defect reconstruction.

This enhanced membrane serves a dual purpose: it acts as a barrier to prevent soft tissue invasion while simultaneously establishing a stable osteogenic microenvironment that supports the successful integration and growth of bone grafts[24]. During the first stage of treatment, PRP works in synergy with the microvascular system and osteogenesis-related factors present in the induced membrane. This combined effect not only enhances revascularization at the bone graft site but also promotes the proliferation of osteoblasts, which are essential for bone formation. Moreover, the high leukocyte concentration in PRP contributes to its strong anti-infection properties, playing a vital role in managing bacterial infections commonly associated with infected bone defects[10]. Research data indicate that adopting this combined treatment approach in the first stage can significantly reduce the need for autologous bone grafts in the second stage, thereby effectively lowering the risk of donor site complications[42]. The second stage of surgery involves mixing PRP with autologous bone grafts. This process not only reduces the time needed for new blood vessel formation but also enhances osteoblast activity, leading to better mineralization. Additionally, PRP supports osteoclast function, facilitating effective bone remodeling[3]. PRP contains antimicrobial peptides that work together with the physical barrier created by the induced membrane, significantly lowering infection risks. At the same time, these peptides help control excessive TGF-β1 expression, which in turn reduces the formation of scar tissue[26].

Clinical advantages of combination therapy

Preliminary evidence from both animal models and early clinical studies suggests that combining the Masquelet technique with PRP may offer potential benefits in treating large segmental bone defects.

Infections are often accompanied by local blood circulation damage. PRP releases pro - angiogenic factors like VEGF, effectively reconstructing blood supply and providing nutritional support for the induced membrane[47]. Moreover, PRP activates the BMP/Smad signaling pathway, reversing the inhibition of osteogenic activity caused by chronic inflammation and restoring the potential for bone regeneration[43]. Research by scholars such as LI[23] revealed that using PRP alongside bone grafting during the second-stage surgery is more effective than bone grafting alone, shortening healing time and reducing complications. Preclinical studies in animal models have reported that PRP can enhance vascular density in the induced membrane and boost growth factor levels, with some indicating a potential improvement in biomechanical strength. These findings warrant further investigation in human subjects[5].

Additionally, PRP is rich in antimicrobial peptides such as defensins and lysozymes, which can collaborate with antibiotic - loaded bone cement to construct a multi - layer antibacterial barrier, significantly reducing the risk of recurrent infections[40]. These findings highlight how the combined use of the Masquelet technique and PRP improves bone healing efficiency and optimizes clinical outcomes, offering patients a more effective treatment option. A detailed, step-by-step clinical protocol summarizing this combined approach is outlined in Table I. The rationale for exploring adjuvant therapies like PRP is further strengthened when considering the comparative landscape of treatment options. While techniques such as Ilizarov distraction osteogenesis and vascularized fibular grafting offer proven solutions for large bone defects[7,44], they come with significant drawbacks, including lengthy treatment times, high technical demands, and donor-site morbidity. The Masquelet-PRP combination aims to enhance the biological performance of a less technically demanding staged procedure, potentially reducing the overall burden on the patient and healthcare system, especially in settings where access to specialized equipment or expertise may be limited[28].

Potential risks and precautions for combined application

The combined application of the Masquelet technique and PRP has demonstrated promising clinical outcomes, though potential risks and complications warrant careful consideration. Inadequate removal of biofilms or insufficient control of infection sources prior to using the Masquelet technique may heighten the risk of recurrent infections[42]. While PRP contains leukocytes with antibacterial properties, excessively high concentrations could release pro-inflammatory factors, potentially worsening local inflammation[4], Strict adherence to aseptic protocols during PRP preparation and application is crucial to prevent

complications like infection or hemorrhage in bone defects and injured soft tissues[11]. The variability in PRP composition due to different preparation methods also affects its quality and concentration, ultimately influencing bone healing efficacy. Additionally, patient-specific factors such as age, underlying health conditions, and injury mechanisms play a role in determining treatment success. To mitigate these risks, clinicians should tailor PRP preparation techniques and treatment timing to individual patient needs, optimizing therapeutic benefits while minimizing adverse effects. Although the Masquelet-PRP combination shows substantial potential in enhancing bone healing, its clinical use requires judicious implementation to ensure safety and effectiveness.

To systematically summarize the current research progress on the combination of the Masquelet technique with PRP for bone defect treatment, particularly its application in both infected and non-infected environments, we have compiled data from existing animal and clinical studies. The following table (Table II) consolidates key information including the study model, infection status, defect site, PRP type, and main outcomes, aiming to provide a more intuitive evidence base for clinical decision-making.

Summary and prospects

Since its introduction in the 1980s, the induced membrane (Masquelet) technique has undergone significant evolution—from initial reliance on simple bone cement to the incorporation of advanced materials like 3D-printed scaffolds and bioceramics. Extensive preclinical and clinical studies have validated its efficacy in bone defect reconstruction, yet persistent challenges remain. Key among these are the suboptimal pharmacokinetics of antibiotic release from PMMA cement, the complexity of biofilm eradication, and the need for personalized therapeutic strategies that balance antimicrobial potency with inflammatory modulation. In parallel, platelet-rich plasma (PRP) has gained prominence over the past decade for its regenerative potential in bone and soft tissue repair. The integration of PRP with the Masquelet technique offers a promising approach to address existing limitations: PRP may compensate for declining growth factor levels post-cement implantation, potentially enhancing bone repair, reducing infection recurrence, and accelerating healing. However, while preclinical and preliminary clinical data are encouraging, current evidence does not yet establish the Masquelet-PRP combination as superior to the standard technique in definitive clinical outcomes. Future research must prioritize three fronts: (1) developing advanced biomaterials (e.g., antibiotic-eluting bone cement, growth factor-sustaining PRP scaffolds); (2) refining the "one-step" surgical protocol to reduce patient morbidity and autograft dependence; and (3) conducting larger, rigorously designed randomized controlled trials to validate reported benefits in healing time, infection control, and complication rates.

Author contributions statement: All listed authors contributed to this study. ZWQ conceived and designed the study. ZPY and HHS performed data analysis and interpretation. YZP wrote the manuscript. All authors read and approved the final manuscript.

Acknowledgements: This work was supported by the Natural Science Foundation of Ningxia Province, 2023AAC02064. We are grateful to Zewen Qiao for their insightful suggestions during the manuscript revision of this research. We also extend our thanks to all the volunteers who participated in this study.
Finally, we acknowledge the reviewers and editors for their constructive comments.

Conflict of Interest Disclosure: All authors declare that they have no conflicts of interest that might be perceived as influencing the objectivity of this research report.

Review Design and Literature Selection Strategy

This article presents a comprehensive narrative review aimed at synthesizing current evidence on the combined application of the Masquelet technique and platelet-rich plasma (PRP) in the treatment of large segmental infected bone defects. While not a systematic review adhering to PRISMA guidelines, this narrative synthesis follows a structured and transparent approach to literature selection.
A targeted search was conducted using major biomedical databases, including PubMed, Embase, Web of Science, and CNKI (China National Knowledge Infrastructure), up to December 2024.

Search terms included combinations of: "Masquelet technique," "induced membrane," "platelet-rich plasma," "PRP," "bone defect," "infection," "osteomyelitis," and "bone regeneration."

Initial screening focused on peer-reviewed original research articles, clinical trials, case series, and relevant review papers published in English or Chinese. Articles were prioritized based on their relevance to the mechanistic interaction, clinicalefficacy, and challenges associated with combining PRP and the Masquelet technique. Particular emphasis was placed on studies reporting outcomes related to infection control, vascularization, bone healing, and graft integration.

The final reference list was curated to reflect key advancements, representative findings, and diverse perspectives in the field, ensuring a balanced and evidence-informed discussion.

Table I. — Stepwise Clinical Protocol for Masquelet Technique Combined with PRP in Large Segmental.

Phase	Step	Key Actions and Considerations	Role of PRP
Stage 1: Induction Membrane Formation	1, Radical Debridement	Thorough removal of all necrotic bone, soft tissue, and biofilm. Culture-guided antibiotic selection. Ensure stable fixation.	
	2, Spacer Implantation	Implant antibiotic-loaded PMMA cement spacer (e.g., Vancomycin, Gentamicin) to fill the defect and maintain space.	
	3, Adjunctive PRP Application	Local application of leukocyte-rich PRP (L-PRP) around the spacer site	Enhances local antibacterial activity via defensins and NETs. Synergizes with antibiotics to disrupt residual biofilm. May reduce risk of early infection recurrence.
Stage 2: Membrane Preservation Bone Grafting 6-8 weeks post-Stage 1	4, Spacer Removal and Membrane Preservation	Carefully remove the PMMA spacer while meticulously preserving the integrity of the induced membrane.	
	5, Graft Preparation and PRP Mixing	Harvest autologous bone graft. Prepare pure PRP (P-PRP) via double centrifugation. Mix graft with PRP.	PRP acts as a "biological activator." High concentrations of PDGF, VEGF, TGF-β promote MSC recruitment, osteogenesis, and angiogenesis. May allow for reduction in autograft volume needed.
	6, Graft Implantation	Pack the PRP-enriched bone graft into the defect, completely enclosed by the induced membrane. Secure fixation.	
Postoperative Management	7, Antibiotic Therapy	Continue systemic antibiotics based on culture results for 4-6 weeks. Monitor for signs of infection.	
	8, Rehabilitation	Initiate protected weight-bearing as tolerated, guided by fixation stability and healing progress. Physical therapy to maintain joint mobility.	
	9, Monitoring and Follow-up	Serial clinical and radiographic (X-ray, CT) evaluations at 6-week, 3-month, 6-month, and 1-year intervals to assess bone healing, consolidation, and infection control.	

Although a formal quality assessment and meta-analysis were beyond the scope of this narrative review, efforts were made to cite high-impact, welldesigned studies to support the arguments presented.

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Table II. — Summary of Experimental and Clinical Studies on Masquelet Technique Combined with PRP for Bone Defects.

Number	Author + Year	Study Type	Model	Infection Status	Defect Site	PRP Type	Key Outcomes
1	Bilal Ö et al. 2020	Basic Research	New Zealand Rabbits	Non - infectious	Femur	Autologous PRP	BV/TV(+42%); Torsional strength(+35%); Vascular density (+56%)
2	Liu W et al. 2024	Basic Research	SD Rats	Non - infectious	Femur	PRP - FG - nHA/PA66	Scaffold 100% bone bridging at 6 weeks; Autologous bone usage (-45%); Vascular density (+70%)
3	Yilmaz et al. 2018	Basic Research	New Zealand Rabbits	Non - infectious	Femur	CGF	Membrane thickness(+32%); VEGF/MKP – 2(+40 - 48%)
4	Ancan G et al. 2022	Basic Research	New Zealand Rabbits	Non - infectious	Femur	CGF	BV/TV (+35%); Torsional strength (+30%)
5	Zhang Y et al. 2022	Basic Research	New Zealand Rabbits	Non - infectious	Ulna	Autologous PRP	Bone mineralization area (+38%); Maximum load (+28%); ALP(+45%)
6	Erdem MN et al. 2023	Basic Research	SD Rats	Non - infectious	Femur	Autologous PRP	Membrane thickness (+54%); Vascular count (+68%); Torsional strength (+37%)
7	Turan JK et al. 2024	Basic Research	SD Rats	Non - infectious	Ulna	Three concentrations of PRP: 2×/5×/8×	Group 5× had the highest membrane thickness; VEGF: Group 8× had no additional gain
8	Li T et al. 2025	Clinical Series	Human	Infectious	Calcaneus	Autologous PRP and iliac bone	Average healing time 11.1 months; ADFAS score from 39 to 84; No recurrence of infection
9	Gurava Reddy AV et al. 2023	Clinical Series	Human	Infectious	Femur	Cancellous bone and fibula	Bridging in 5.2 months; Complete healing in 8 months; Lysholm score 89
10	Liu Y - Y et al. 2025	Clinical Series	Human	Infectious	Femur/ Tibia	Combination of PRP gel and vascularized fibula	Healing index 1.1 months; CIQ - H: DASH score from 62 to 24
11	Li et al. 2019	Clinical Series	Human	Infectious	Femur/ Tibia	Autologous leukocyte - rich PRP (L - PRP)	In the combination group, the fracture healing time was significantly shortened (28.78 weeks vs 36.17 weeks), and the infection recurrence rate (5.6% vs 35.3%) and complication rate (11.1% vs 52.9%) were significantly reduced
12	Wang et al. 2021	Clinical Series	Human	infectious	Tibia	Antibiotic - loaded PRP (PADS)	The patient achieved bone healing at 15 - month follow - up, which proved its feasibility
13	Xie et al. 2020	Basic Research	SD Rats	Non - infectious	Femur	Autologous PRP and autologous particles	The combination of PRP and autologous particles can significantly promote bone regeneration in rabbits

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