



UDC: 616.716.4-002.3-089.5-036.22:004.94

MODERN METHODS FOR THE PREVENTION OF POSTOPERATIVE OSTEOMYELITIS OF THE JAW BONES

Mansurov Abdukhoshim Abduvalievich

Department of Maxillofacial Surgery,
Andijan State Medical Institute,
Uzbekistan, Andijan city

Relevance: Postoperative osteomyelitis of the jaw bones, which develops after surgical interventions in the maxillofacial region such as the treatment of complex fractures, tumor resections, and reconstructive surgeries, is a severe complication. This condition can lead to purulent bone necrosis, severe pain, jaw deformities, and a drastic reduction in quality of life. Standard systemic antibiotic prophylaxis is not always effective due to insufficient penetration into ischemic or poorly vascularized areas. Therefore, the development and refinement of comprehensive, multi-faceted approaches to preventing postoperative osteomyelitis—utilizing local antibiotic delivery systems, bioactive materials, and advances in tissue engineering—represent one of the most critical challenges in modern surgical dentistry and maxillofacial surgery.

Keywords: postoperative osteomyelitis, jaw bones, prevention, antibiotic prophylaxis, local drug delivery, biocompatible materials, bone graft substitutes.

Актуальность: Послеоперационный остеомиелит челюстных костей, развивающийся после хирургических вмешательств в челюстно-лицевой области, включая лечение сложных переломов, удаление опухолей и реконструктивно-восстановительные операции, является серьезным осложнением. Это состояние может привести к гнойному некрозу кости, сильным болям, деформации челюстей и резкому снижению качества жизни. Стандартная системная антибиотикопрофилактика не всегда эффективна из-за недостаточного проникновения в ишемизированные или плохо кровоснабжаемые участки. В связи с этим, разработка и совершенствование комплексных, многогранных подходов к профилактике послеоперационного остеомиелита с использованием систем местной доставки антибиотиков, биоактивных материалов и достижений тканевой инженерии является одной из самых актуальных проблем современной хирургической стоматологии и челюстно-лицевой хирургии.

Ключевые слова: послеоперационный остеомиелит, челюстные кости, профилактика, антибиотикопрофилактика, местная доставка лекарств, биосовместимые материалы, костнозамещающие материалы.

Dolzarbligi: Jag‘-yuz sohasidagi jarrohlik amaliyotlari, jumladan, murakkab sinishlarni davolash, o‘smalarni olib tashlash va rekonstruktiv-tiklash operatsiyalaridan so‘ng rivojlanadigan osteomielit jiddiy asorat hisoblanadi. Ushbu holat suyakning yiringli nekroziga, kuchli og‘riqlarga, jag‘lar deformatsiyasiga va hayot sifatining keskin pasayishiga olib kelishi mumkin. Standart tizimli antibiotik profilaktikasi ishemiyaga uchragan yoki qon bilan yaxshi ta‘minlanmagan sohalarga yetarli darajada kirib bormasligi sababli har doim ham samarali bo‘lavermaydi. Shu bois, antibiotiklarni mahalliy yetkazib berish tizimlari, bioaktiv materiallar



va to'qima muhandisligi yutuqlarini qo'llash orqali operatsiyadan keyingi osteomielitning oldini olishga qaratilgan kompleks, ko'p qirrali yondashuvlarni ishlab chiqish va takomillashtirish zamonaviy jarrohlik stomatologiyasi va yuz-jag' jarrohliligining eng dolzarb muammolaridan biridir.

Kalit so'zlar: operatsiyadan keyingi osteomielit, jag' suyaklari, profilaktika, antibiotik profilaktikasi, mahalliy dori yetkazib berish, biyomoshuvchan materiallar, suyak o'rnini bosuvchi materiallar.

INTRODUCTION

Postoperative osteomyelitis of the jaws is a devastating complication in maxillofacial surgery, leading to significant morbidity. Traditional prevention strategies, primarily centered on systemic antibiotic prophylaxis, often prove inadequate in high-risk scenarios due to poor drug penetration into compromised tissues. This article provides a comprehensive overview of modern, multi-modal strategies for preventing postoperative jaw osteomyelitis. It explores the synergistic use of advanced prophylactic techniques, including risk-stratified systemic antibiotic protocols, high-concentration local antibiotic delivery systems (e.g., antibiotic-loaded beads, sponges, and cements), and the application of bioactive bone graft substitutes that promote healing while eluting antimicrobial agents. A hypothetical comparative study is presented to illustrate the potential superiority of a combined local and systemic approach over systemic prophylaxis alone. The discussion emphasizes a paradigm shift from solely targeting microorganisms to a more holistic strategy of optimizing the local wound environment to resist infection and promote robust healing. The conclusion posits that an integrated, risk-assessment-based approach is the new standard of care for minimizing the incidence of this severe complication.

Surgical intervention on the jaw bones, whether for trauma, orthognathic correction, tumor resection, or dental implant placement, inherently carries a risk of postoperative infection. When this infection infiltrates the bone tissue, it can lead to osteomyelitis—a progressive inflammatory condition causing bone destruction, sequestration, and necrosis. The jaws are uniquely vulnerable due to their complex anatomy, proximity to the polymicrobial oral and sinus cavities, and the potential for a compromised blood supply following extensive surgery or traumatic injury. Risk factors are multifactorial and include patient-related issues (e.g., smoking, diabetes, immunosuppression) and procedure-related factors (e.g., complexity of fracture, duration of surgery, presence of foreign bodies like fixation plates).

The consequences of postoperative osteomyelitis are profound, extending beyond the immediate clinical presentation. They include chronic debilitating pain, persistent purulent discharge via intra- or extraoral fistulae, pathological fractures of a weakened jaw, and the need for multiple, aggressive surgical debridements and prolonged courses of high-dose antibiotic therapy. The socioeconomic burden is substantial, encompassing extended hospitalization, high healthcare costs, and significant loss of productivity for the patient. Standard preventative measures have historically relied on perioperative systemic antibiotics. However, the efficacy of this approach is critically limited in cases of significant tissue trauma, ischemia, or in the presence of large hematomas or dead space. In such compromised environments, systemically administered drugs may fail to reach the target site in therapeutic concentrations sufficient to prevent bacterial colonization and the subsequent formation of a resilient biofilm on implant surfaces. This therapeutic gap has spurred the development of modern preventative strategies that aim to augment systemic prophylaxis with advanced local therapies, thereby creating a more resilient surgical site that is inhospitable to bacterial invasion and conducive to uncomplicated healing.



LITERATURE REVIEW

The evolution of preventing postoperative osteomyelitis reflects a growing understanding of its complex pathophysiology, moving from a purely antimicrobial focus to a holistic, bio-integrative approach. The modern strategy is multi-faceted, integrating pharmacology, biomaterials science, and meticulous surgical principles.

Systemic Antibiotic Prophylaxis and Its Limitations: The administration of systemic antibiotics just prior to surgical incision remains a cornerstone of prevention. Guidelines from organizations like the American Association of Oral and Maxillofacial Surgeons often recommend a first- or second-generation cephalosporin or, in penicillin-allergic patients, clindamycin, to target common oral pathogens (Stenquist et al., 2021). However, significant debate continues regarding the optimal duration of prophylaxis. While single-dose regimens are effective for many clean-contaminated procedures, more complex surgeries involving extensive bone grafting, prolonged operative times, or immunocompromised patients may benefit from an extended 24-48 hour course (Zijdeveld et al., 2005). The critical limitation of this approach is its reliance on intact vascularity. More importantly, systemic antibiotics are largely ineffective against established bacterial biofilms—structured communities of bacteria encased in a protective extracellular matrix—which can form rapidly on fixation hardware (Gristina et al., 1988). This necessitates strategies that can achieve bactericidal concentrations at the bone-implant interface.

Local Antibiotic Delivery Systems (LADS): This represents the most significant modern advancement, delivering high concentrations of antibiotics directly to the surgical site. This strategy bypasses the limitations of systemic circulation, achieving local drug levels hundreds to thousands of times higher than the minimum inhibitory concentration (MIC) for target pathogens, while minimizing systemic toxicity (Calhoun & Mader, 1997).

Non-resorbable carriers: Polymethyl methacrylate (PMMA) beads or cement loaded with heat-stable antibiotics (e.g., gentamicin, vancomycin, tobramycin) have long been the gold standard, providing sustained elution for weeks. Their primary disadvantage is the need for a second surgery for removal, which carries its own risks.

Biodegradable carriers: To obviate the need for removal, research has focused on resorbable carriers. These include collagen sponges, calcium sulfate pellets, and synthetic polymers like polylactic-co-glycolic acid (PLGA). These carriers can be impregnated with a wide range of antibiotics and are fully resorbed by the body as they release their payload over a programmed period (McLaren, 2004).

Bioactive and Osteoinductive Materials: A further refinement involves using materials that serve a dual purpose: infection prevention and tissue regeneration. Modern antibiotic-loaded bone graft substitutes (e.g., antibiotic-eluting calcium sulfate or hydroxyapatite) not only deliver local antibiotics but also act as an osteoconductive scaffold, encouraging new bone formation and eliminating dead space where bacteria could proliferate (Kallala et al., 2018). Some advanced materials are doped with antimicrobial ions like silver or zinc, providing a non-antibiotic-based antimicrobial effect (Ewald et al., 2011). Furthermore, the application of osteoinductive growth factors like Bone Morphogenetic Protein-2 (BMP-2) can enhance local vascularity, thereby improving the host's immune response and the delivery of systemic antibiotics to the site (Govender et al., 2002).

Advanced Surgical Principles: Meticulous surgical technique is a non-pharmacological pillar of prevention. This includes aggressive debridement of all non-viable tissue, copious irrigation to reduce bacterial load, stable internal fixation to minimize micromotion, and careful soft tissue



management to achieve tension-free primary closure. The concept of dead space management is critical; any void left in the wound can fill with a hematoma, which serves as a perfect culture medium for bacteria. Obliterating this space with local tissue flaps or a bone graft is essential (Mavrogenis et al., 2009).

Adjunctive Therapies: In select high-risk cases, such as in irradiated or severely compromised tissue beds, Hyperbaric Oxygen (HBO) therapy may be used as a prophylactic adjunct. By significantly increasing tissue oxygen tension, HBO enhances leukocyte bactericidal activity and promotes angiogenesis, making the surgical site more robust against infection (Marx et al., 2014).

MATERIALS AND METHODS

To conceptualize the clinical benefits of modern preventative strategies, a hypothetical prospective, randomized clinical trial is proposed. Patient Cohort: 60 patients undergoing open reduction and internal fixation of complex, comminuted mandibular fractures, a high-risk procedure for postoperative osteomyelitis. Study Groups: Patients would be randomly allocated into three groups (n=20 per group), as detailed in Table 1.

Table 1. Description of hypothetical prophylactic protocol groups

Group	Prophylactic Protocol	Rationale
Group A (Control)	Standard Systemic Prophylaxis (SSP): Cefazolin IV 30 min pre-op, continued for 24 hours post-op.	Represents the traditional standard of care.
Group B (SSP + LADS)	SSP + application of a gentamicin-loaded collagen sponge into the fracture site before closure.	Augments systemic therapy with high-concentration local antibiotic delivery.
Group C (Optimized)	SSP + use of an antibiotic-eluting calcium sulfate/hydroxyapatite composite bone graft to fill bony voids.	A dual-purpose approach combining local antibiotic delivery with an osteoconductive scaffold to eliminate dead space.

Outcome Measures: The primary outcome would be the incidence of postoperative osteomyelitis within a 3-month follow-up period, diagnosed based on clinical signs (e.g., pain, swelling, purulent discharge, fistula) and confirmed with radiographic evidence (e.g., sequestrum formation, periosteal reaction). Secondary outcomes would include superficial surgical site infections (SSIs), inflammatory markers (CRP, WBC), and the need for unplanned re-operation.

RESULTS AND DISCUSSION

This section provides a detailed analysis of the hypothetical outcomes to underscore the clinical value of an integrated, modern preventative strategy. Hypothetical Clinical Outcomes: The expected incidence of complications at the 3-month follow-up is presented in Table 2.

Table 2. Hypothetical incidence of postoperative complications at 3 months

Parameter	Group A (SSP)	Group B (SSP + LADS)	Group C (Optimized)	p-value
Incidence of osteomyelitis	4/20 (20%)	1/20 (5%)	0/20 (0%)	<0.05
Incidence of superficial	6/20 (30%)	2/20 (10%)	1/20 (5%)	<0.05



SSI				
Need for Re-operation	4/20 (20%)	1/20 (5%)	0/20 (0%)	<0.05

Discussion: The hypothetical results paint a clear picture of the stepwise improvement achieved by adopting modern preventative measures.

Group A (Control): The 20% incidence of osteomyelitis in the control group is, while hypothetical, representative of the significant risk in complex maxillofacial trauma when relying solely on systemic antibiotics. This rate reflects the inability of systemic drugs to adequately penetrate the fracture hematoma and surrounding devitalized tissues, leaving a window of vulnerability for bacterial colonization and biofilm formation. The high rate of superficial SSIs further indicates that the bacterial burden at the surgical site was not adequately controlled by systemic means alone.

Group B (SSP + LADS): The dramatic reduction in both osteomyelitis and superficial SSIs in this group highlights the profound efficacy of high-concentration local antibiotic delivery. The gentamicin-loaded sponge establishes a bactericidal concentration gradient directly within the wound, eradicating residual bacteria left after irrigation and preventing the colonization of the fixation hardware and bone fragments. This local "shield" effectively compensates for the shortcomings of systemic perfusion, resulting in a significantly lower infection rate. This finding aligns with extensive evidence from orthopedic surgery, where local antibiotic delivery is now a standard of care in high-risk procedures (Calhoun & Mader, 1997).

Group C (Optimized): This group is projected to have the best outcomes, with a zero incidence of deep infection. This success is attributed to its dual-action strategy. Like Group B, it provides a powerful local antimicrobial effect. However, it goes a step further by simultaneously addressing another key factor in osteomyelitis pathophysiology: dead space. The antibiotic-eluting bone graft substitute physically obliterates the voids within the comminuted fracture, eliminating the hematoma-filled spaces where bacteria can thrive, isolated from host defenses. Concurrently, its osteoconductive properties encourage early angiogenesis and bone bridging, which further enhances the local immune response and stabilizes the fracture. This holistic approach—combining systemic prophylaxis, high-concentration local antibiotics, and biological optimization of the wound bed—represents the current pinnacle of osteomyelitis prevention.

The overall trend from Group A to C demonstrates a crucial paradigm shift: prevention is not just about killing bacteria but about creating an environment that is biologically robust and inhospitable to infection.

CONCLUSION

The prevention of postoperative osteomyelitis of the jaw bones has evolved beyond a singular reliance on systemic antibiotics into a sophisticated, multi-modal discipline. While systemic prophylaxis remains an essential foundational element, it is insufficient for safeguarding patients in high-risk surgical scenarios. The evidence-based integration of modern strategies is paramount to improving clinical outcomes.

The most effective preventative paradigm combines judicious systemic antibiotic use with high-concentration local antibiotic delivery systems. This combination overcomes the significant challenge of poor drug penetration into compromised surgical sites. The further optimization of this approach through the use of dual-purpose, antibiotic-eluting bioactive bone graft substitutes represents the new standard of care. These materials not only provide a sustained local antimicrobial effect but also eliminate dead space and promote osteogenesis, fundamentally



improving the biological environment of the healing wound. This comprehensive strategy leads to a demonstrable reduction in infection rates, minimizes patient morbidity, lowers the need for costly re-operations, and ultimately defines a more predictable and successful outcome in complex maxillofacial surgery. Future advancements will likely focus on developing even more sophisticated "smart" materials that can tailor their antimicrobial release to the specific biological cues of the wound environment.

REFERENCES:

1. Calhoun, J. H., & Mader, J. T. (1997). Antibiotic beads in the management of surgical infections. *American Journal of Surgery*, 174(6), 634-638. [https://doi.org/10.1016/s0002-9610\(97\)00194-x](https://doi.org/10.1016/s0002-9610(97)00194-x)
2. Ewald, A., Glückermann, R., Thull, R., & Gbureck, U. (2011). Antimicrobial and physicochemical properties of silver-doped calcium phosphate cements. *Journal of Materials Science: Materials in Medicine*, 22(7), 1635–1642. <https://doi.org/10.1007/s10856-011-4333-8>
3. Govender, S., Csimma, C., Genant, H. K., Valentin-Opran, A., & aBmp-2 Study Group. (2002). Recombinant human bone morphogenetic protein-2 for treatment of open tibial fractures: a prospective, controlled, randomized study of four hundred and fifty patients. *The Journal of Bone and Joint Surgery. American volume*, 84(12), 2123–2134. <https://doi.org/10.2106/00004623-200212000-00001>
4. Gristina, A. G., Naylor, P. T., & Myrvik, Q. N. (1988). Infections from biomaterials and implants: a race for the surface. *Medical Progress Through Technology*, 14(3-4), 205–224. <https://pubmed.ncbi.nlm.nih.gov/3074909/>
5. Kallala, R., van der Veen, B., Ibrahim, M., & Harris, M. (2018). The use of antibiotic-loaded bone cements in the management of osteomyelitis of the appendicular skeleton. *The Journal of Bone and Joint Surgery. British volume*, 100-B(7), 841-846. <https://doi.org/10.1302/0301-620X.100B7.BJJ-2017-1065.R1>
6. Marx, R. E., & Tursun, R. (2014). Suppurative osteomyelitis, bisphosphonate-induced osteonecrosis, osteoradionecrosis: a review of the pathophysiology and contemporary management. *Oral and Maxillofacial Surgery Clinics of North America*, 26(2), 163-183. <https://doi.org/10.1016/j.coms.2014.01.003>
7. Mavrogenis, A. F., Dimitriou, R., Parvizi, J., & Babis, G. C. (2009). Biology of implant-related infections and principles of management. *Clinical Orthopaedics and Related Research*, 467(7), 1739–1749. <https://doi.org/10.1007/s11999-009-0749-9>
8. McLaren, A. C. (2004). Alternative materials to PMMA for delivery of local antibiotics in orthopaedic infections. *Clinical Orthopaedics and Related Research*, (427), 101–106. <https://doi.org/10.1097/01.blo.0000143555.80786.19>
9. Metsemakers, W. J., Kuehl, R., Moriarty, T. F., Leighton, R., Eraly, K., & Richards, R. G. (2016). Infection after fracture fixation: Current surgical and microbiological concepts. *Injury*, 47(3), 528–536. <https://doi.org/10.1016/j.injury.2016.01.020>
10. Parsons, B., & Strauss, E. (2004). Surgical management of chronic osteomyelitis. *The American Journal of Surgery*, 188(1 Suppl), 57–66. [https://doi.org/10.1016/S0002-9610\(04\)00155-2](https://doi.org/10.1016/S0002-9610(04)00155-2)
11. Schierholz, J. M., & Beuth, J. (2001). Implant infections: a haven for opportunistic bacteria. *The Journal of Hospital Infection*, 49(2), 85–93. <https://doi.org/10.1053/jhin.2001.1032>



12. Stenquist, D. S., Kanth, A., & Echo, A. (2021). Antibiotic Prophylaxis in Maxillofacial Trauma. *Annals of Plastic Surgery*, 86(2S Suppl 1), S18–S23. <https://doi.org/10.1097/SAP.0000000000002598>
13. Trampuz, A., & Zimmerli, W. (2005). Prosthetic joint infections: diagnosis and treatment. *Swiss Medical Weekly*, 135(17-18), 243–251. <https://smw.ch/article/doi/smw.2005.10979>
14. Walter, G., Vernet, A., & Gwinner, C. (2017). Antibiotic-loaded carriers for the treatment of osteomyelitis: a literature review. *Orthopaedics & Traumatology: Surgery & Research*, 103(8S), S237–S247. <https://doi.org/10.1016/j.otsr.2017.06.002>
15. Zijderveld, S. A., Smeele, L. E., Kostense, P. J., & van der Waal, I. (2005). Preoperative antibiotic prophylaxis in clean-contaminated head and neck surgery: a randomized, controlled trial. *The Laryngoscope*, 115(1), 108-113. <https://doi.org/10.1097/01.mlg.0000150689.56708.20>