Quantitative Analysis of the Working Windows for Sitting and Park Bench Positions Through the Retrosigmoid Approach Evaluated in a Cadaver Model

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BACKGROUND AND OBJECTIVES: The choice of the optimal surgical position in the treatment of posterior fossa lesions still remains a controversial and debated issue. Morphometric data on the different perspective of vision offered by different surgical position are scarce. This article investigated the differences due to the vision perspectives provided by the sitting and park bench positions.

METHODS: The study was conducted using 4 fixed cadaver heads. A standardized retrosigmoid approach was performed on each side of each head. Three operators collected anatomic observation and 2 separate measurements each, for all the sides and diagonals of the projections of 2 areas delimited by the cranial nerves in the cerebellopontine angle (defined as working windows ABCD and ABEF). The collection of the measurements was repeated for each side of each head, both in the sitting and in the park bench positions. The average areas of the working windows were calculated for each position and then compared by statistical analysis.

RESULTS: The park bench position is associated to larger areas for both working windows (P = .0013 for ABCD; P < .001 for ABEF) compared with the sitting position. These measures allow to quantify the differences of the working windows that are an indirect expression of the different angle of vision of each position.

CONCLUSION: Our cadaveric study shows that there is a better vision perspective offered by the park bench position for lesions that do not modify the course of the cranial nerves in the cerebellopontine angle. However, different positioning of patients presents different advantages and limitations for surgeon based on size of the tumor and lesion location. In our opinion, choice of patient positioning could be tailored to lesion's peculiarities more than on surgical habits.

KEY WORDS: Cerebellopontine angle, Cranial nerves, Morphometric cadaver study, Park bench position, Retrosigmoid approach, Sitting position

Patient positioning represents an essential step of neurosurgical procedures. This affects the optimal trajectory to the lesion, patient safety, degree of brain retraction, venous and cerebrospinal fluid drainage, and surgeon's comfort. The patient's position adopted in the surgery of posterior fossa is still a controversial and debated issue[1-6] because choice depends on several factors such as surgeon's experience and preference.[2,3]

Among surgical positions, the sitting position (SP) and the park bench positions (PBP) are frequently used in posterior fossa lesions through retrosigmoid approach. This provides 2 different surgical prospective. In our department, we adopt both SP and PBP during surgical treatment of the lesions affecting the posterior fossa. This experience allowed us to observe qualitative differences in vision perspective and to identify advantages and disadvantages associated with each of the abovementioned positions. In our experience, in the SP, the visual perspective puts the lower cranial nerves on a more superficial plane, while the VII to VIII cranial nerves and trigeminal nerve are deeper and farther from the surgeon's observation point (Figure 1).

Instead, in the PBP, the visual perspective of the cerebellopontine angle (CPA) places the cranial nerves (from V to XII) on roughly horizontal planes with similar depth (Figure 2).

ABBREVIATIONS: PBP, park bench position; **SP,** sitting position.

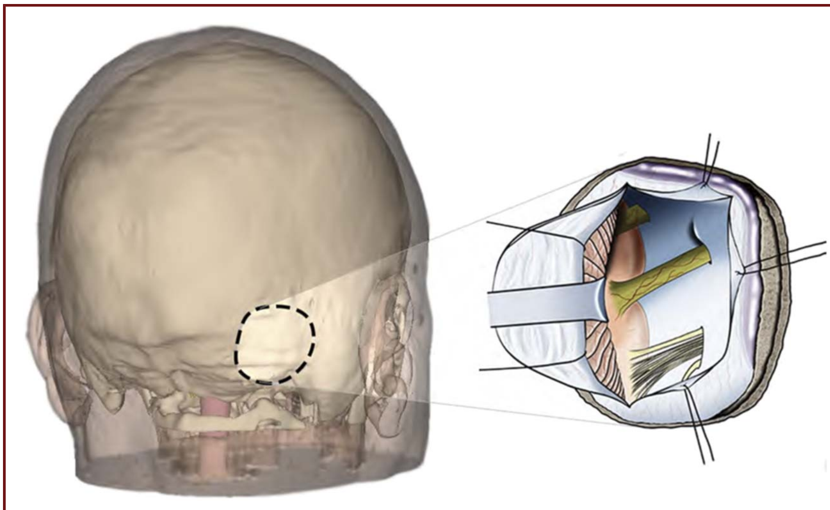

FIGURE 1. *Three-dimensional model of the head in the sitting position. The dotted line shows the site where retrosigmoid craniotomy is performed. On the right side, the drawing shows the perspective of vision of cerebellopontine angle cranial nerves in the sitting position.*

Based on these qualitative differences on vision perspective, we decided to investigate this idea, with a quantitative analysis through a comparative morphometric study of the CPA working windows on cadaver.

Currently, there is a paucity of data on the different perspective of vision offered by different surgical positions.[7-9] To the best of our knowledge, the studies available in the literature with the aim of comparing surgical positions are mainly focused on assessing their complication rates.[2-4,6,10-14] Furthermore, morphometric studies on cadaver reported in literature are mainly focused on assessing the exposure related to different skull base approaches rather than the benefits related to perspective of vision provide by different surgical positions.[15-28] Instead, the differences because of the vision perspectives offered by sitting and PBP are still a poorly investigated issue. There is a lack of morphometric studies on cadaver, and no data have been published to investigate this issue.

The purpose of this pilot study on cadaver was to investigate the differences of the surgical vision perspectives offered by the sitting and PBP through a quantitative analysis of 2 working windows. The 2 working windows are defined as the projections, on a plane perpendicular to the direction of surgeon's vision, of 2 areas delimited by the cranial nerves of the CPA. Being the area projections an indirect expression of the angle of vision of each

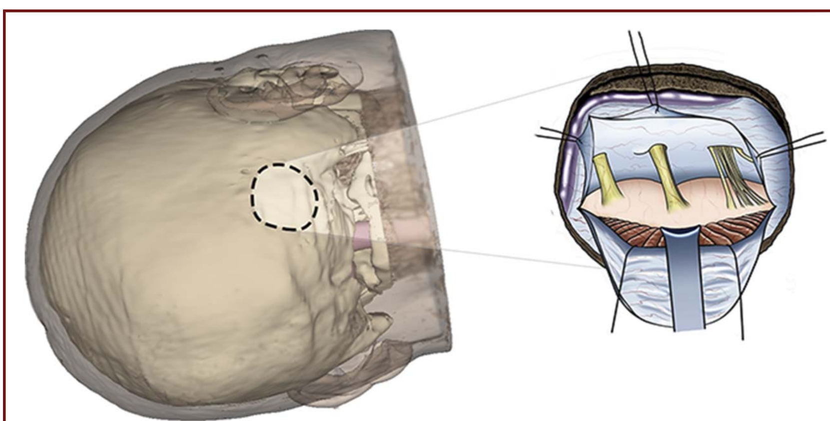

FIGURE 2. *Three-dimensional model of the head in the park bench position. The dotted line shows the site where retrosigmoid craniotomy is performed. On the right side, the drawing shows the perspective of vision of cerebellopontine angle cranial nerves in the park bench position.*

position, these measures allow to evaluate and quantify the differences because of the vision perspectives.

METHODS

The ethical approval and informed consent are not applicable for this study.

Four fixed and colored silicone-injected cadaveric heads without any known brain pathology were used to obtain bilateral measurements in 2 different surgical positions (sitting and PBP). A standardized retrosigmoid approach was performed on each side of the heads for a total of 8 craniotomies. Three independent operators collected 2 separate measurements each of the 2 working windows defined as the projections, on a plane perpendicular to the direction of surgeon's vision, of 2 areas delimited by the cranial nerves of the CPA. The collection of the measurements was repeated for each retrosigmoid approach, both in the sitting and in the PBP. The average areas of the working windows were then calculated for each position.

Retrosigmoid Approach

The retrosigmoid approach has been previously described in detail and is reviewed here only briefly.[7,9,15] The retrosigmoid approach was performed on each of the 4 cadaveric heads fixed on a laboratory Mayfield clamp. A 10-cm skin incision was made about 1.5 cm medially to the posterior margin of the mastoid, extending approximately 2 cm above the superior nuchal line. The skin incision was followed by a craniotomy of 3.5 cm in diameter to expose the medial edge of the sigmoid sinus laterally, the inferior border of transverse sinus superiorly, the angle between the transverse and sigmoid sinus, and the lateral two-thirds of the cerebellar hemisphere medially. The mastoid bone was drilled to partially unroof the sigmoid sinus (Figure 3). The dura mater was opened in a C-shaped manner to expose the craniotomy site completely. The arachnoid of the CPA cistern was opened to expose the cranial nerves (Figure 3). In our study, we maintained 1.5 cm of cerebellar retraction away from sigmoid sinus in all measurements to ensure the vision of the entry and exit zones of the cranial nerves, in both surgical positions. All the parameters characterizing this approach have been standardized to minimize any variables not dependent on surgical positions that could be a confounding factor on the interpretation of morphometric data.

Definition of Neurosurgical Positions Adopted

The simulation on cadaver specimens of the SP required a vertical orientation of the cranio-caudal axis of the head and a rotation of 30° toward the analyzed side (Figure 4A).

The simulation of the PBP was defined as: (1) the cranio-caudal axis of the head was placed in a 90° lateral position, (2) the head was contralaterally rotated 30° to the analyzed side, (3) the head was anteflexed 30°, and (4) the calvarium was flexed 15° toward the floor (Figure 4B).

For both positions, the correct placement of the cadaveric sample was evaluated with a protractor and a bubble level. This method ensures a correct and repeatable position, allowing to minimize any confounding factors during the procedure.

Determination of the Working Windows and Definition of the Data Collection Protocol

The working windows of the CPA are defined as the projection, on a plane perpendicular to the direction of surgeon's vision, of the areas delimited:

•In the cranio-caudal direction by the cranial nerves of the CPA.
•Anteriorly by the posterior surface of the petrous bone.
•Posteriorly by the brainstem.

These anatomic landmarks define 2 quadrangles, called ABCD and ABEF, respectively, described in more detail as follows.

The quadrangle ABCD (Figure 5A and 5B) is localized caudal to the VIII cranial nerve, and it is defined based on the projection of the following anatomic points:

- Point A—the VIII cranial nerve exiting the brainstem.
- Point B—the internal auditory meatus.
- Point C—the IX cranial nerve entering in the jugular foramen.
- Point D—the glossopharyngeal nerve exiting the brainstem.

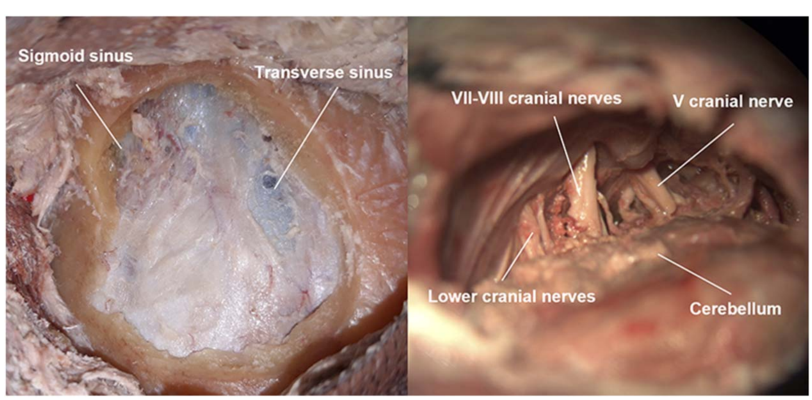

FIGURE 3. *On the left, retrosigmoid approach with exposure of the medial edge of the sigmoid sinus laterally, the inferior border of transverse sinus superiorly, the angle between the transverse-sigmoid sinus junction. On the right, C-shaped opening of the dura mater and exposure of the cranial nerves of the cerebellopontine angle.*

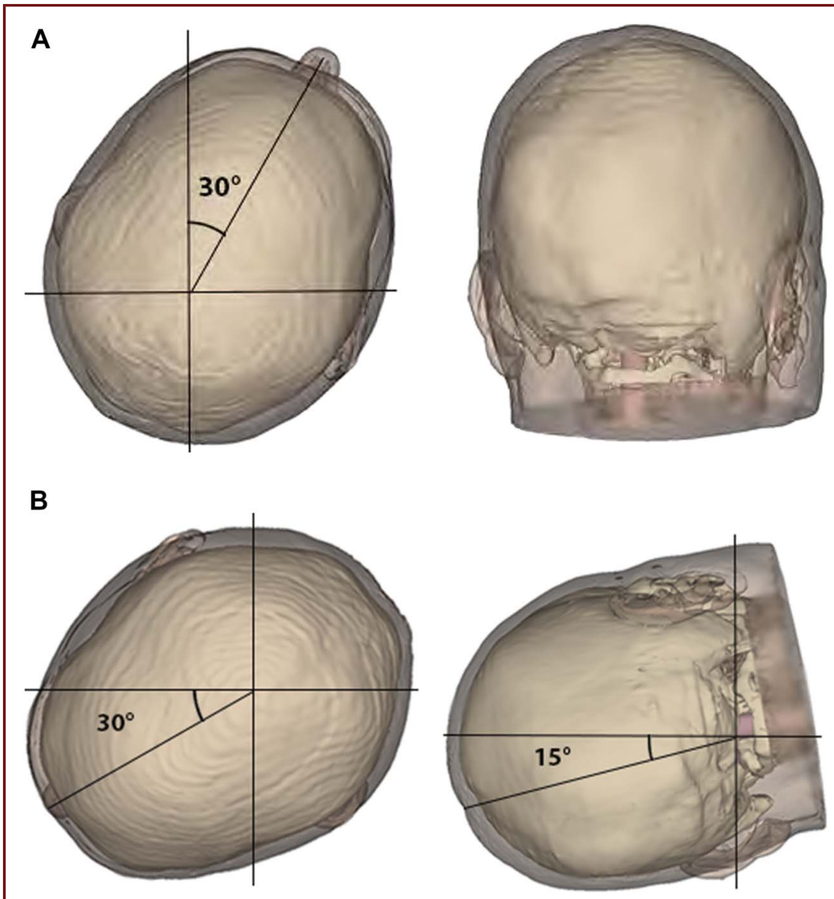

FIGURE 4. **A**, *Scheme of the orientation of the head in the sitting position.* **B**, *Scheme of the orientation of the head in the park bench position.*

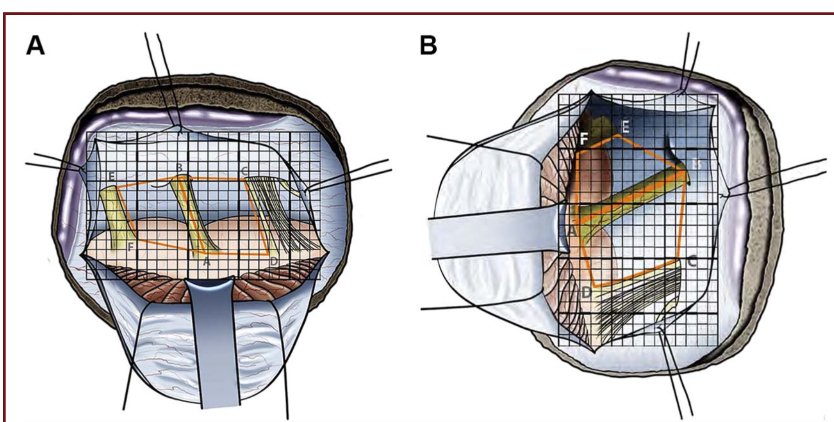

FIGURE 5. **A**, *Vision perspective of working windows ABCD and ABEF in park bench position. The measurements of the working windows are made on a millimeter grid plan.* **B**, *Scheme of the working windows delimited by the cranial nerves of the cerebellopontine angle. Vision perspective of working windows ABCD and ABEF in sitting position. The measurements of the working windows are made on a millimeter grid plan.*

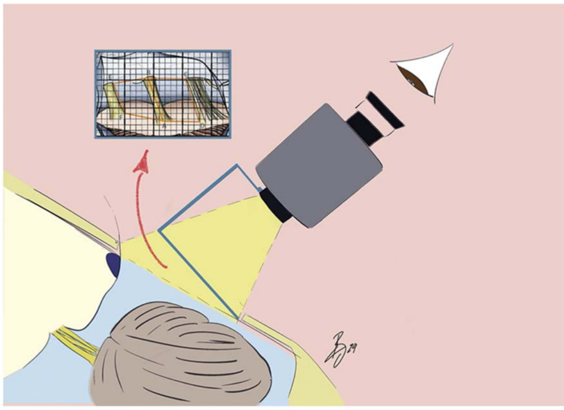

FIGURE 6. *Schematic drawing showing the set up of the plexiglass panel applied to the microscope during each measurement. The lower edge of the plexiglass panel leaned against the dural plane. The angulation of the plexiglass panel with the dural plan depends on the surgical position of the head.*

The quadrangle ABEF (Figure 5A and 5B) is localized cranially to the VIII cranial nerve, and it is defined based on the projection of the following anatomic points:

- Point A and point B as previously defined.
- Point E—the trigeminal nerve exiting the Meckel cave.
- Point F—the root entry zone of the trigeminal nerve at the pons.

The protocol adopted for the morphometric data collection involves the head immobilization in a Mayfield head holder clamped to an operating table in each surgical position. To define the plane where the measurements are made, we used a microscope to which a small plexiglass panel was applied. The plexiglass panel is equipped with a millimeter grid fixed at a distance of 20 cm from the objective lens of the microscope and oriented perpendicular to the direction of the operator's vision. With the aid of the microscope as described above, the observation point is determined by the following parameters:

- Operator's field of view centered on cranial nerves VII to VIII using the millimeter grid drawn on the plexiglass panel.
- The lower edge of the plexiglass panel leaned against the dural plane. The angulation of the plexiglass panel with the dural plan depends on the surgical position of the head (Figure 6).

The stiffness of the cerebellum, in a cadaveric sample, requires the use of a retractor to maintain 1.5-cm cerebellar retraction away from the sigmoid sinus in all measurements, in both surgical positions. It is important to standardize the degree of cerebellar retraction to minimize any variables not dependent on surgical positions that could be a confounding factor on morphometric data interpretation.

The measurements of the sides and diagonals of the working windows were recorded in millimeters using a digital gauge. All operators collected 2 measurements of the sides and diagonals of the working windows for each side of the heads in both surgical positions (sitting and PBP). The average areas of the working windows were then calculated for each position.

TABLE. **Average Areas and SD of the Working Windows ABCD and ABEF According to Both Surgical Positions Examined**

	Average areas of the working windows	
Positions	**ABCD (mm^2)**	**ABEF (mm^2)**
Sitting position	33.94 ± 2.85	39.12 ± 2.12
Park bench position	36.32 ± 2.26	41.99 ± 2.03

Area Calculation and Statistical Analysis

The data were recorded into Microsoft excel (Microsoft Inc) and analyzed using MATLAB R2021a (The MathWorks Inc).

To calculate the areas of the working windows of the CPA, the formula of Bretschneider was used $\text{Area} = \frac{1}{4}\sqrt{4p^2q^2 - (a^2 - b^2 + c^2 - d^2)^2}$ (where a, b, c, and d represent the 4 sides, while p and q represent the 2 diagonal of the quadrangles ABCD and ABEF).[29] The area of the working windows obtained averaging the 2 measurements of the same operator, for each surgical position, was calculated. The normality of these data distribution was verified and confirmed using the Shapiro-Wilk test. The comparison of the working windows areas, between the sitting and the PBP, was made using the paired *t*-test. The results with P value ≤.05 were considered statistically significant. Interobserver and intraobserver variability in measurements made by the 3 independent observers were calculated using Pearson product moment correlation.

RESULTS

The PBP is associated with a greater area of both working windows (Table and Figure 7). The average working window area ABEF is significantly increased ($P < .001$) in PBP compared with SP. In addition, the average working window area ABCD is significantly greater ($P = .0013$) in PBP than that of the SP.

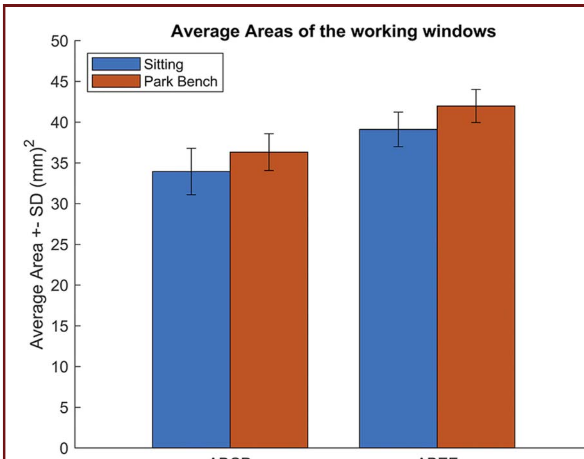

FIGURE 7. *Bar graph showing the average areas of working windows (ABCD and ABEF) for each surgical position (sitting and park bench position). Error bars represent SD.*

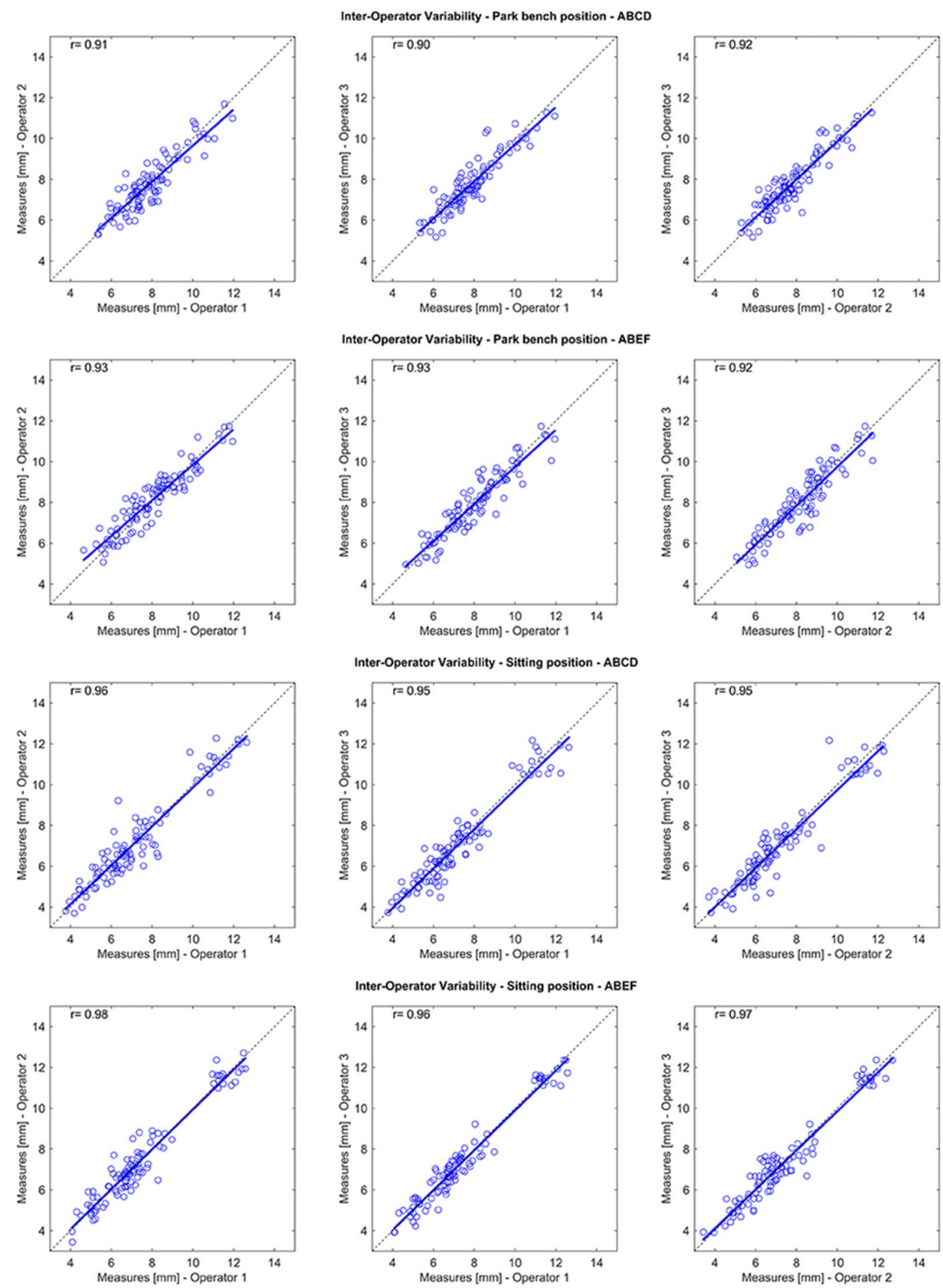

FIGURE 8. *Interoperator variability for measurements (sides and diagonals, mm) of the working windows in the park bench and sitting positions. The linear fit (continuous blue line) and the identity line (blue dotted line) as reference is reported.*

Measurements of the sides and diagonals of the working windows were obtained by 3 independent operators in 8 sides of 4 cadaveric heads in both surgical positions (sitting and PBP). The interobserver variability for each pair of operators is shown in Figure 8. There was strong a correlation for measurements (sides and diagonals) of both working windows in both surgical positions, with Pearson coefficient values ranging from 0.90 to 0.98.

The intraobserver variability for each operator is shown in Figure 9. There was a strong correlation with Pearson coefficient values ranging from 0.91 to 0.98.

For both Figures 8 and 9, the linear fit of the data is very close to the identity line representing the ideal case in which measurements, respectively, of different operators and same operator perfectly match. Measurements do not seem prone to both interobserver and intraobserver variability. Nevertheless, the results obtained may be affected by the small number of the specimen.

DISCUSSION

The sitting and PBP are frequently adopted in the treatment of several lesions involving the CPA and petroclival region through retrosigmoid approach. Advantages and disadvantages of both surgical positions are well known and must be taken into account in the planning of surgical intervention. In brief, the benefits of the SP are a low cerebral venous and intracranial pressure during

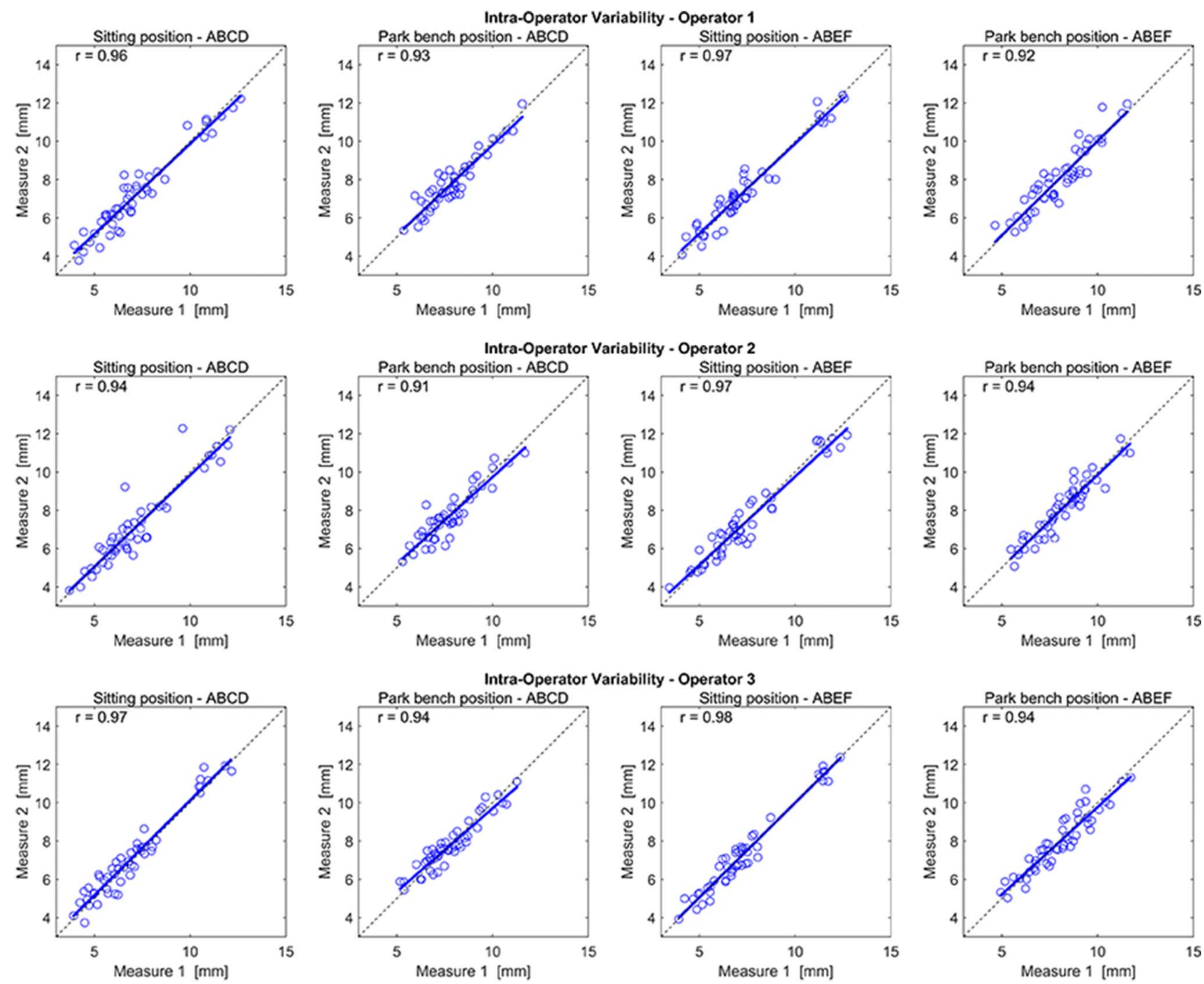

FIGURE 9. *Intraobserver variability for repeated measurements (sides and diagonals, mm) of the working windows in the park bench and sitting position. The linear fit (continuous blue line) and the identity line (blue dotted line) as reference are reported.*

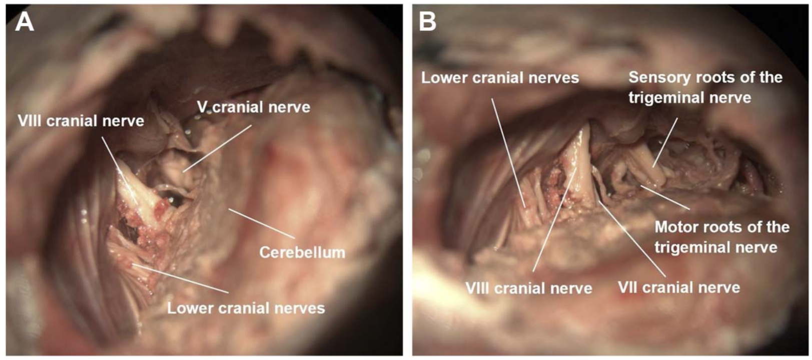

FIGURE 10. *Perspective of vision of the CPA in both surgical positions analyzed.* **A**, *CPA in sitting position.* **B**, *The illustration on the right showed CPA in park bench position. The angle of vision provided by park bench position allows a better exposition of the proximal aspect of the seventh cranial nerve and of the motor branch of trigeminal root at the entry zone at the pons than sitting position. CPA, cerebellopontine angle.*

the surgery and the gravity drainage of both blood and irrigation fluid that keeps the surgical field clear.[30] On the other hand, the disadvantages of this surgical position include increased fatigue to the hands of a surgeon and higher risk of hemodynamic instability, venous air embolism, and tension pneumocephalus compared with PBP.[2,30,31] Therefore, the advantages of PBP are a lower risk of venous air embolism and hemodynamic instability in addition to a more comfortable position for the operator. However, the main disadvantages of PBP are the need for continuous suction of the blood and irrigation fluid that pool in the operative field during the surgery and the potential injuries to the brachial plexus due to malposition of the shoulder and arm.[31]

Nevertheless, the different perspective of vision offered by these surgical positions has not been quantitatively analyzed yet. Indeed, the available studies are mainly focused on assessing the outcome and complication rates of different surgical positions.[2-4,6,10-14] Usually, the choice of patient positioning is due to surgeon habits, neurosurgical school, and experience. Less frequently, the surgeon chooses the position of the patient based on pathology or CPA location of lesion. Our study shows that sitting and PBP offer different surgical views and different size of surgical working windows. Our study was based on objective data based on cadaveric measurements but also on simple anatomic observations on the cadaveric head CPA in both investigated surgical positions.

To investigate the different perspective of visions offered by the sitting and PBP, a quantitative analysis of the 2 working windows delimited by the cranial nerves of the CPA was performed in this study. These measures allow to evaluate and quantify the differences of the working windows areas that are an indirect expression of the angle of vision in each position. Our data show that the PBP provides larger average areas compared with the SP for both working windows ($P = .0013$ for ABCD; $P < .001$ for ABEF). These results suggest that PBP offered a better surgical perspective of vision of both quadrangles analyzed. Practical implications of these results are that the PBP seems to offer a better visualization of CPA lesions, especially those that do not distort the normal anatomy (for example small vestibular schwannomas, neurovascular compression, and small petroclival meningiomas). However, it must be noted that the lower number of specimens could not accurately estimated the anatomic variability of the CPA. In addition, during the collection of the morphometric data, we observed that the angle of vision provided by park bench position (Figure 10B) allows a better exposure of the proximal aspect of the seventh cranial nerve in the vestibulocochlear complex than SP (Figure 10A). Differently, the distal course of facial nerve is easily identifiable in SP just medially to acoustic nerve while is hidden by the VIII cranial nerve in PBP. Regarding IX to X cranial nerves, in the PBP, they lay just in the caudal part of surgical ground field, out of the petroclival region and far from VII to VIII complex, while in the SP, they are between surgeon and medium petroclival region, more proximal to VII to VIII complex. This point must be considered when approaching a medium size tumor of middle petroclival area. With regard to trigeminal nerve, in PBP (Figure 10B), the exposure of the motor branch of trigeminal root at the entry zone seems to be better visualized than SP (Figure 10A). Given the variability in the location of the motor root of the trigeminal nerve compared with the sensory root, these data may be affected by the low number of specimens used.

In PBP, the V cranial nerve is far from VII to VIII complex in all its course and its relationship with Dandy vein is more clear. In SP, trigeminal nerve is deep to VII to VIII nerve complex, and working area is more restricted compared with the wider field offered by the PBP. Moreover, in SP, the relationship between trigeminal nerve-Dandy vein is more strict. These observations could be helpful when dealing with neurovascular conflict involving trigeminal entry zone (Figure 10A and 10B).

Limitations

The number of cadaveric specimens analyzed was relatively small. This could be affected the generalization of the results, and therefore, future studies with a higher number of specimens would increase the robustness of the data. In addition, the absence of pathology does not allow to evaluate the implications of anatomic distortion because of large CPA lesions, on working windows areas. Therefore, given that the heads of cadavers used do not have tumor lesions, our results should be applied only to small lesions, which do not modify the anatomy of the cranial nerves in the CPA. Another limitation of our study is the use of only one point of vision defined as the operator's field of view centered on vestibulocochlear complex in both surgical positions. We decide to make this choice to evaluate the whole CPA because of the central position of VII to VIII cranial nerves and to standardize the measurements collection. Another limitation of the study was the difficult to quantify the advantage of gravity removal of surgical debris and blood drainage. This point is difficult to quantify on cadaver specimens, but it is a well-known advantage of SP. Further studies should be addressed to explore the implications on working window areas, adopting different points of vision in both surgical positions. In future, this study should be recommended for the use of technological tools, such as neuronavigation, to facilitate the collection of morphometric data.

CONCLUSION

This comparative morphometric study on cadaver suggests a statistically significant differences between the mean areas of the CPA working windows in the 2 surgical positions analyzed. These differences represent the indirect expression of the different angle of vision that characterizes each position.

Our preliminary data do not show the superiority of one positioning over the other but point out that each surgical position investigated present different advantages and limitations for surgeon. Our morphometric study suggests that it could be a better vision perspective in the PBP for lesions that do not distort the course of the cranial nerves in the CPA. In our opinion, choice of patient positioning could be tailored to kind of lesion and particularly to lesion location more than on surgical habits.

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COMMENTS

In this nice cadaveric study the authors carried out a quantitative analysis of the retrosigmoid exposure of cranial nerves and vessels at the cerebellopontine angle (CPA), comparing it under the park-bench position and the sitting position. This is a very interesting way to analyze anatomy in a region of interest and the results shown in this study may have a direct impact on neurosurgical practice. In this cadaveric study, sitting position brought advantages in exposure of lower cranial nerves, but park-bench position was superior in exposing cranial nerves VIII and above. Limitations of this study was clearly mentioned by the authors, namely the absence of the pathology that displaces the anatomy of CPA. Of course, this will make a fundamental difference. Nevertheless, for lesions that do not change the trajectory of cranial nerves and vessels (such as small vestibular schwannomas, small meningiomas, microvascular compressions…) the results presented in this study are valid. I fully agree with the authors that the greatest advantages of (semi-) sitting position is observed in those large, vascularized lesions that displace the CPA anatomy, such as large vestibular schwannomas, and petroclival meningiomas. In our experience, sitting position does not add great advantages for microvascular compression syndromes and small CPA tumors. The authors are commended for this thorough analyses and beautiful work.

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