Accuracy Comparison between Frameless Biopsy and Frame-Based Biopsy: A Retrospective Study of a Case Series

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Abstract

Objective To compare the efficacy and safety of frameless and frame-based techniques for biopsies of intracranial lesions in an exclusive assistance service at a public health center in Brazil (SUS).

Method A review of 65 medical records of patients with brain lesions who underwent a frame-based or frameless biopsy from September 2017 to July 2019 was performed.

Results Among the 65 patients who underwent biopsy, 42 were male, and 23 were female. The mean age was 53.1 years. Most patients (49; 75.4%) presented hemispheric lesions, and, of these, 27 were in the frontal lobe (41,5%). The diagnostic rate was 78.5% (51 of 65 patients), and glial neoplasia was the most common diagnosis. In addition to glial neoplasia, a wide range of pathologies were diagnosed, such as toxoplasmosis, metastasis, lymphoma, inflammatory lesions, and abscesses. Among the 14 patients (21.5%) with inconclusive results, 8 had gliosis without neoplasia (12.3%), 4 had necrosis (6.1%), and 2 had insufficient samples (3%).

The morbidity rate was 9.2%, with 4 cases of hemorrhage, 1 case of infection, and 1 case of worsening of neurological deficits. The mortality rate was 6.1% and occurred in all cases with hemorrhage.

There were no significant differences in the diagnosis or complication (morbidity and mortality) rates between the frame-based and frameless groups.

Conclusion The frame-based and frameless techniques for stereotactic biopsy present similar efficacy and safety.

Keywords
- neurosurgery
- biopsy
- frameless
- frame-based
- intracranial
- lesions

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Resumo

Objetivo Comparar a eficácia e a segurança das técnicas frameless e frame-based para biópsias de lesões intracranianas em um serviço de atendimento exclusivo de um centro de saúde público do Brasil (SUS).

Método Foi realizada uma revisão de 65 prontuários de pacientes com lesões cerebrais submetidos a biópsia com ou sem moldura no período de setembro de 2017 a julho de 2019.

Resultados Dos 65 pacientes submetidos à biópsia, 42 eram do sexo masculino e 23 do sexo feminino. A média de idade foi de 53,1 anos. A maioria dos pacientes (49; 75,4%) apresentava lesões hemisféricas e, destes, 27 eram no lobo frontal (41,5%). A taxa de diagnóstico foi de 78,5% (51 de 65 pacientes), e a neoplasia glial foi o diagnóstico mais comum. Além da neoplasia glial, foram diagnosticadas diversas patologias, como toxoplasmose, metástase, linfoma, lesões inflamatórias e abscessos. Dos 14 pacientes (21,5%) com resultados inconclusivos, 8 apresentavam gliose sem neoplasia (12,3%), 4 apresentavam necrose (6,1%) e 2 apresentavam amostras insuficientes (3%). A taxa de morbidade foi de 9,2%, com 4 casos de hemorragia, 1 caso de infecção e 1 caso de agravamento de déficits neurológicos. A taxa de mortalidade foi de 6,1% e ocorreu em todos os casos com hemorragia. Não houve diferenças significativas nas taxas de diagnóstico ou complicações (morbidade e mortalidade) entre os grupos frame-based e frameless.

Conclusão As técnicas frame-based e frameless para biópsia estereotáxica apresentam eficácia e segurança semelhantes.

Palavras-chave
- neurocirurgia
- biópsia
- frameless
- frame-based
- intracraniana
- lesões

Introduction

For patients with intracranial lesions without indication for surgical removal, stereotactic guided biopsy remains the gold standard for diagnosis, since treatment based only on the clinical and radiological aspects is insufficient in up to one third of cases, even when modern diagnosis techniques are used.[1,2] Thus, histopathological diagnosis is fundamental in handling these patients.[3]

When using stereotaxis in these procedures, the concept of minimally invasive surgery is adopted,[4] and the advantages of this approach are countless, including less surgery time, less damage in eloquent areas, and, consequently, less morbidity.[5]

Stereotactic biopsy is usually performed using the lesion spatial coordinates in an adjustable rigid instrument holder (stereotaxis halo) on the patient's skull (frame-based biopsy). This technique is widely used, and its efficacy and safety have been proven by many studies.[6–9]

More recently, with the development of image-guided surgery, new biopsy techniques are evolving, such as frameless biopsy, which uses fiducial markers in the patient's anatomy as coordinates for the lesion spatial localization, with no need to use a stereotaxis halo.[6–10]

The objective of this study is to compare frame-based and frameless techniques for intracranial lesion biopsies regarding efficacy and safety in an exclusive assistance service at a public health center in Brazil (SUS).

Materials and Methods

An observational and retrospective study with 65 patients was performed using medical records of patients who underwent intracranial lesion biopsy at Santa Casa de Misericórdia de Belo Horizonte between September 2017 and July 2019. The study was approved by the ethics committees of the Santa Casa de Belo Horizonte (CAAE: 8146331720005138).

The patients were divided into two groups: frame-based and frameless biopsy.

Frame-Based Biopsy

Frame-based biopsies were performed supported by the device for stereotactic biopsy CRW (Integra LifeSciences Corporation, Princeton, NJ, USA).

With the patient under local anesthesia, the stereotaxis halo was placed, and then, the patient underwent a brain tomography scan out of the operating room. The tomography slice thickness was 1 mm (with an interval of 1 mm), and 9 fiducial markers were identified for surgical planning.

After imaging, the test was transferred to the StealthStation S7 neuronavigation station (Medtronic). Then, planning was performed with the definition of coordinates x, y, z, arc, and ring for the proposed target.

The surgical procedure was performed with sedation and local anesthesia. After the coordinates are placed in the halo, a linear incision is made on the skin based on the target center, followed by trepanation. The needle used for the biopsy of fragments on the proposed target was Micromar.

Frameless Biopsy

The frameless procedures were performed with a neuronavigation system based on infrared light StealthStation S7 (Medtronic). The system is composed of portable hands recognized by a set of cameras connected to a mobile

workstation that, in turn, displays the hands' position on the monitor screen.[11]

Surgical planning was performed based on presurgical brain tomography or magnetic resonance imaging (MRI) and transferred to the neuronavigation system with the patient's record. This procedure was usually preoperative, aiming to obtain a biopsy trajectory with minimal tissue trauma and avoid critical structures. The arteries and veins could be observed in images reconstructed in multiple plans to minimize the risk of intracerebral hemorrhage. The trajectory can be modified interactively with no need for another stereotactic calculation.[12,13]

The patients are submitted to general anesthesia and then have their brain secured with holders of the Mayfield or Sugita type. After the holder is placed, the cranial markers are registered, guided by the portable hands for the neuronavigation procedure.

Once the neuronavigation was set, a skin marking was made with an incision, usually following the direction of the proposed target as a center, as well as the trepanation. A stereotactic guide using a flexible surgical arm (Vertec – Medtronic Navigation, Louisville, CO, USA) was projected to allow the fine adjustment trajectory. The arm is locked into place, and the needle was inserted according to the planned target. The necessary depth of needle insertion was calculated by the system. The biopsies were obtained with Micromar needles.

Statistical Analysis

The frameless biopsy was compared with the frame-based biopsy.

The diagnosis, morbidity and mortality rates were evaluated. These data were compared between the two techniques using the SPSS Statistics for Windows software and the Fisher exact test or the X^2 test.

Location

The diagnosis rates of the two techniques were also compared according to tumor locations. They were divided into two groups: superficial and deep. Superficial lesions were those located in the frontal, parietal, temporal, occipital regions, and cerebellum. Deep lesions were those located in the basal ganglia, insula, and brainstem.

Results

Population

A total of 65 patients underwent biopsy by stereotaxis, and their data were analyzed. Of these, 42 were male, and 23 were female. The mean age was 53.1. Most patients (49; 75.4%) presented hemispheric lesions, out of which 27 were in the frontal region (41.5%). In 16 patients with deep lesions (24; 6%), 12 had lesions located in the basal ganglia (18; 5%) (►**Table 1**).

By analyzing the data from each group, it can be observed that the frame-based group comprised 26 patients, 20 of whom were male and 6 of whom were female, with an average age of 57.7 years. The frameless group comprised 39 patients, including 22 males and 17 females, with a mean age of 50.3 years.

Table 1 Locations of lesions and characteristics of patients who underwent biopsy by stereotaxis

Characteristics	
Number of procedures, n	65
Gender n (%)	
Female	23 (35.4)
Male	42 (64.6)
Age n (%)	
< 60	36 (55.4)
≥ 60	29 (44.6)
Mean (SD/min-max)	53.1(17.8/5–89)
Location, n %	
Hemispheric	49 (75.4)
Frontal	27 (41.5)
Parietal	15 (23.1)
Occipital	1 (1.5)
Temporal	5 (7.6)
Deep	16 (24.6)
Basal ganglia	12 (18.5)
Insula	2 (3)
Brainstem	2 (3)

Abbreviations: Min, minimal; Max, maximal; n, absolute number; SD, standard deviation.

The main tumor location in both groups was hemispheric, and the frontal region was the most common, as it was observed in 13 patients in the frame-based group (50%) and 14 patients in the frameless group (35.9%). The frame-based group had a higher incidence of deep location biopsies, with 9 patients (34.6%) compared with 7 patients in the frameless group (17.9%) (►**Table 2**).

Mortality, Morbidity, and Diagnosis Rates

The diagnosis rate was 51 out of 65 patients (78%); glial neoplasia was the most common diagnosis, given that low- and high-grade diffuse gliomas accounted for 55.3% of the results.

In addition to glial neoplasia, a large number of pathologies were diagnosed, such as toxoplasmosis, metastasis, lymphoma, inflammatory lesions, and abscesses. In the 14 inconclusive samples (21.5%), the results were 8 patients with gliosis without neoplasia (12.3%), 4 patients with necrosis (6.1%), and 2 patients with insufficient sample (3%).

The morbidity rate was 9.2%, including 4 cases of hemorrhage, 1 case of infection, and 1 case of worsening of neurological deficit. The mortality rate was 6.1% and occurred in all the cases that presented hemorrhage (►**Table 3**).

In the histological diagnosis analysis separated by group, we observed the largest prevalence for both high-grade gliomas, with 9 patients in the frame-based group (34.6%) and 18 patients in the frameless group (46.2%). (►**Table 4**)

Table 2 Location of lesions in the frameless and frame-based groups

Characteristics:	Stereotactic biopsy method	
	Frame-based	Frameless
Number of procedures, n	26	39
Location, n (%)		
Hemispheric	17 (65.4)	32 (82.1)
Frontal	13 (50)	14 (35.9)
Parietal	4(15.4)	11 (28.2)
Occipital	–	1 (26.1)
Temporal	–	5 (12.8)
Deep	9 (34.6)	7 (17.9)
Basal ganglia	7 (26.9)	5 (12.8)
Insula	2 (7.7)	–
Brainstem	–	2 (5.1)

Abbreviation: n, absolute number.

Morbimortality and Diagnosis Rates: Frame-based Versus Frameless

Regarding the diagnosis rate, 21 out of 26 patients in the frame-based group were diagnosed (80.8%), whereas in the frameless group, 30 out of 39 patients showed no significant difference ($p = 0.71$).

Two patients in the frame-based group had complications (7.7%); one patient had worsening deficits, and the other had bleeding in the surgical site and posterior evolution to death (3.8%). Four patients in the frameless group had complications: one patient had an infection in the surgical site, and the other 3 presented bleeding, all of whom evolved to death (7.7%). When comparing the complication rates, there was no significant difference between the techniques ($p = 0.64$) (►**Table 5**).

Diagnosis Rate in Superficial and Deep Lesions: Frame-based Versus Frameless

For superficial lesions in the frame-based group, the diagnostic rate was 14 out of 17 lesions (82.4%). In turn, in the frameless group, the diagnosis rate was 24 out of 32 cases (75%). There was no significant difference in diagnostic rates between the two groups. (►**Table 6**)

For deep lesions in the frame-based group, the diagnostic rate was 7 out of 9 cases (77.8%). In the frameless group, the diagnosis was made in 6 out of 7 cases (85.7%). As in the superficial lesions, there was no significant difference in diagnostic rate between the groups. (►**Table 7**)

Discussion

In the present study, we revised our retrospective experience with frameless and frame-based stereotactic intracranial biopsies for 2 years. There are considerable differences regarding the two surgical techniques.

First, frame-based stereotactic biopsy is performed with local anesthesia and sedation, and general anesthesia is hardly used, whereas the frameless approach is performed under general anesthesia due to the holder (Mayfield or Sugita) placed on the head. Therefore, in frameless stereotactic biopsy, the patient is unable to cooperate to identify possible complications: the start of a headache, some change in the neurological test, or other signs that could point to some hemorrhage.[14]

Second, in frame-based biopsy, after securing the stereotactic halo, the patient needed to undergo a brain computed tomography (CT) scan out of the operating room. This requires more surgical time. In the frameless group, since the imaging test guiding the biopsy was performed before the procedure, the surgical time was shorter. Dorwardet et al. reported that the procedure in the frameless group lasted between 20 and 180 minutes, and the frame-based group procedure lasted between 80 and 235 minutes. The surgery time in the frame-based group was longer ($p < 0.0001$).[15]

Another point worth mentioning with respect to the frameless technique is that the trajectory can be interactively modified during the surgery, in contrast to the frame-based technique, in which a new stereotactic calculation needs to be made in the trajectory change.[12,13]

Some authors have suggested that the frame-based technique has greater accuracy in intracranial lesion biopsies.[10,13] However, when data from the literature on both techniques are analyzed, the diagnosis rates do not show significant differences.[16,17] In the meta-analysis performed by Dhawan et al. (2,400 patients), which comprised 15 studies on both techniques, the diagnostic rate for frame-based biopsy ranged from 84 to 100%, and in the studies on the frameless technique, the results ranged from 86.6 to 100%, with no significant difference between the 2 techniques.[18] The current study also presented similar results between the two techniques. However, in relation to the overall diagnostic rate, the study showed lower rates of diagnosis.

With respect to morbimortality, the literature shows that morbidity rates range from 3.8 to 27.8% and mortality rates range from 1.2 to 3.9% in the frame-based group. Morbidity and mortality rates ranged from 3 to 24.5% and 1.3 to 3.6%,

Table 3 Morbimortality and diagnosis rates of patients who underwent biopsy by stereotaxis

Morbimortality and diagnosis rates	
Number of procedures, n	65
Morbidity, n (%)	
Procedures with complications	6 (9.2)
Hemorrhage	4 (6.1)
Worsening of deficits	1 (3)
Infection	1 (1.5)
Mortality, n (%)	
Deaths	4 (6.1)
Biopsies with histological diagnosis, n (%)	
Conclusive	51 (78.5)
High-grade diffuse glioma	27 (41.5)
Low-grade glioma	9 (13.8)
Unspecified inflammatory lesions	5 (7.6)
Abscess	3 (4.6)
Lymphoma	3 (4.6)
Metastasis	2 (3)
Toxoplasmosis	2 (3)
Inconclusive	14 (21.5)
Gliosis without neoplasia	8 (12.3)
Necrosis	4 (6.1)
Insufficient sample	2 (3)

Abbreviation: n, absolute number.

respectively, in the frameless group; there were no significant differences in morbimortality rates between the groups.[18] The current study also presented similar results between the two techniques. We observed that in cases in which complications occurred, a part of them were severe, the most frequent being bleeding at the biopsy site with symptomatic hemorrhage. In contrast showed that in our study the most cases that ocurred hemorrhage, it was symtomatic hemorrhage. In the study of Ungar et al, the most cases that ocurred hemorrhage, it was assyntomatic hemorrhage. The difference in small asymptomatic hemorrhaged detection may be related to the higher CT image currently available.[19]

Some authors suggest that the frame-based technique should be indicated in the case of tumors located in the brainstem, basal ganglia, pineal, lesions located less than 10 mm from vascular structures as well as those located less than 5 mm from vascular structures, due to its greater accuracy.[20,21] Considering these indications, Owen et al. believed that lesions that did not present these criteria should have frameless biopsies; in 100 cases of brainstem biopsies, 82% should undergo a frameless biopsy as an alternative to frame-based biopsies.[14]

In this study, lesions located in the brainstem, basal ganglia, and vascular structures (located in the insula) were classified as deep lesions. Even in these cases, we found similar efficacy results when the two techniques are compared.

One limitation of this study is that it was a single-center retrospective analysis of a relatively small number of cases. In addition, although the groups were similar, it was a nonrandomized study, and the indication of which technique to use was in line with the experience of the surgeons in the center using frame-based or frameless techniques.

Conclusion

Evaluating our neurosurgery department, the frameless techniques for stereotactic biopsy had similar results to those of frame-based biopsy, becoming an effective, fast, and safe method.

Conflict of Interests

The authors have no conflict of interests to declare.

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