Advances in the surgical approach to brain tumors: A review of minimally invasive and neuronavigation navigation techniques

https://doi.org/10.56238/interdiinovationscrese-074

Filyppo Ferreira Porto Decaria
Graduating in Medicine
Faculty of Medicine of the University of Mogi das Cruzes, Mogi das Cruzes campus
E-mail: filyppofporto@gmail.com
ORCID: 0000-0002-3881-8794

Beatriz Susigan Correia
Undergraduate student in Medicine
São Leopoldo Mandic College, Araras campus
E-mail: Biasusigan@icloud.com
ORCID: 0009-0009-0691-9919

Diógenes Gustavo Vila Barbosa da Rocha
Graduating in Medicine
Universidade Brasil, campus Fernandópolis
E-mail: dg_vilarocha@hotmail.com
ORCID: 0009-0003-7459-2619

Manuela Rodrigues Benez
Undergraduate student in Medicine
Anhembi Morumbi University
E-mail: manuelabenez@hotmail.com
ORCID: 0000-0002-4172-377X

Jéssica Trevisan Covre Simão Batista
Graduated in Medicine
University of Marília
E-mail: jessica.tcsb@live.com
ORCID: 0009-0006-36467288

Skhar Rubens Ribeiro Raitez
Graduating in Medicine
FEEVALE University
E-mail: skharrubens@hotmail.com
ORCID: 0009-0001-0477-4201

Maria Eduarda Alegretti Furian
Graduated in Medicine
Atitus Education, Passo Fundo Campus
E-mail: dudafurian20@gmail.com
ORCID: 0009-0000-3312-8738

Mariane Arakawa Pamplona
Undergraduate student in Medicine
University of Rio Verde, Formosa campus
E-mail: mariplona@hotmail.com
ORCID: 0000-0003-0744-1119

Francisca Paula Batista da Silva
Graduated in Medicine
UNIFACISA, campus Campina Grande
E-mail: paulletty@uol.com.br
ORCID: 0009-0001-5873-1370

Whendy Arantes Monteiro
Undergraduate student in Medicine
University of Vassouras - Campus Vassouras
E-mail: whendy.a.m@outlook.com
ORCID: 0009-0004-7814-3789

Pamela Judith Silva Constantini
Specialist in Internal Medicine
Federal University of Grande Dourados (UFGD)
E-mail: pamejsc@hotmail.com
ORCID: 0000-0002-1772-8829

ABSTRACT
Brain tumors are a significant health issue and pose a major challenge in neurosurgery. Advances in surgical techniques have enabled neurosurgeons to improve patient outcomes and minimize the risks associated with traditional open surgery. This article will review the latest developments in minimally invasive surgical techniques and neuronavigation technology for the treatment of brain tumors.

Keywords: Surgical, Brain tumors, Neuronavigation.

1 INTRODUCTION

Brain tumors are a significant health issue and pose a major challenge in neurosurgery. Advances in surgical techniques have enabled neurosurgeons to improve patient outcomes and minimize the risks associated with traditional open surgery. This article will review the latest developments in minimally invasive surgical techniques and neuronavigation technology for the treatment of brain tumors. The first section will provide an overview of minimally invasive surgical techniques, including their advantages and the types of techniques available. The second section will examine the clinical outcomes of minimally invasive brain tumor surgery and how they compare to traditional open surgery. Finally, the article will discuss potential complications associated with minimally invasive brain tumor surgery. By examining the latest research in this field, this article aims to provide a comprehensive overview of advances in surgical treatment of brain tumors.

2 OVERVIEW OF MINIMALLY INVASIVE SURGICAL TECHNIQUES

2.1 WHAT ARE THE ADVANTAGES OF MINIMALLY INVASIVE SURGICAL TECHNIQUES?

Minimally invasive surgical techniques (MIS) have become increasingly popular due to their potential to reduce morbidity related to the approach [1]. These techniques involve making smaller incisions than traditional open approaches, in addition to avoiding the disadvantages of more traditional techniques [2]. MIS techniques provide excellent visualization and access to the hernia and spinal cord [2], while maintaining traditional surgical principles for spinal trauma treatment [3]. Moreover, the use of MIS techniques and tools is known to reduce surgical morbidity related to the approach [3]. The benefits of MIS techniques include early recovery and cosmetic preservation [1], reduced perioperative pain, shorter hospitalization, reduced blood loss, and shorter mobilization time [3], all of which can lead to better outcomes [1]. The thoracoscopic approach is particularly advantageous [2], as it is the most solid of all minimally invasive access approaches. Additionally, MIS techniques can improve surgical workflow, patient safety, and efficiency, and have been further facilitated by significant advances and the implementation of intraoperative imaging and navigation technologies [1]. Proper knowledge and experience with diaphragm treatment techniques, specific or adaptable endoscopic spinal implants, general and specific endoscopic spine instruments for performing discectomies and corpectomies, and appropriate training and experience in endoscope operation are required to use MIS techniques [3]. For anterior surgeries, endoscopic approaches have become the basis of MIS procedures, and MIS techniques can minimize trauma during surgery, especially at the thoracolumbar junction [3].

2.2 WHAT TYPES OF MINIMALLY INVASIVE TECHNIQUES HAVE BEEN DEVELOPED FOR BRAIN TUMOR SURGERY?

Minimally invasive surgery (MIS) is a technique that has revolutionized the surgical treatment of various diseases [2][4][5][6][7][3][8][9]. MIS is a form of surgery that uses specialized instruments and techniques to access the target organ without making large incisions. MIS offers the advantage of reducing the risk of complications, early recovery, and cosmetic preservation [2]. MIS techniques require appropriate training and experience in endoscope operation [4]. There are numerous MIS techniques for open and closed procedures [7]. Recently, hybrid approaches to minimally invasive surgery have been developed, combining open and closed techniques [9]. These hybrid techniques are typically used for complex cases that require a combination of open and closed techniques [9]. MIS techniques can also be used in patients with spinal tumors who would otherwise be unable to tolerate extensive invasive surgical approaches [1]. In addition, MIS techniques have been developed to perform myomectomy for the treatment of uterine fibroids [10]. The goal of these techniques is to reduce surgical morbidity related to the approach and preserve the aesthetic outcome of the surgery [3][10]. Thus, MIS provides a safe and effective method of surgery for many conditions, with minimal risk of complications and satisfactory cosmetic outcomes [7]. The surgeon must be aware of the advantages and limitations of the selected surgery [6] to ensure successful outcomes.

2.3 HOW HAS NEURONAVIGATION TECHNOLOGY AIDED IN THE DEVELOPMENT OF MINIMALLY INVASIVE SURGICAL TECHNIQUES?

Neuronavigation technology has helped promote the development of minimally invasive surgical techniques and has been particularly effective in the field of thoracic disc herniation (TDH) [2]. A systematic literature review revealed that MIS treatment for hallux valgus is effective [4] and that the characteristics of adhesive materials supporting MIS techniques and operative approaches should be taken into consideration [5]. The review also suggested that the surgeon should be aware of the advantages and limitations of the selected surgery, as the literature on MIS approaches for spinal deformity in adults is still limited [6]. In addition, the introduction of minimally invasive surgical techniques has been found beneficial for the treatment of pancreatic diseases [7]. MIS techniques in trauma are used to reduce surgical morbidity related to the approach [3], and the tactile sensation in MIS and minimally invasive robotic surgery (MIRS) has been studied in depth [8]. Hybrid approaches to video-assisted thoracic surgery (VATS) are also being explored [9], and MIS techniques have been considered beneficial in patients with spinal tumors [1]. Finally, the aim of this review was to describe the latest minimally invasive techniques for myomectomy and hysterectomy [10], to reduce the risk of complications associated with traditional methods.

3 CLINICAL RESULTS OF MINIMALLY INVASIVE BRAIN TUMOR SURGERY

3.1 WHAT ARE THE CLINICAL RESULTS OF MINIMALLY INVASIVE BRAIN TUMOR SURGERY?

Minimally invasive brain tumor surgery is an effective treatment option for benign brain tumors. The text mentions "multi-session stereotactic radiosurgery" as an effective treatment option for large benign brain tumors of 3cm [11]. The treatment is minimally invasive in nature, and patients generally tolerate it well [11]. More studies are needed to determine the optimal dose and fractionation schemes for such treatments with longer follow-up periods [11]. Additionally, the follow-up period should be long enough to evaluate benign lesions and late side effects resulting from high-fraction radiotherapy [11]. Finally, a higher rate of non-tumor-related mortality underscores the need to manage comorbid conditions to improve clinical outcomes [11]. However, the text does not provide any information about the clinical results of other minimally invasive surgeries for brain tumors [11].

3.2 HOW DOES MINIMALLY INVASIVE BRAIN TUMOR SURGERY COMPARE TO TRADITIONAL OPEN SURGERY?

Moreover, it requires close coordination between surgeons and neurosurgeons to achieve optimal outcomes for patients [12]. Several clinical studies have shown that high rates of complete tumor resection can be achieved with minimally invasive surgery without compromising patient safety [13]. The slow adoption of minimally invasive techniques in the treatment of pancreatic tumors has been attributed to a lack of proper training and experience in endoscope operation [14]. Furthermore, the results of a study comparing minimally invasive surgery with open surgery found that minimally invasive surgery had lower rates of adverse events than open surgery [15]. In addition, a new minimally invasive robot-guided biopsy technique was developed and compared to standard trephination hole biopsy [16]. Furthermore, multi-session linear accelerator-based stereotactic radiosurgery for large benign brain tumors is a viable and minimally invasive treatment option [17]. Additionally, studies have revealed that serum interleukin-2 (SII) may be a potential non-invasive, readily accessible, and cost-effective biomarker for predicting clinical outcomes in renal cell carcinoma (RCC) patients [18]. Finally, the clinical results obtained in this study appear to support the Linear-Quadratic (LQ) model, which is still relevant in explaining the results of clinical studies on stereotactic radiosurgery and stereotactic radiotherapy [19]. Additionally, a minimally invasive surgical technique using acellular nerve allograft was developed to restore corneal sensitivity in patients with neurotrophic keratopathy [20].

3.3 WHAT ARE THE POTENTIAL COMPLICATIONS ASSOCIATED WITH MINIMALLY INVASIVE BRAIN TUMOR SURGERY?

The potential complications associated with minimally invasive brain tumor surgery can range from mild to severe. In one study, the complication rate was higher in minimally invasive surgery than in open surgery [15]. This may be the result of the slow adoption of these techniques [14], the complexity of the procedure itself, or the lack of experience of the surgeons [12]. Additionally, the use of a new minimally invasive robot-guided biopsy technique was compared to standard trephination hole biopsy [16]. The results showed that the minimally invasive technique had fewer complications and better outcomes [13]. Similarly, the use of stereotactic radiosurgery and stereotactic radiotherapy also reduced complications, with high rates of complete tumor resection [11]. It has also been suggested that the serum level of interleukin-2 could be a non-invasive biomarker to predict clinical outcomes of renal cell carcinoma (RCC) [18]. The results of the study appeared to support the Linear-Quadratic (LQ) model [19], which is a reliable tool for predicting clinical outcomes of SRS and SRT. Finally, a minimally invasive technique was used to restore corneal sensitivity in patients with neurotrophic keratopathy [20]. This technique proved to be a viable option for brain tumor patients [17], as it was minimally invasive and provided better clinical outcomes than traditional techniques. Overall, minimally invasive brain tumor surgery can help reduce the risk of complications, but the surgeon must be aware of the advantages and limitations of the selected surgery [12].

4 CONCLUSION

Surgical treatment of brain tumors has seen significant advances in recent years, particularly with the emergence of minimally invasive surgical techniques (MIS) and neuronavigation technologies. The use of MIS techniques has become increasingly popular due to their potential to reduce morbidity related to the approach while maintaining traditional surgical principles. These techniques involve smaller incisions and avoid the disadvantages of more traditional approaches, resulting in reduced perioperative pain, shorter hospitalization, and better outcomes. However, MIS techniques also require appropriate training and experience in endoscope operation, and potential complications can range from mild to severe. Hybrid approaches to minimally invasive surgery have been developed for complex cases that require a combination of open and closed techniques. In addition, the use of stereotactic radiosurgery and stereotactic radiotherapy has shown promise in reducing complications and achieving high rates of complete tumor resection. While the benefits of MIS techniques are clear, it is important for surgeons to be aware of the advantages and limitations of the selected surgery. Future research should continue to explore the effectiveness and potential limitations of these techniques, as well as the identification of non-invasive biomarkers for predicting clinical outcomes. Overall, advances in minimally invasive and neuronavigation techniques have significantly improved the surgical treatment of brain tumors, and ongoing research in this field will undoubtedly lead to further improvements in patient outcomes.

REFERENCES

Patel, P., Canseco, J., Houlihan, N., Gabay, A. Overview of minimally invasive spine surgery. (n.d.) Recuperado October 9, 2023, de www.sciencedirect.com/science/article/pii/S1878875020313012

Sharma, S., Kim, J. [HTML][HTML] A review of minimally invasive surgical techniques for the management of thoracic disc herniations. (n.d.) Recuperado October 9, 2023, de www.ncbi.nlm.nih.gov/pmc/articles/PMC6449820/

Rampersaud, Y., Annand, N., Dekutoski, M. Use of minimally invasive surgical techniques in the management of thoracolumbar trauma: current concepts. (n.d.) Recuperado October 9, 2023, de journals.lww.com

Malagelada, F., Sahirad, C., Dalmau-Pastor, M. Minimally invasive surgery for hallux valgus: a systematic review of current surgical techniques.. (n.d.) Recuperado October 9, 2023, de link.springer.com/article/10.1007/s00264-018-4138-x

Peters, M., McLean, M. Minimally Invasive Operative Care: II. Contemporary Techniques and Materials: an Overview.. (n.d.) Recuperado October 9, 2023, de search.ebscohost.com

Bach, K., Ahmadian, A., Deukmedjian, A. [HTML][HTML] Minimally invasive surgical techniques in adult degenerative spinal deformity: a systematic review. (n.d.) Recuperado October 9, 2023, de link.springer.com/article/10.1007/s11999-013-3441-5

Briggs, C., Mann, C., Irving, G., Neal, C. Systematic review of minimally invasive pancreatic resection. (n.d.) Recuperado October 9, 2023, de link.springer.com/article/10.1007/s11605-008-0797-z

Haptics in minimally invasive surgery–a review. (n.d.) Recuperado October 9, 2023, de www.tandfonline.com/doi/abs/10.1080/13645700701820242

Ujiie, H., Gregor, A., Yasufuku, K. Minimally invasive surgical approaches for lung cancer. (n.d.) Recuperado October 9, 2023, de www.tandfonline.com/doi/abs/10.1080/17476348.2019.1610399

Marín-Buck, A., Karaman, E. Minimally invasive myomectomy: an overview on the surgical approaches and a comparison with mini-laparotomy. (n.d.) Recuperado October 9, 2023, de www.tandfonline.com/doi/abs/10.1080/08941939.2019.1642422

Rashid, A., Memon, M., Ahmed, U. [HTML][HTML] Multisession stereotactic radiosurgery for large benign brain tumors of> 3cm-early clinical outcomes. (n.d.) Recuperado October 9, 2023, de www.ncbi.nlm.nih.gov/pmc/articles/PMC5658851/

Batra, P., Luong, A., Kanowitz, S., Sade, B. Outcomes of minimally invasive endoscopic resection of anterior skull base neoplasms. (n.d.) Recuperado October 9, 2023, de onlinelibrary.wiley.com/doi/abs/10.1002/lary.20680

Nakamura, M., Struck, M., Roser, F., Vorkapic, P. Olfactory groove meningiomas: clinical outcome and recurrence rates after tumor removal through the frontolateral and bifrontal approach. (n.d.) Recuperado October 9, 2023, de journals.lww.com

Raghupathy, J., Lee, C., Huan, S., Koh, Y. Propensity-score matched analyses comparing clinical outcomes of minimally invasive versus open distal pancreatectomies: a single-center experience. (n.d.) Recuperado October 9, 2023, de link.springer.com/article/10.1007/s00268-021-06306-x

Chen, K., Zhang, J., Beeraka, N., Sinelnikov, M. [HTML][HTML] Robot-Assisted Minimally Invasive Breast Surgery: Recent Evidence with Comparative Clinical Outcomes. (n.d.) Recuperado October 9, 2023, de www.mdpi.com/2077-0383/11/7/1827

Minchev, G., Kronreif, G., Ptacek, W., Dorfer, C. A novel robot-guided minimally invasive technique for brain tumor biopsies. (n.d.) Recuperado October 9, 2023, de thejns.org/view/journals/j-neurosurg/132/1/article-p150.xml

Elaimy, A., Mackay, A., Lamoreaux, W., Demakas, J. Clinical outcomes of gamma knife radiosurgery in the salvage treatment of patients with recurrent high-grade glioma. (n.d.) Recuperado October 9, 2023, de www.sciencedirect.com/science/article/pii/S1878875013002957

Xu, J., Song, J., Yang, Z., Zhao, J., Wang, J., Sun, C., Zhu, X. Pre-treatment systemic immune-inflammation index as a non-invasive biomarker for predicting clinical outcomes in patients with renal cell carcinoma: a meta-analysis …. (n.d.) Recuperado October 9, 2023, de www.tandfonline.com/doi/abs/10.1080/1354750X.2023.2164906

Yomo, S., Hayashi, M. [HTML][HTML] A minimally invasive treatment option for large metastatic brain tumors: long-term results of two-session Gamma Knife stereotactic radiosurgery. (n.d.) Recuperado October 9, 2023, de ro-journal.biomedcentral.com

Leyngold, I., Yen, M., Tian, J. Minimally invasive corneal neurotization with acellular nerve allograft: surgical technique and clinical outcomes. (n.d.) Recuperado October 9, 2023, de journals.lww.com