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BONE RECONSTRUCTION IN COMPLEX HAND TRAUMA: USE OF MODULAR EXTERNAL FIXATORS IN EXPOSED CARPAL AND PHALANX FRACTURES

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ABSTRACT

Introduction: Complex hand traumas, especially in exposed carpal and phalangeal fractures, represent a challenge due to the need to balance anatomical restoration and functional preservation. This study reviewed the use of modular external fixators in these cases, highlighting advantages, limitations, and clinical outcomes. Methods: A systematic review of the literature was performed in the MEDLINE databases via PubMed and SciELO, covering publications between 2001 and 2024. After strict inclusion and exclusion criteria, 20 relevant articles were selected, analyzed qualitatively, and synthesized in a narrative format. Results: Modular external fixators demonstrated efficacy in mechanical stabilization and functional recovery, but presented complications such as infections. Complementary

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techniques, such as Kirschner wires and intramedullary screws, increased mobility and accelerated recovery. The choice of method should consider the patient's profile, trauma characteristics, and the surgeon's experience. Conclusion: Modular external fixators are effective in the management of complex hand traumas, with good functional results. Future studies are needed to compare methods and consolidate best practices.

Keywords: Complex Hand Trauma. Modular External Fixators. Bone Reconstruction.

INTRODUCTION

Complex hand traumas, particularly those involving exposed fractures of the carpal and phalangeal bones, pose a significant challenge in orthopedic practice. These injuries often compromise the structural stability and biomechanical functionality of the hand, requiring interventions that balance anatomical restoration with the preservation of adjacent tissues (Müller et al., 2003). The high risk of complications, such as infections and pseudoarthrosis, necessitates the use of techniques that minimize secondary damage and promote efficient functional recovery.

Modular external fixators have emerged as an effective option for managing exposed fractures, offering immediate mechanical stability and allowing alignment of bone fragments without excessive manipulation of soft tissues (Carula et al., 2020). The use of complementary techniques, such as Kirschner wires and headless intramedullary screws, has expanded therapeutic possibilities while reducing complications associated with prolonged immobilization (Chen et al., 2019).

The selection of a treatment method, however, should consider the biomechanical aspects of the injury, the systemic conditions of the patient, the availability of technological resources, and the experience of the surgeon (Brei-Thoma et al., 2015). Comparative studies indicate that the choice of fixation device can directly influence functional outcomes and long-term complication rates (Belloti et al., 2020).

In this context, this study aims to systematically review the available literature on bone reconstruction in complex hand traumas, focusing on the effectiveness of modular external fixators. The analysis will address the advantages and limitations of the methods, as well as explore gaps in current knowledge, contributing to the improvement of evidence-based clinical practices (Reis et al., 2022).

MATERIALS AND METHODS

A systematic literature review was conducted with the aim of understanding bone reconstruction in complex hand traumas: use of modular external fixators in exposed fractures of the carpal and phalangeal bones. Articles published in scientific journals were reviewed to provide a comprehensive overview of the topic.

SEARCH STRATEGIES AND DATA SOURCES

Data were searched in the MEDLINE database via PubMed and Scielo. In the MEDLINE database, using the PubMed search platform, articles published between 2001

and 2024 were identified, from which 12 were selected after applying the inclusion and exclusion criteria. In Scielo, 8 articles were found, 5 of which were selected.

SEARCH TERMS

The search terms included combinations of keywords related to bone reconstruction in complex hand traumas: use of modular external fixators in exposed fractures of the carpal and phalangeal bones: "Reconstruction," "Bones," "Complex trauma," and "External fixators." The Boolean operator AND was used.

INCLUSION AND EXCLUSION CRITERIA

The search was limited to studies published in the last 23 years to ensure the relevance of the data and was conducted with the following inclusion and exclusion criteria:

Inclusion Criteria

Studies addressing bone reconstruction in complex hand traumas: use of modular external fixators in exposed fractures of the carpal and phalangeal bones • Articles describing bone reconstruction in complex hand traumas: use of modular external fixators in exposed fractures of the carpal and phalangeal bones • Research published in peer-reviewed scientific journals • Studies available in English, Spanish, and Portuguese

Exclusion Criteria

Studies not focusing on bone reconstruction in complex hand traumas: use of modular external fixators in exposed fractures of the carpal and phalangeal bones • Case reports that do not provide relevant information on bone reconstruction in complex hand traumas: use of modular external fixators in exposed fractures of the carpal and phalangeal bones • Duplicate or repeated studies • Articles not available in full or without free access

STUDY SELECTION

The studies identified were initially reviewed based on their titles and abstracts to determine their relevance to the topic. The selected articles were then analyzed in full to confirm their inclusion in the literature review. Boolean operators mentioned above were used to optimize the precision of the search and ensure that all relevant articles were identified. After selecting based on relevant titles, methodology, objectives, and results, a compilation of 20 articles was obtained for analysis.

DATA EXTRACTION AND SYNTHESIS

Relevant data were extracted from the selected articles, including information on bone reconstruction in complex hand traumas: use of modular external fixators in exposed fractures of the carpal and phalangeal bones. The selected articles were then analyzed in full to confirm their inclusion in the literature review. Relevant data were extracted from the selected articles, providing an overview of the topic. The extracted data were qualitatively analyzed and synthesized narratively.

ASSESSMENT OF STUDY QUALITY

The methodological quality of the included studies was assessed using specific criteria for each type of study, considering aspects such as study design, sample representativeness, and analysis methodology. Patterns and trends were identified to understand bone reconstruction in complex hand traumas: use of modular external fixators in exposed fractures of the carpal and phalangeal bones. The methodological quality of the included studies was assessed using criteria related to the type of study: Cohort, Case Report, and Systematic Review. Aspects such as study design, sample representativeness, and analysis methodology were considered.

ETHICAL CONSIDERATIONS

This article is based on the analysis of previously published data and does not involve the collection of information directly from human participants. Therefore, no additional ethical considerations are required.

RESULTS AND DISCUSSION

Data from studies addressing bone reconstruction in complex hand traumas, focusing on the use of modular external fixators in exposed fractures of the carpal and phalangeal bones, were analyzed. The results highlight the diversity of methods and therapeutic approaches, as well as their respective clinical and functional implications. It was observed that the techniques vary in efficacy, complication rates, and recovery time, emphasizing the need for treatment personalization based on the trauma characteristics, patient profile, and surgeon's experience.

COMPARISON OF TREATMENT METHODS

A comparative analysis between the dorsal bridge plate and external fixator in distal radius fractures showed similar functional and radiological results between the methods.

However, complications such as infection were more frequent with the use of external fixators, while sympathetic reflex neuropathy was associated with the dorsal bridge plate. There was no consensus on the superiority of one method, and the choice should consider the patient's profile and material availability (Carula et al., 2020). A retrospective study conducted by Barbieri et al. in 2001 involving 60 patients demonstrated that external fixation can restore the distal radius anatomy, providing good clinical and functional outcomes with a low complication rate.

SPECIFIC INJURIES AND SURGICAL METHODS

In the case of pseudoarthroses, Belloti et al. (2020) noted that percutaneous fixation without bone graft for scaphoid pseudoarthroses showed positive results, with a high consolidation rate and low technical morbidity. Patients had good functional scores (DASH and PRWE) and minimal residual pain after six months of follow-up.

Recently, regarding the efficacy of volar plates in distal radius fractures, Bezirgan et al. (2024) stated that the use of volar plates in distal radius fractures, particularly in dorsal fragments, showed satisfactory results in terms of grip strength, range of motion, and radiographic stability. The technique was effective even for challenging cases, such as fragments in the ulnar corner and the Lister's tubercle.

EVALUATION OF IMPLANTS AND ADVANCED TECHNIQUES

The use of plates in extra-articular fractures of the proximal phalanx resulted in improvements in total active finger mobility, but complications such as tendon adhesions persisted. Approximately 43% of patients required secondary surgery (Brei-Thoma et al., 2015). Headless cannulated screws showed excellent performance in the fixation of metacarpal neck fractures, allowing early mobility and avoiding external immobilization (Folberg et al., 2021).

COMPARISON OF MINIMALLY INVASIVE TECHNIQUES

Elastic fixation with two Kirschner wires proved effective in the treatment of hammer finger fractures, avoiding complications associated with surgical incisions. Functional recovery was satisfactory, with no recurrence after six months (Chen et al., 2019). Furthermore, extensor tendon interposition was identified as a rare complication in metacarpal neck fractures. After open reduction and fixation with Kirschner wires, good recovery of motion and strength was achieved (Krishna et al., 2021).

Minimally invasive techniques with three types of implants (volar plate, intramedullary rod, and external fixator) showed superior clinical-functional results up to the sixth week of postoperative follow-up, with equivalent stabilization over 12 months. (Aita et al., 2014) Later, Aita et al. (2021) noted that intramedullary fixation with headless screws and Kirschner wires showed similar results, with a low complication rate and early return to activities.

COMPARISON OF INTRAMEDULLARY TECHNIQUES

Antegrade intramedullary fixation showed initial clinical advantages over retrograde fixation in displaced fractures of the fifth metacarpal neck. However, both techniques showed similar long-term results, indicating that the choice may be based on the surgeon's preference (Kim et al., 2015).

Intramedullary fixation of metacarpal and phalangeal fractures with locked nails showed sufficient stability to allow early mobilization, with low soft tissue irritation and a high consolidation rate (Orbay et al., 2006).

FINAL CONSIDERATIONS

Bone reconstruction in complex hand traumas requires an individualized approach, considering the type of injury, patient conditions, and surgeon experience. Modular external fixators and complementary techniques have proven effective, with good functional results and variable complication rates. Continuous advancements in technology and surgical methods are essential to improve outcomes and treatment quality. Further studies are needed to consolidate best practices and enhance the long-term effectiveness of bone reconstruction in complex hand trauma. Moreover, comparative studies with larger sample sizes and long-term follow-up would provide more reliable data for clinical decision-making. The role of modular external fixators in the rehabilitation process, as well as the impact of early intervention and postoperative care, remains a critical area for future research to further optimize outcomes for patients with exposed fractures of the carpal bones and phalanges. Additionally, improving our understanding of the biomechanical properties of various fixation methods and the potential for combining them with innovative biological healing techniques may lead to even better functional recovery. Ultimately, the development of personalized, patient-centered approaches that combine modern technologies with evidence-based practices will be essential to achieving the best possible outcomes in hand trauma management.

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