Original Article

Comparison of head positioning using the Mayfield skull clamp versus padded headrest in anterior cervical discectomy and fusion surgery

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Background: Anterior cervical discectomy and fusion (ACDF) is a commonly implemented surgical intervention for a variety of pathologies affecting the cervical spine. The current literature and daily practice reveal variations on patient head positioning for this procedure with both rigid fixations in the Mayfield skull clamp as well as use of a padded headrest being used. In this study, we therefore examine whether patients undergoing surgery using head positioning in the Mayfield skull clamp versus a padded headrest differ in regard to adverse events, surgical parameters and clinical outcome.

Methods: A single-center, retrospective analysis of 121 patients treated with ACDF for degenerative disease, traumatic cervical spine injury and infectious disease between November 2019 and March 2023 was performed. Clinical and imaging data for 59 patients positioned in the Mayfield skull clamp and 62 patients positioned in a padded headrest were evaluated using electronic medical records. In addition to demographic data, surgical indications, procedures performed were analyzed for both groups. Level of training (chief, attending and resident), length of surgery and intraoperative radiation exposure (measured by dose area product and total radiation time) were also examined. Finally, modified Rankin Scale (mRS) preoperatively and at last follow-up as well as adverse events were compared between groups.

Results: We found no statistically significant differences between the Mayfield and headrest groups regarding surgical indications (P=0.583), procedures performed (P=0.069), level of training of the surgeon (P=0.218), length of surgery (P=0.752), adverse events (P=0.619) or neurological impairment (P=0.080) following surgical intervention. There was a significant difference regarding dose area product between both groups with patients positioned in the Mayfield skull clamp showing lower mean levels of radiation than those in the headrest group (99 versus 131 cGy/cm^2; P=0.003).

Conclusions: Patient positioning using the Mayfield skull clamp may reduce required radiation exposure during ACDF procedures versus use of a padded headrest.

Keywords: Mayfield; headrest; head positioning; anterior cervical discectomy and fusion (ACDF); complications

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Introduction

Anterior cervical discectomy and fusion (ACDF) is a common surgical treatment for cervical spine disorders including degenerative disease, trauma and infection (1-3) with a total of 1,059,403 ACDF procedures being performed in the United States from 2006 to 2013 (4).

With the increasing frequency of ACDF procedures, evidence underscoring the importance of patient positioning regarding postoperative complications including C5 (cervical spinal nerve) palsies, brachial plexus and peripheral nerve injuries continues to emerge (5-7). Understanding of the complex anatomical relationships in the cervical spine as they are affected by common practices of positioning including retroflexion and intraoperative distraction may contribute to safer interventions, particularly in patients with myelopathy or potentially unstable injuries (8).

Positioning for ACDF can be achieved using head fixation in the Mayfield skull clamp or a padded headrest (9). Whereas use of a padded headrest provides a fast and non-invasive method to position the patient's head for ACDF surgery, it can also provide less stability to intraoperative manipulation. In contrast, the Mayfield skull clamp provides fixed positioning, but can also be associated with local injuries including lacerations or skull fractures (10).

The current study therefore aims to determine whether the use of one form of head positioning offers any benefit or disadvantage over the other. We present this article in accordance with the STROBE reporting checklist (available at https://jss.amegroups.com/article/view/10.21037/jss-23-117/rc).

Highlight box

Key findings

- Patients positioned in the Mayfield skull clamp for anterior cervical discectomy and fusion (ACDF) surgery are exposed to lower amounts of radiation than those positioned in a padded head rest.

What is known and what is new?

- Patient positioning for ACDF surgery is based on individual preference of surgeons without evidence for superiority of a certain method.
- We found that the use of a Mayfield skull clamp is associated with lower doses of radiation exposure than use of a padded headrest.

What is the implication, and what should change now?

- Patient positioning in Mayfield skull clamps may be preferred for ACDF surgery with larger prospective studies being necessary to confirm these preliminary findings.

Methods

Study design

The study was conducted retrospectively by examining a demographically homogenous patient cohort of 121 patients undergoing ACDF procedures in our institution between 2019 and 2023. Analysis was based on the data from medical records and imaging studies. Cases were separated into two groups depending on their recorded positioning in the Mayfield skull clamp or padded headrest. Sample size was arrived at by including patients for two years before and after introduction of patient positioning using the padded headrest in our institution. Patients who were either positioned using the Mayfield skull clamp or the padded headrest were retrospectively compared regarding potential differences in surgical parameters [length of surgery, dose area product (DAP) and radiation time], postoperative complications and modified Rankin Scale (mRS) at last follow up.

The study was approved by the Ethics Committee of the Medical Faculty of the Goethe University of Frankfurt am Main (No. 2023-1312) and was conducted in accordance with the Declaration of Helsinki (as revised in 2013). As the analysis was performed retrospectively on routinely acquired patient data, informed consent from participants was not required. Patients were excluded from analysis if ACDF was performed as part of a ventro-dorsal strategy performed in the same surgical session or if they were undergoing surgery as part of a revision of previously performed ACDF due to improper placement, loosening or dislocation of material.

Patient positioning

All patients were in the supine position on a radiolucent table and slight hyperextension of the neck was achieved by placing a small cushion between the shoulder blades. When positioned in the Mayfield skull clamp, a radiolucent clamp was used. For prevention of head rotation among those patients in the headrest, fixation using Leukoplast tape was used. Continuous shoulder depression was generally not used.

Variables

Electronic medical records were used to retrieve data on patient demographics including age, gender, and body mass index (BMI). Diagnoses leading to ACDF were categorized as either degenerative, traumatic, or infectious. Among degenerative disease radiological images were analyzed to determine whether cervical Myelopathy was present based on T2 weighted magnetic resonance imaging (MRI) images in the segment to be surgically addressed. Surgical data including the procedure performed (number and localization of levels, with or without anterior plating), training level and amount of ACDF experience of the surgeon (Chief, attending or resident) and length of surgery. Surgical levels were categorized into three groups: 1: C1–C4, 2: C5–C7 or 3: spanning the C4/5 junction to include both upper and lower segments (for example C3-C6).

We also examined the use of intraoperative fluoroscopy by recording the DAP (measured by a transmission ionization chamber built into the X-ray tube) and total radiation time in each intervention. Intraoperative fluoroscopy was performed using a Ziehm Solo single unit C-arm which underwent annual inspection procedures.

Degree of neurological impairment was assessed using the mRS before surgery and at last follow-up. Occurrences of adverse events were recorded over the course of follow-up and included dysphagia, C5 nerve root palsy, hemorrhage, injury of the recurrent laryngeal nerve (RLN), esophageal injury and the necessity of repeat surgery due to unsatisfactory material placement.

Statistical analysis

Data is presented as absolute counts and percentages of total or mean with standard deviation (as indicated). Group comparisons were performed by using the chi-square test for categorical variables and the Mann-Whitney *U* test for metric variables. Multiple linear regression analysis was performed using DAP as an independent variable. Wilcoxon signed-rank test was used to compare pre- and postoperative changes in mRS scores. P values of less than 0.05 were considered statistically significant, however, due to the exploratory nature of this setting, no adjustment for multiplicity was conducted and hence, P values are interpreted in a hypothesis-generating way. Any missing data is indicated in tables. All analyses were performed in SPSS (version 24; IBM, Armonk, NY, USA).

Results

Patient demographics

We analyzed a total of 121 patients who underwent ACDF surgery in our institution between November 2019 and March 2023. Among these patients, 59 were positioned using the Mayfield head clamp and 62 in a padded headrest. The mean follow-up time was 146 days (standard deviation 184 days) for the headrest group and 167 days (standard deviation 200 days) for the Mayfield group). There was no statistically significant difference between the Mayfield and Headrest groups regarding age (mean 63 versus 59 years, P=0.463) or gender (66% versus 63% male; 34% versus 37% female, P=0.849). Patients in the Mayfield group had a mean BMI of 26.0 versus 27.5 kg/m^2 among patients in the headrest group (P=0.460) (*Table 1*).

The most frequent category of diagnosis underlying surgical intervention across both groups was degenerative disease (n=104), followed by traumatic injury (n=11) and infectious disease (n=6). Within the category of degenerative disease 45 patients (43%) suffered from degenerative disc disease across both Mayfield and Headrest groups, 10 (10%) of which showed radiological signs of myelopathy. The most common diagnosis was 1-level disc herniation without myelopathy. A total of 76 patients (73%) suffered from degenerative stenosis, 31 (41%) of which showed radiological signs of myelopathy. There was no statistically significant difference in the levels which were operated between both groups (P=0.419). The most common diagnosis was 1-level stenosis with myelopathy. Distribution of diagnoses among patients positioned in the Mayfield head clamp versus the headrest was not statistically significantly different (P=0.557). Also, the presence of myelopathy on MRI scans did not differ significantly between the Mayfield and headrest groups (P=0.250) (*Table 1*). Within the category of traumatic injury, there was one case of fracture at each of the C3, C4, C5 and C6 levels. Additional fractures involving the levels C4/5 and C5/6 occurred once each and two fractures at the level C6/7 were reported. One Hangman's fracture was included as well as two cases of traumatic disc herniation at the levels C3/4, one of which was associated with radiological signs of myelopathy. The C3 and C4 fractures as well as the C4/5 fracture were in the Mayfield group.

Surgical procedures and intraoperative data

The most common surgical procedure performed was a 1-level fusion with no anterior plate among 41 (69%) of patients in the Mayfield group and 36 (58%) patients in the headrest group. There was no statistically significant difference in the distribution of procedures performed between both groups (P=0.069) (*Table 2*).

Surgery was performed by the chief of the department

Table 1 Patient demographics

Characteristics	Mayfield (n=59)	Headrest (n=62)	P
Age (years), mean [SD]	63 [13]	59 [16]	0.463
Gender, n (%)			0.849
Male	39 (66%)	39 (63%)	
Female	20 (34%)	23 (37%)	
BMI (kg/m^2), mean [SD]	26.0 [4.6]	27.5 [4.2]	0.460
Level, n (%)			0.419
C1–4	12 (20%)	15 (24%)	
C5–7	31 (53%)	34 (55%)	
Both	16 (27%)	13 (21%)	
Diagnosis, n (%)			0.557
Degenerative			
1-level disc herniation w/o myelopathy	12 (20%)	19 (31%)	
1-level disc herniation w/ myelopathy	6 (10%)	4 (6%)	
2-level disc herniation w/o myelopathy	2 (3%)	2 (3%)	
1-level stenosis w/o myelopathy	8 (14%)	7 (11%)	
1-level stenosis w/ myelopathy	16 (27%)	12 (19%)	
2-level stenosis w/o myelopathy	2 (3%)	5 (8%)	
2-level stenosis w/ myelopathy	2 (3%)	1 (2%)	
3-level stenosis w/o myelopathy	4 (7%)	2 (3%)	
3-level stenosis w/ myelopathy	0	0	
Traumatic	3 (5%)	8 (13%)	
Infectious	4 (7%)	2 (3%)	
Myelopathy on MRI, n	24	17	0.250

Gender, age and diagnoses among all patients in the study cohort according to form of head fixation (Mayfield versus Headrest). Surgical levels were categorized into three groups: C1–4, C5–7 and Both (i.e., spanning the C4/5 junction to include both upper and lower segments). Presence (with; w/) or absence (without; w/o) of radiological signs of myelopathy is indicated. Analysis of group differences among categorical variables was performed using Chi-squared analysis and Mann-Whitney *U* test for numerical variables with P<0.005 considered significant. SD, standard deviation; BMI, body mass index.

in 37 cases (14 patients in the Mayfield group, 23 patients in the headrest group), by attending in 50 cases (25 patients in each group), and residents in 34 cases (20 patients in the Mayfield group, 14 patients in the headrest group). There was no statistically significant difference in the distribution of surgeons performing the procedures between the two groups (P=0.218) (*Table 2*).

The mean length of surgery in the Mayfield group was 123 minutes (standard deviation 61 minutes) and 115 minutes (standard deviation 48 minutes) in the headrest group. There was no statistically significant difference in the length of the surgical procedure between these two groups (P=0.752).

Data on DAP was missing for three patients in the Mayfield group and one patient in the headrest group. DAP was significantly higher in the headrest group (mean 131 cGy/cm^2, standard deviation 127 cGy/cm^2) than in the Mayfield group (99 cGy/cm^2, standard deviation 162 cGy/cm^2) (P=0.003) (*Table 2*). The total radiation time was not statistically and significantly different between

Table 2 Surgical procedures and intraoperative data

Variables	Mayfield (n=59)	Headrest (n=62)	P
Procedure, n (%)			0.069
1-level w/o anterior plate	41 (69%)	36 (58%)	
1-level w/ anterior plate	5 (8%)	14 (23%)	
2-levels w/o anterior plate	5 (8%)	9 (15%)	
2-levels w/ anterior plate	5 (8%)	1 (2%)	
3-levels w/ anterior plate	3 (5%)	2 (3%)	
Surgeon, n (%)			0.218
Chief	14 (24%)	23 (37%)	
Attending	25 (42%)	25 (40%)	
Resident	20 (34%)	14 (23%)	
Length of surgery (minutes), mean [SD]	123 [61]	115 [48]	0.752
Dose area product (cGy/cm^2), mean [SD]	99 [162]	131 [127]	0.003*
Total radiation time (seconds), mean [SD]	27 [32]	41 [35]	0.156

Surgical procedures performed (with; w/ or without; w/o anterior plate), training level of the surgeon, length of surgery and dose area products with total radiation time were compared between patients positioned in headrests versus Mayfield head clamp. Data on dose area product was missing for three patients in the Mayfield group and one patient in the headrest group. Statistical analysis was performed using Mann-Whitney *U* test for numerical variables and the Chi-squared test for categorical variables. *, P value <0.05 is considered statistically significant. SD, standard deviation.

the Mayfield and headrest groups (mean 27±32 versus 41±35 seconds) (P=0.156) (*Table 2*).

We then performed multiple linear regression analysis using DAP as an independent variable to determine whether factors of the procedure itself (number of levels, use of an anterior plate and length of surgery) are responsible for the observed differences in DAP between the Mayfield and Headrest groups.

Here we found that length of surgery (B=0.041; P=0.868), use of an anterior plate (B=0.041; P=0.868) and number of levels (B=−0.037; P=0.888) were not significantly associated with DAP.

Adverse events and clinical outcome

Regarding preoperative mRS, 36 patients in the Mayfield group (61%) and 40 in the headrest group (65%) presented before surgery with an mRS of 1. This was the most common presenting score among both groups. Six patients (10%) in the Mayfield group and 2 (3%) in the headrest group displayed an mRS of 4 prior to surgery. Analysis of mRS distribution prior to surgery in both groups revealed no statistically significant differences between patients positioned in the Mayfield skull clamp and headrest (P=0.458) (*Table 3*).

At last follow-up mRS was missing for 26 patients in the Mayfield group and 18 patients in the headrest group. The distribution of mRS scores among postoperative patients was not statistically significantly different between those in the Mayfield and headrest groups (P=0.080). There was a statistically significant difference in pre- and postoperative mRS scores in both the Mayfield group ($Z=-4.516$; P=0.001) and headrest group ($Z=-3.222$; P=0.001) indicating an improvement of mRS score following surgery. An mRS score of 1 remained the most common score among both groups with 20 patients (61%) in the Mayfield group and 29 patients (66%) in the headrest group. Postoperatively 3 patients in the Mayfield group (9%) and 1 patient in the headrest group (2%) had an mRS of 4 (*Table 3*).

The rate of adverse events was the same among both groups with 9 patients (16%) in the Mayfield group and 10 patients (16%) in the headrest group (P=0.619). The most common adverse events among the Mayfield group were postoperative dysphagia and RLN injury which occurred in 4 patients (7%) each. Among the headrest group, revision surgery was performed to correct material placement in

Table 3 Adverse events and outcome

Variables	Mayfield (n=59)	Headrest (n=62)	P
mRS before surgery, n (%)			0.458
0	0	0	
1	36 (61%)	40 (65%)	
2	13 (22%)	14 (23%)	
3	4 (7%)	6 (10%)	
4	6 (10%)	2 (3%)	
mRS at last follow-up, n (%)			0.080
0	1 (3%)	4 (9%)	
1	20 (61%)	29 (66%)	
2	6 (18%)	10 (23%)	
3	3 (9%)	0	
4	3 (9%)	1 (2%)	
Adverse events, n (%)			0.619
None	50 (85%)	52 (84%)	
Dysphagia	4 (7%)	1 (2%)	
Correction of material placement	1 (2%)	3 (5%)	
C5 nerve root palsy	0	2 (3%)	
Hemorrhage	0	2 (3%)	
RLN injury	4 (7%)	1 (2%)	
Esophageal injury	0	1 (2%)	

Comparison of the distribution of mRS before surgery and at last follow-up between patients positioned using headrest versus Mayfield clamp. mRS at last follow-up was missing for 26 patients in the Mayfield group and 18 patients in the headrest group. Adverse events between the two groups were also compared. Statistical analysis was performed using the Chi-squared test for categorical variables. A P value <0.05 is considered statistically significant. mRS, modified Rankin Scale; RLN, recurrent laryngeal nerve.

3 cases (5%) and C5 nerve root palsy occurred in 2 patients (3%) (*Table 3*).

Discussion

Patient positioning for any surgical procedure can affect the ease of operation itself as well as possible postoperative sequalae resulting from mal positioning. Although the positioning for ACDF surgery may initially appear trivial, recent studies have demonstrated that the practice of shoulder depression, which has been commonly implemented to gain access to lower cervical segments, or in obese patients may increase the probability of postoperative C5 nerve root palsy (5).

The current study therefore aimed at characterizing possible risks and benefits of two commonly utilized forms of head positioning for ACDF surgery: the Mayfield skull clamp versus a padded headrest.

In the case of the Mayfield skull clamp, head and neck positioning remains highly stable during the surgical procedure, whereas headrest positioning can potentially be associated with rotation or loss of reclination during surgery. On the other hand, headrest positioning is fast and not associated with potential risks of the Mayfield skull clamp such as skin lacerations, hematoma or skull fractures (10). Ultimately, the use of either form of head positioning in this study was based on the personal preference of the surgeon. As our study was conducted in a neurosurgical department, further analysis of procedures performed in orthopedic departments may provide additional insights into differences in positioning preference as these surgical subspecialties both perform ACDF procedures and have been shown to differ regarding injury assessment (11).

Among the two demographically similar groups, we found no statistically significant differences in the rates of surgical complications including dysphagia, C5 nerve root palsy, hemorrhage, RLN injury, esophageal injury, and correction of material placement. In both groups, 84% of patients experienced no adverse events. These findings are in line with previously described meta-analyses of complications among ACDF procedures (1).

Whereas the complication rates of ACDF procedures did not differ between the Mayfield and headrest groups, we did find that the DAP applied over the course of the procedure was significantly higher among those patients positioned in a padded headrest versus the Mayfield skull clamp (99 versus 131 cGy/cm^2, P=0.003). Compared to the current literature on the average DAP applied in cervical spine surgery which ranges from 4–42 cGy/cm^2, the values in our cohort are higher (12-14), however no procedure in our study approached the threshold considered as a significant radiation dose with a DAP >500 Gy/cm^2 (15). This may be explained by the heterogeneous group of surgeons in our academic training institution as well as the complexity of procedures, and differences in the X-ray systems used in our study. It must also be considered that the majority of trauma cases were positioned in the headrest, so that although the distribution of etiologies was not significantly different between groups, these cases may require more imaging therefore possibly being associated with higher doses of radiation. We also found that the total radiation time was higher among patients in the headrest group than in the Mayfield group (41 versus 27 seconds, although this difference did not reach statistical significance (P=0.156). The mean total radiation time found in our study is, however, comparable with previously described values which range from 9–48 seconds (12-14). Although both the DAP and total radiation time did not exceed established thresholds or diverge strongly from the literature, cumulative applied doses of ionizing radiation are associated with various neoplastic diseases and local reactions such as skin irritation, so that the individual DAP applied during surgery should always be held to a minimum for both the patient and the surgeon (16).

In linear regression analysis, we could exclude the possible confounding factors such as number of levels, use of an anterior plate and length of surgery as the sole effectors of the observed differences. We can postulate that a binary independent variable (Mayfield/Headrest) may not be strong enough an effector of DAP to create a significant effect within the context of a linear model. Increasing sample size through future observations may provide further insights.

Whereas previous studies have found that patients with severe obesity are at greater risk of higher radiation exposure than patients with lower BMI, the two groups in our study did not significantly differ in BMI (26.0 versus 27.5 in the Mayfield and headrest groups, respectively) (17-19). We therefore cannot directly attribute increased DAPs in the headrest group to higher BMI, although this may have contributed to the difference.

It may also be hypothesized that positioning in the Mayfield skull clamp allows for better reclination and slight distraction of the cervical spine which may result in less required dose application during the subsequent procedure once adequate positioning is achieved. Positioning in the headrest may be more prone to variation over the course of the procedure, therefore requiring repeating imaging. Furthermore, our study did not include patients undergoing corporectomy procedures, which have been shown to have better long-term lordosis corrections when used over two-levels compared to three-level ACDF procedure (20). It therefore should be considered that the advantage of stable positioning in the Mayfield for optimizing lordotic correction and minimizing radiation exposure could differ between procedures. Further verification on larger cohorts including corporectomies may provide further insight into the reason for these differences.

Compared to lumbar spine surgery, which reaches DAPs up to 700 cGy/cm^2, radiation exposure acquired during ACDF can be considered comparatively low (14,21). Regardless of head positioning, efforts should be made to reduce exposure wherever possible, such as use of collimation which can also reduce exposure to the surgeon (22). These findings may provide the first basis for an additional measure to reduce radiation exposure, namely patient positioning in the Mayfield skull clamp rather than the padded headrest.

Conclusions

In conclusion, our study presents preliminary results which indicate that patient positioning using the Mayfield skull clamp may reduce required radiation exposure during ACDF procedures versus use of a padded headrest. Further prospective, randomized studies will be necessary to elucidate these initial findings.

Limitations of the current study include the monocentric and retrospective design. Prospective, randomized studies including a larger study sample could more robustly verify the initial observations described in this study. Inclusion of traumatic and infectious etiologies for ACDF procedures may add heterogeneity to the patient cohort which may mask possible additional significant differences between the two groups aside from DAP.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jss.amegroups.com/article/view/10.21037/jss-23-117/rc

Data Sharing Statement: Available at https://jss.amegroups.com/article/view/10.21037/jss-23-117/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jss.amegroups.com/article/view/10.21037/jss-23-117/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was approved by the Ethics Committee of the Medical Faculty of the Goethe University of Frankfurt am Main (No. 2023-1312) and was conducted in accordance with the Declaration of Helsinki (as revised in 2013). As the analysis was performed retrospectively on routinely acquired patient data, informed consent from participants was not required.

References

1. Epstein NE. A Review of Complication Rates for Anterior Cervical Diskectomy and Fusion (ACDF). Surg Neurol Int 2019;10:100.
2. Burkhardt BW, Müller SJ, Wagner AC, et al. Anterior cervical spine surgery for the treatment of subaxial cervical spondylodiscitis: a report of 30 consecutive patients. Neurosurg Focus 2019;46:E6.
3. Kandziora F, Pflugmacher R, Scholz M, et al. Treatment of traumatic cervical spine instability with interbody fusion cages: a prospective controlled study with a 2-year follow-up. Injury 2005;36 Suppl 2:B27-35.
4. Saifi C, Fein AW, Cazzulino A, et al. Trends in resource utilization and rate of cervical disc arthroplasty and anterior cervical discectomy and fusion throughout the United States from 2006 to 2013. Spine J 2018;18:1022-9.
5. Alonso F, Voin V, Iwanaga J, et al. Potential Mechanism for Some Postoperative C5 Palsies: An Anatomical Study. Spine (Phila Pa 1976) 2018;43:161-6.
6. Kamel I, Barnette R. Positioning patients for spine surgery: Avoiding uncommon position-related complications. World J Orthop 2014;5:425-43.
7. Uribe JS, Kolla J, Omar H, et al. Brachial plexus injury following spinal surgery. J Neurosurg Spine 2010;13:552-8.
8. St-Arnaud D, Paquin MJ. Safe positioning for neurosurgical patients. Can Oper Room Nurs J 2009;27:7-11, 16, 18-9 passim.
9. Cunha PD, Barbosa TP, Correia G, et al. The ideal patient positioning in spine surgery: a preventive strategy. EFORT Open Rev 2023;8:63-72.
10. Thijs D, Menovsky T. The Mayfield Skull Clamp: A Literature Review of Its Complications and Technical Nuances for Application. World Neurosurg 2021;151:102-9.
11. Lambrechts MJ, Schroeder GD, Karamian BA, et al. Effect of surgical experience and spine subspecialty on the reliability of the AO Spine Upper Cervical Injury Classification System. J Neurosurg Spine 2023;38:31-41.
12. Lee YS, Lee HK, Cho JH, et al. Analysis of radiation risk to patients from intra-operative use of the mobile X-ray system (C-arm). J Res Med Sci 2015;20:7-12.
13. Crawley MT, Rogers AT. Dose-area product measurements in a range of common orthopaedic procedures and their

possible use in establishing local diagnostic reference levels. Br J Radiol 2000;73:740-4.
14. Fransen P. Fluoroscopic exposure in modern spinal surgery. Acta Orthop Belg 2011;77:386-9.
15. Stecker MS, Balter S, Towbin RB, et al. Guidelines for patient radiation dose management. J Vasc Interv Radiol 2009;20:S263-73.
16. Srinivasan D, Than KD, Wang AC, et al. Radiation safety and spine surgery: systematic review of exposure limits and methods to minimize radiation exposure. World Neurosurg 2014;82:1337-43.
17. Bratschitsch G, Leitner L, Stücklschweiger G, et al. Radiation Exposure of Patient and Operating Room Personnel by Fluoroscopy and Navigation during Spinal Surgery. Sci Rep 2019;9:17652.
18. Kukreja S, Haydel J, Nanda A, et al. Impact of body habitus on fluoroscopic radiation emission during minimally invasive spine surgery. J Neurosurg Spine 2015;22:211-8.
19. Gross EG, Laskay NMB, Mooney J, et al. Morbid Obesity Increases Length of Surgery in Elective Anterior Cervical Discectomy and Fusion Procedures but Not Readmission or Reoperation Rates: A Cohort Study. World Neurosurg 2023;173:e830-7.
20. Lofrese G, Trungu S, Scerrati A, et al. Two-Level Corpectomy and Fusion vs. Three-Level Anterior Cervical Discectomy and Fusion without Plating: Long-Term Clinical and Radiological Outcomes in a Multicentric Retrospective Analysis. Life (Basel) 2023;13:1564.
21. Perisinakis K, Theocharopoulos N, Damilakis J, et al. Estimation of patient dose and associated radiogenic risks from fluoroscopically guided pedicle screw insertion. Spine (Phila Pa 1976) 2004;29:1555-60.
22. Erken HY, Yilmaz O. Collimation Reduces Radiation Exposure to the Surgeon in Endoscopic Spine Surgery: A Prospective Study. J Neurol Surg A Cent Eur Neurosurg 2022;83:6-12.

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