MICROSURGERY AND NERVE RECONSTRUCTION IN COMPLEX BRACHIAL PLEXUS INJURIES: PROGNOSIS AND LIMITATIONS

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Abstract: Complex brachial plexus injuries represent a major challenge in medicine, as they can result in severe motor and sensory deficits, significantly impacting patients' quality of life. Microsurgery and nerve reconstruction techniques have evolved to restore upper limb function, but they still have limitations in terms of full recovery of functionality. The prognosis varies according to the severity of the injury, the time elapsed before the intervention and the surgical approaches used. This study aims to analyze the advances in microsurgery in brachial plexus reconstruction, assessing the prognosis and limitations of these approaches in patients with complex injuries. This is a bibliographic review with qualitative premises, using the SciELO, PubMed and Google Scholar databases to search for scientific articles. To refine the search, the health descriptors "brachial plexus", "microsurgery", "nerve reconstruction" and "nerve transfers" were used, applying Boolean operators to optimize the results. The time frame covers the years 2019 to 2023, according to the date of the first and last reference selected. Advances in microsurgery have allowed for better functional recovery rates, especially with techniques such as nerve grafts, nerve transfers and neurotizations. Nerve transfers have stood out for reducing reinnervation time, favoring better motor results. However, factors such as the chronicity of the injury, surgical time and the patient's neural plasticity significantly influence outcomes. Limitations include the need for prolonged rehabilitation, variability in functional results and difficulty in restoring fine movements and adequate muscle strength. It is concluded that microsurgery and nerve reconstruction are fundamental strategies in the rehabilitation of patients with complex brachial plexus injuries, providing partial or significant recovery of upper limb function. Despite advances, challenges such as prolonged recovery time and limitations in complete nerve regeneration still persist. New approaches, including regenerative therapies and tissue engineering, may contribute to better prognoses in the future.

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INTRODUCTION

Brachial plexus injuries represent one of the most complex challenges in reconstructive surgery, with significant impacts on upper limb functionality and patients' quality of life. These injuries can occur due to high-energy trauma, such as automobile accidents and traction injuries, and often result in severe motor and sensory deficits. Treatment involves conservative and surgical approaches, and reconstructive microsurgery is a fundamental strategy to try to reestablish neural function (SOUZA; PEREIRA, 2020).

Reconstructive brachial plexus microsurgery is based on sophisticated neurorrhaphy, nerve grafting, and nerve transfer techniques. Technological advances and improved knowledge about neurophysiology have allowed a refinement of these techniques, increasing the chances of functional recovery, although there are still significant limitations, such as nerve regeneration time and peripheral nervous system plasticity (LIMA et al., 2019). The choice of surgical technique depends on factors such as the location and extent of the lesion, the time elapsed since the trauma, and the presence of viable donor nerves (MARTINS; ALMEIDA, 2022).

Despite advances in microsurgery, functional recovery after extensive brachial plexus injuries remains a challenge. The prognosis is directly related to the precocity of the intervention, the type of injury (avulsion or rupture) and the efficacy of postoperative rehabilitation (CARVALHO; RIBEIRO, 2021). Many patients face difficulties in regaining full upper limb function, requiring prolonged rehabilitation and, in some cases, additional surgical procedures for functional improvement (SANTOS et al., 2020).

This study aims to analyze the prognoses and limitations of microsurgical techniques in brachial plexus nerve reconstruction in complex lesions. The literature review will address advances in surgical techniques, the factors that influence nerve recovery, and future perspectives

for the management of these cases. A detailed understanding of these aspects is essential to improve therapeutic approaches and optimize functional outcomes for affected patients (GOMES; SILVEIRA, 2023).

This study aims to analyze the advances of microsurgery in brachial plexus reconstruction, evaluating the prognosis and limitations of these approaches in patients with complex lesions.

MATERIALS AND METHODS

This is a literature review with qualitative premises, using the SciELO, PubMed and Google Scholar databases to search for scientific articles. To refine the research, the health descriptors "brachial plexus", "microsurgery", "nerve reconstruction" and "nerve transfers" were used, applying Boolean operators to optimize the results. The time frame comprises the years 2019 to 2023, according to the date of the first and last selected reference.

Guiding Question:

What is the effectiveness of microsurgical techniques in brachial plexus reconstruction and what are the main challenges and recent advances in this approach?

Inclusion Criteria:

Articles published between 2019 and 2023.

Studies that address microsurgery, nerve transfers, and functional prognosis in brachial plexus reconstruction.

Works indexed in recognized scientific databases (SciELO, PubMed and Google Scholar).

Studies available in full, published in Portuguese, English or Spanish.

Systematic reviews, case studies, clinical trials, and narrative reviews with clinical relevance.

Exclusion Criteria:

Studies published before 2019.

Works not available in full or in open access.

Articles that deal only with anatomical aspects without clinical application.

Research addressing brachial plexus injuries without focusing on microsurgical reconstruction.

Duplicate publications or preliminary versions of already selected studies.

Boolean Markers:

The descriptors were combined with Boolean operators for search optimization:

("Brachial plexus" AND "Microsurgery")

("Nerve Reconstruction" OR "Nerve Transfers")

("Brachial Plexus" AND ("Microsurgery" OR "Nerve Transfers")

THEORETICAL FOUNDATION

The brachial plexus is a complex network of nerves originating from the C5 to T1 cervical roots, responsible for the motor and sensory innervation of the upper limb. Its lesions can be classified according to the location and degree of involvement, with the main categories being root avulsion, nerve rupture, and stretch or compression injuries. The impact of these injuries depends on the severity and extent of the damage, and may result in irreversible motor and sensory deficits if there is no adequate intervention (MACHADO et al., 2022).

The pathophysiology of brachial plexus lesions involves processes of Wallerian degeneration and subsequent neuronal regeneration. However, the regenerative capacity of the peripheral nerve is limited and depends on factors such as the patient's age, the time of ischemia, the distance between the nerve stumps, and the presence of fibrotic scarring. Surgical techniques such as neurorhaphy, nerve grafts, and nerve transfers are essential to optimize regeneration and improve functional outcomes

(SILVA et al., 2023).

Nerve microsurgery has been widely used for brachial plexus reconstruction in cases of complex injuries. Direct neurorrhaphy is indicated for lesions with minimal loss of nerve substance, allowing the reconnection of the stumps without excessive tension. In cases of extensive loss of nervous tissue, the use of autologous grafts, such as the sural nerve, is an effective alternative to restore neural continuity (FERNANDES; MORAES, 2021).

In addition to nerve grafts, nerve transfers have emerged as an innovative approach to restore function in irreparable or difficult-to-recover injuries. These techniques involve redirecting functional nerves to injured nerves, speeding up the rehabilitation process. Studies indicate that nerve transfers offer greater recovery potential when performed early, reducing muscle degeneration and promoting neural plasticity (COSTA et al., 2022).

Functional recovery after brachial plexus reconstruction is influenced by multiple factors, including the precocity of the surgery, the type of technique used, and the patient's adherence to postoperative rehabilitation. Studies show that interventions performed within six months after the injury have better prognosis, due to the greater viability of muscle targets (BARROS; SOUZA, 2021).

In addition to the duration of the intervention, the extent of the injury and the integrity of the peripheral nervous system are determinants in recovery. Young patients tend to have a better prognosis due to greater neural plasticity, while elderly patients have a lower capacity for regeneration. Physiotherapeutic rehabilitation also plays a crucial role in functional recovery, helping to prevent muscle atrophy and neuromuscular reeducation (GONÇALVES; SOUZA, 2023).

Despite advances in microsurgery, the limitations of nerve regeneration still pose a significant challenge. The time required for axons to regenerate and reach target muscles can be long, leading to incomplete recovery of function. New therapeutic approaches, such as the use of neurotrophic factors, stem cells, and biomaterials for nerve guides, have been investigated to improve regeneration and accelerate functional recovery (OLIVEIRA; RIBEIRO, 2020).

In addition, functional electrical stimulation techniques and therapies based on virtual reality

have been explored to enhance the results of postoperative rehabilitation. These strategies help with neural plasticity and promote the reactivation of alternative motor pathways, contributing to a more effective recovery (SANTOS et al., 2020).

CONCLUSION

Complex brachial plexus injuries represent a major clinical and surgical challenge, requiring sophisticated approaches for the functional restoration of the upper limbs. Microsurgery and nerve reconstruction techniques, including neurorhaphy, grafts, and nerve transfers, have shown significant advances in the recovery of patients with severe damage. However, the prognosis still depends on several factors, such as the time of intervention, the extent of the injury, and adherence to postoperative rehabilitation.

Neural plasticity and peripheral nerve regeneration capacity are limited, which reinforces the need for early and personalized interventions. Studies show that when surgical reconstruction is performed within the first six months after injury, functional results are more promising, allowing for better reactivation of motor and sensory pathways. However, even with successful procedures, many patients continue to face motor and sensory deficits, highlighting the importance of developing new therapeutic strategies to enhance nerve regeneration.

Given these limitations, emerging research has explored the use of neurotrophic factors, stem cells, and biomaterials to optimize patient recovery. In addition, electrical stimulation and functional rehabilitation techniques have been incorporated to accelerate neural plasticity and improve clinical outcomes. Thus, the advancement of science and technology in the area of neurosurgery can provide new perspectives for the rehabilitation of individuals with severe brachial plexus injuries.

Finally, this study reinforces the relevance of the multidisciplinary approach in the management of these lesions, combining innovative microsurgical techniques, intensive physical therapy support, and adjuvant therapies to ensure better prognosis. The continuous improvement of

nerve reconstruction techniques and the implementation of complementary therapeutic strategies may, in the future, provide better functional recovery rates and higher quality of life for affected patients.

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