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Three different surgical positions on radiological outcomes in the proximal femoral nail: supine, lateral decubitus and traction table

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Abstract. – OBJECTIVE: While the proximal femoral nail (PFN) is deemed a successful therapeutic approach for intertrochanteric femoral fractures, medical professionals lack agreement as to the optimal surgical positioning. Our objective was to determine the radiological superiorities of three different surgical positions (supine, lateral decubitus, and traction table).

PATIENTS AND METHODS: In this clinical study, 157 prospectively followed-up patients who were operated with PFN for intertrochanteric femur fractures between 2019 and 2022 were analyzed retrospectively. The demographic data of the patients, fracture type, preparation and surgery duration, recorded number of fluoroscopy shots, femoral neck quadrant of the lag screw, tip-apex distance, collodiaphyseal angle, and reduction quality were evaluated.

RESULTS: Of the 157 patients evaluated in the study, 35 patients (22.3%) were operated in the supine position without traction table, 52 patients (33.1%) in the lateral decubitus position, and 70 patients (44.6%) in the supine position with a traction table. Significant differences were found between groups in terms of preparation duration (p<0.001) and number of fluoroscopy shots (p<0.001). Post-hoc analyses revealed that the preparation duration and the number of fluoroscopy shots were significantly lower in the supine position with manual traction. In radiological examinations, significant differences were found between the groups in all radiological parameters evaluated. Post-hoc analyses showed that the use of the traction table is associated with the lag screw quadrant (p<0.001), the reduction quality (p<0.001), the tip-apex distance (p=0.011), and the collodiaphyseal angle (p<0.001).

CONCLUSIONS: Despite the disadvantages, such as prolonged preparation duration and increased fluoroscopy usage, the use of a traction table stands out in PFN due to superior radiological results, such as a more successful reduction quality, a more accurately positioned lag screw and ideal tip-apex distance, and collodiaphyseal angulation.

Key Words:
Cleveland zone, Manual traction, Patient position, Proximal femoral nail, Tip-apex distance, Traction table.

Introduction

Proximal femur fractures, along with distal radius and proximal humerus fractures, are among the most common types of fractures in the elderly[1,2]. Furthermore, with the prolongation of life expectancy, elderly hip fractures are becoming a more important health problem day by day. Although discussions continue, the prevailing opinion in the literature is that intramedullary nails are the preferred implants in proximal extracapsular femur fractures[3,4]. In 1996, the Arbeitsgemeinschaft. für Osteosynthesefragen/Association for the Study of İnternal Fixation (AO/ASIF) developed the proximal femoral nail (PFN) as an intramedullary device for the treatment of unstable per-, inter-, and subtrochanteric femoral fractures, and since then, PFN continues to be widely used in geriatric hip fractures[2-4].

Proximal femoral nails can be performed in the supine position with or without the use of a traction table or in the lateral decubitus position, depending on the surgeon's experience and physical conditions[5]. While the use of a traction table has the advantage of eliminating the need for manual traction, it is not preferred in many clinics due to its inadequacy in cases where dynamic traction is required, its absence in some hospitals, long preparation period, and complications related to traction[5]. The clinical and radiological advantages of different patient positions that are frequently preferred for PFN have been investigated in the literature[6,7]. On the other hand, to the best of our knowledge, the number of studies comparing the radiological advantages of three different methods together is quite limited.

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The main question of our study was whether the use of a traction table was radiologically superior to the other two surgical positions. Our hypothesis is that, despite some limitations, the radiological parameters and screw positioning will be superior in cases using the traction table compared to the other two surgical positions. Our second question was which of the other two surgical positions is superior to the other.

Patients and Methods

Following the Institutional Review Board approval, patients older than 18 years old and operated with proximal femoral nails for intertrochanteric femur fractures between 2019 and 2022 were scanned retrospectively. Patients with femoral neck, subtrochanteric, open, or pathological fractures; patients with non-displaced (AO/OTA Type 31A1) or reverse-oblique intertrochanteric fractures; patients who required open reduction; patients with previous lower extremity fractures; and patients who were lost to follow-up were excluded from the study. The reason why non-displaced fractures were excluded from the study was that the evaluation of the reduction quality could not be made because these fractures were already in the reduced position. Considering the inclusion and exclusion criteria, 157 patients were evaluated. This study was organized following the principles of the Declaration of Helsinki.

All patients were operated by the same surgical team in one of the three different patient positions defined and accepted in the literature: supine position without the use of a traction table (Group 1), lateral decubitus position (Group 2), and supine position with traction table (Group 3)[5-7]. Patients' positions were determined randomly, based on the day the patient was operated. The same proximal femoral nail system (Profin PFN Antirotator Proximal Femur Nail, TST Orthopedics®, TST Medical Tools®, İstanbul, Türkiye) was applied to all patients under the surgical techniques described in the literature[8,9]. In the postoperative period, isometric quadriceps exercise was started in all patients. Partial weight bearing was allowed as long as the patient tolerated it postoperatively. Full weight bearing was not allowed before 6 weeks.

The demographic data of the patients, fracture type, preparation and surgery duration, recorded number of fluoroscopy shots, and radiological parameters were recorded and analyzed. Fracture type was classified based on AO/OTA Classification[10]. Preparation duration was defined as the time between the completion of the intervention of the anesthesia team and handing over the patient to the surgical team. This duration was used to evaluate the time for positioning the patient. Operation duration was evaluated as the time between the start and end of the operation. The number of fluoroscopy shots was recorded on the fluoroscopy device. All durations and number of shots were recorded prospectively in patient files after surgery, and this prospectively collected data were retrospectively scanned for the study.

To evaluate the reductions radiologically, several parameters were analyzed on the postoperative radiographs; femoral neck quadrant where the lag screw is inserted based on the Cleveland zone, tip-apex distance, collodiaphyseal angle, and reduction quality. The position of the lag screw in the femoral neck was categorized according to the Cleveland zone, as defined in the literature[11]. Tip-apex distance was evaluated as the sum of the distance between the tip of the lag screw to the apex of the femoral head on both the anterior-posterior and lateral radiographs[11-13]. The collodiaphyseal angle was measured as the angle between the longitudinal axis of the femoral neck and the shaft[14,15]. Reduction quality was categorized as anatomical, near-anatomical (minimally displaced), and non-anatomical (displaced but acceptable) reduction[11]. All radiological measurements were performed by the same author (OG), who was blind to the patient's position, using the Picture Archiving Communication System (PACS).

Statistical Analysis

Statistical analyses were performed using SPSS 26.0 software (IBM Corp., Armonk, NY, USA). Compliance of the variables with normal distribution was evaluated by visual (histogram and probability graphs) and analytical (Kolmogorov-Smirnov Test) methods, and it was found all of the parameters fit the skewed distribution. As descriptive statistics, percentage-frequency values were used to define categorical data, and median, interquartile range, and minimum-maximum range values were used to define the numerical data. Kruskal-Wallis Test was used to compare the groups in the evaluation of numerical parameters according to patient position, and post-hoc analyses were conducted using the

Table I. Comparison of demographic profile, fracture type and surgery durations.

		Supine, no traction table (N = 35)	Lateral decubitus (N = 52)	Supine, with traction table (N = 70)	*p*-value
Age (years)		82 (8) (42-96)	78 (13) (51-95)	78 (13) (30-105)	0.478
Gender	Female	18 (51.4%)	33 (63.5%)	41 (58.6%)	0.536
	Male	17 (48.6%)	19 (36.5%)	29 (41.4%)	
AO/OTA fracture classification	31A12	0	0	2 (2.8%)	0.625
	31A13	2 (5.7%)	2 (3.8%)	4 (5.7%)	
	31A21	7 (20%)	9 (17.3%)	9 (12.8%)	
	31A22	10 (28.6%)	20 (38.5%)	23 (32.8%)	
	31A23	16 (45.7%)	17 (32.7%)	27 (38.8%)	
	31A31	0	4 (7.7%)	5 (7.1%)	
Preparation duration (minutes)		15 (5) (10-38)	25 (15) (10-45)	34 (10) (10-75)	**< 0.001**
Surgery duration (minutes)		90 (40) (60-160)	87.5 (24) (11-170)	95 (40) (55-165)	0.194
Number of fluoroscopy shots		48 (21) (28-86)	87 (52) (32-183)	90 (35) (32-259)	**< 0.001**

N: number of patients, *p*: statistical significance value.

Mann-Whitney U Test. The Chi-Square Test was used to compare the categorical data. Statistical significance was considered significant when the *p*-value was below 0.05.

Results

Of the 157 patients evaluated in the study, 35 patients (22.3%) were operated in the supine position without traction table, 52 patients (33.1%) were operated in the lateral decubitus position, and 70 patients (44.6%) were operated in the supine position with a traction table. The preparation duration of the patient groups was 15 minutes in Group 1 (Range: 10-38 minutes), 25 minutes in Group 2 (Range: 10-45 minutes), and 34 minutes (Range: 10-75 minutes) in Group 3, respectively, and a significant difference was detected between the groups ($p<0.001$). The number of fluoroscopy shots seen during the operation were 48 shots (Range: 28-86), 87 shots (Range: 32-183), and 90 shots (Range: 32-259), respectively ($p<0.001$). The detailed distribution of patient and fracture information is shown in Table I.

Post-hoc analyses to determine the group that caused the significant difference showed that the preparation duration showed a significant difference between all pairs, but the number of fluoroscopy shots was significantly lower in cases

Table II. Post-hoc analyses of statistically significant demographic variables.

Post-hoc analysis		Preparation duration (minutes)		
		Group 1	Group 2	Group 3
Preparation duration (minutes)	Group 1	N/A	**< 0.001**	**< 0.001**
	Group 2	**< 0.001**	N/A	**< 0.001**
	Group 3	**< 0.001**	**< 0.001**	N/A
		Number of fluoroscopy shots		
Number of fluoroscopy shots	Group 1	N/A	**< 0.001**	**< 0.001**
	Group 2	**< 0.001**	N/A	0.868
	Group 3	**< 0.001**	0.868	N/A

N: number of patients, *p*: statistical significance value, N/A: not applicable.

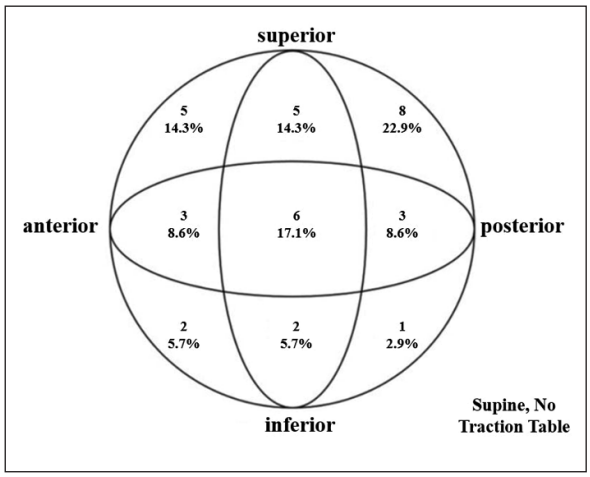

Figure 1. Distribution of lag screw positions according to Cleveland zone in who were operated in the supine position with manual traction (n=35 patients).

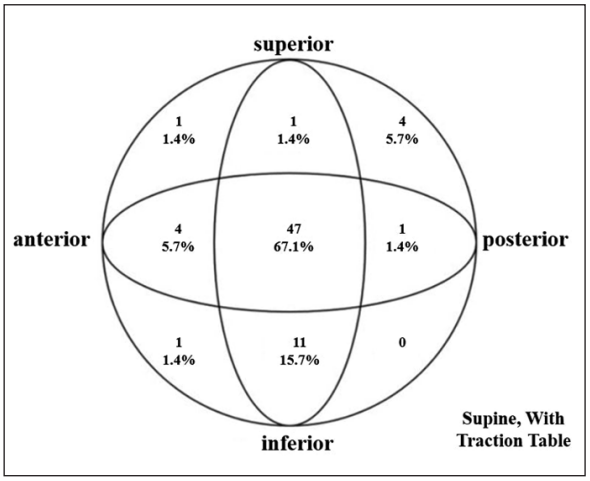

Figure 3. Distribution of lag screw positions according to Cleveland zone in who were operated in the supine position with traction table (n=70 patients).

performed in the supine position without the use of a traction table (Table II).

In terms of radiological examination, significant differences were found in all radiological parameters included in the evaluation between groups (Figures 1-3) ($p<0.05$ for each) (Table III). Post-hoc analyses revealed that while the tip-apex distance was significantly higher in Group 1, no significant difference was observed between Groups 2 and 3. In the post-hoc analysis of the collodiaphyseal angle, it was determined that the patients who were operated in the supine position without the use of a traction table were significantly lower than the group in which the traction table was used ($p=0.011$). When analyzing the position of the lag screw, post-hoc analyses revealed that the use of a traction table made a significant difference ($p<0.001$). Similarly, it was determined that the use of a traction table made a significant difference in reduction quality ($p<0.001$ for each) (Table IV).

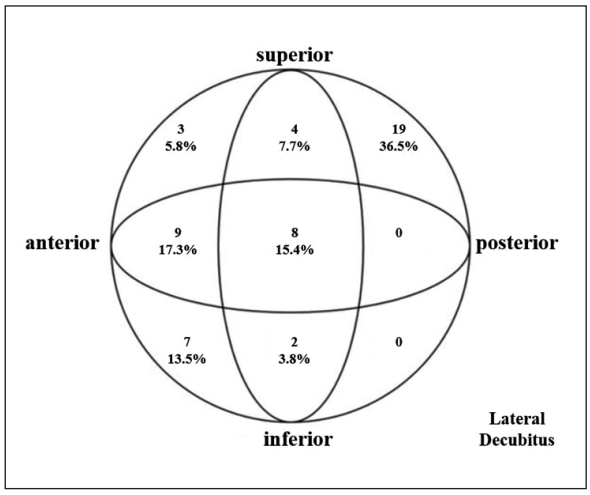

Figure 2. Distribution of lag screw positions according to Cleveland zone in who were operated in the lateral decubitus position with manual traction (n=52 patients).

Discussion

Although the proximal femoral nail (PFN) is considered a successful treatment option for intertrochanteric femoral fractures, there is no consensus among surgeons on which position to perform the surgery[5]. Although there are several studies in the literature, these studies[5-7] are generally designed as a comparison of two different patient positions, such as lateral decubitus *vs.* traction table, supine *vs.* lateral decubitus or supine with *vs.* without traction table. On the other hand, to the best of our knowledge, there is no study comparing all three different surgical positions at the same time. In this sense, this is the most important feature and the main strength of our study and we believe we will make a contribution to the literature. The most important finding of our study is that, while the preparation duration and the number of perioperative fluoroscopy shots were significantly higher in the cases using the traction table in the supine position, nails using the traction table were superior based on all evaluated radiological parameters ($p<0.05$ for each).

Table III. Comparison of radiological reduction quality and early failure rate.

		Supine, no traction table (N = 35)	Lateral decubitus (N = 52)	Supine, with traction table (N = 70)	*p*-value
Tip-apex distance (mm)		24 (8) (10-40)	17 (14) (2-70)	18 (10) (8-40)	**0.001**
Collodiaphyseal angle (°)		132 (10) (118-146)	135 (10) (127-150)	135 (6) (123-145)	**0.048**
Cleveland zone of the lag screw	Zone 1	5 (14.3%)	3 (5.8%)	1 (1.4%)	
	Zone 2	5 (14.3%)	4 (7.7%)	1 (1.4%)	
	Zone 3	8 (22.9%)	19 (36.5%)	4 (5.7%)	
	Zone 4	3 (8.6%)	9 (17.3%)	4 (5.7%)	**< 0.001**
	Zone 5	6 (17.1%)	8 (15.4%)	47 (67.1%)	
	Zone 6	3 (8.6%)	0	1 (1.4%)	
	Zone 7	2 (5.7%)	7 (13.5%)	1 (1.4%)	
	Zone 8	2 (5.7%)	2 (3.8%)	11 (15.7%)	
	Zone 9	1 (2.9%)	0	0	
Reduction quality	Anatomic	2 (5.7%)	6 (11.5%)	31 (44.3%)	**< 0.001**
	Near-anatomic	24 (68.6%)	34 (65.4%)	38 (54.3%)	
	Displaced but acceptable	9 (25.7%)	12 (23.1%)	1 (1.4%)	

N: number of patients, *p*: statistical significance value, N/A: not applicable.

In our study, there was no difference between the three study groups in terms of demographic data such as age, gender and fracture type (p=0.478; p=0.536; p=0.625, respectively). This indicates that the patient groups are homogeneous and similar to each other. In terms of surgical durations, while there was no significant difference in surgery duration between groups (p=0.194), there was a significant difference in preparation duration (p<0.001). Furthermore, a

Table IV. Post-hoc analyses of statistically significant radiologic parameters.

Post-hoc analysis		Tip-apex distance (mm)		
		Group 1	Group 2	Group 3
Tip-apex distance (mm)	Group 1	N/A	**0.003**	**< 0.001**
	Group 2	**0.003**	N/A	0.805
	Group 3	**< 0.001**	0.805	N/A
		Collodiaphyseal angle (°)		
Collodiaphyseal angle (°)	Group 1	N/A	0.076	**0.011**
	Group 2	0.076	N/A	0.864
	Group 3	**0.011**	0.864	N/A
		Cleveland zone of the lag screw		
Cleveland zone of the lag screw	Group 1	N/A	0.087	**< 0.001**
	Group 2	0.087	N/A	**< 0.001**
	Group 3	**< 0.001**	**< 0.001**	N/A
		Reduction quality		
Reduction quality	Group 1	N/A	0.634	**< 0.001**
	Group 2	0.634	N/A	**< 0.001**
	Group 3	**< 0.001**	**< 0.001**	N/A

N: number of patients, *p*: statistical significance value, N/A: not applicable.

significant difference was found between pairwise comparisons in post-hoc analyses, and we determined that the use of a traction table significantly extended the preparation time (34 minutes, range: 10-75 minutes), while the duration was significantly shortened in operations performed in the supine position without the use of a traction table (15 minutes, range: 10-38 minutes) ($p<0.001$). There are conflicting reports in the literature on this subject. He et al[5], in a meta-analysis they conducted, stated that the preparation duration of the manual traction is shorter than that of the traction table. Furthermore, in the same meta-analysis, authors reported no difference in terms of operation duration time between manual traction and traction table. Similarly, Doğan et al[7] reported that the use of the traction table significantly prolongs the preparation duration, but has no effect on operation time. Şahin et al[6], on the other hand, reported that the manual traction shortens both the preparation and operation durations for PFN. The preparation duration, which was evaluated as the time elapsed between the entrance of the patient to the operating room and the start of the surgery, includes the anesthesia time and positioning. Considering that the prolonged anesthesia period will cause complications such as pulmonary complications, deep vein thrombosis and infection, the supine position with manual traction seems to be more advantageous in this regard[16,17]. In addition, surgeries performed in a shorter time can enable more trauma patients to have surgery by using the operating room more effectively. Another point to be emphasized is that, when using the traction table, the position of the c-arm must be changed continuously to switch between anterior-posterior (AP) and lateral imaging, while it is relatively less mobile in the use of manual traction. As a result, the experience of the fluoroscopy technician is also having an effect on the surgery duration since it may be more difficult to position the c-arm when using the traction table.

Although PFN can be applied through several different approaches, it is important to consider both the advantages and disadvantages when deciding on the patient's position for surgery. The supine position offers several advantages, including direct access to the surgical area, good radiological visualization during surgery, a faster start of the surgery, and easy manipulation of the patient. However, it also has some disadvantages, such as limited mobility for the surgeon compared to other positions, difficulty in fluoroscopic visualization, and the need for a resident for manual traction during surgery. The lateral decubitus position offers several, including direct access to the surgical area, good radiological visualization, easier fluoroscopic viewing, and greater mobility for the surgeon. However, proper patient positioning is crucial to ensure adequate surgical exposure. Additionally, the cost of equipment required to maintain a stable lateral position should not be overlooked. Furthermore, the lateral decubitus position is related to several position-related complications[18]. The use of a traction table offers several advantages, including improved fracture reduction, better radiologic visualization, and easier manipulation and alignment of bone fragments through more effective and high-strength traction. However, it is important to consider the disadvantages, such as difficulties of nail entry, especially in nails with trochanteric fossa entry, allowing only axial traction, and the need for additional preparation of the operating table and the patient, which results in increased time and resources required for the procedure, as mentioned[5]. The use of excessive fluoroscopy is among the possible harms for the patient and the surgeon of nailing in intertrochanteric hip fractures. On the other hand, He et al[5] reported that there was no significant difference in terms of fluoroscopy time between manual traction and traction table groups. Doğan et al[7] reported that the use of traction table shortens the fluoroscopy time of the surgery. On the contrary, we observed during the post-hoc analyses that the least fluoroscopy used in our study was in the supine position ($p<0.001$ for each), while there was no significant difference between lateral decubitus and traction table positions ($p=0.868$). Hip anterior-posterior imaging is relatively easy to obtain in the supine position, but lateral imaging is difficult to obtain, especially in a fractured hip. During nailing, difficulties in lateral imaging lead to the surgeon's relative assessment and adoption of broader acceptance criteria, and this may lead to a lower number of fluoroscopy shots in the supine position without a traction table. Another important point is that the resident remains in the operating room for the manual traction while the fluoroscopy is being taken, and we believe that the total radiation exposure will not be that low despite the lower number of fluoroscopy shots. We believe that the reason why more fluoroscopy shots are obtained

in the traction table and lateral position is the more meticulous adjustments due to comfortable viewing in the AP and lateral positions. The fact that the quality of the radiological parameters aimed in PFN, the tip-apex distance, and the lag screw position are more successful on the traction table confirms this.

In proximal femoral nailing, cut-out and failure rates are directly related to the radiological parameters of the surgery[19]. Reduction quality and medial continuity are the primary parameters considered during surgery. Tip-apex distance is one of the important parameters used to predict failure in femoral nailing[20]. Another important radiological parameter is the position of the lag screw, and it is reported[21,22] that it is appropriate to be in the center-center or center-inferior plane. There are several reports[23] in the literature that associates posterior screwing with cut-outs. In the literature, calibrating the collodiaphyseal angle in the slight valgus position is recommended, especially because the increased varus angulation increases the shear forces and adversely affects the union[24]. In the triple comparison, a significant difference was found between the groups in terms of all radiological parameters (Table III). Post-hoc analyses showed that the use of a traction table is significantly superior to manual traction in the supine position in all radiological parameters (Table IV), and it is also superior to the lateral decubitus position in terms of lag screw position and reduction quality ($p<0.001$ for each). Although controversial opinions on the effect of the traction table on reduction quality have been reported in the literature[5-7,21,22], these publications are generally the product of analyses that include pairwise comparisons and clinical outcomes. On the other hand, in our study, which compared three different positions and focused solely on the radiological parameters in detail, it is seen that the use of a traction table is critical in obtaining better results radiologically. The most important reason for this, as mentioned before, is that more meticulous adjustments can be made due to comfortable viewing in the AP and lateral positions on the fluoroscopy image. Another reason is that manual traction is resident-dependent and the desired radiological result cannot be achieved due to the change in its strength during the ongoing operation, while the traction table allows a more stable reduction.

Limitations

Our study has several limitations. First and foremost, although we analyzed prospectively recorded data, the retrospective nature of our study is an important limitation. Another important limitation is the relatively low number of patients. The fact that we did not report the long-term follow-up results and complication rates of the patients can be considered as an important limitation, but we believe that we overcame this limitation as the main focus of our study was radiological results rather than clinical results.

Conclusions

Despite the disadvantages, such as prolonged preparation duration and increased fluoroscopy usage, the use of a traction table stands out in PFN due to superior radiological results, such as a more successful reduction quality, a more accurately positioned lag screw, and ideal tip-apex distance, and collodiaphyseal angulation.

Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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Ethics Approval

This study was approved by the local Ethics Committee of Şehit Prof. Dr. İlhan Varank Training and Research Hospital Scientific Research Ethics Committee (Approval Number: E-46059653-050.99-209534802, Approval Date: 17.02.2023).

Informed Consent

Informed consent was obtained from all individual participants included in the study.

Availability of Data and Materials

All data have been deposited in a private repository, only accessible through authors.

Authors' Contribution

OG: conception and design of the study, acquisition of data, drafting of the article, supervision, validation, and final approval of the version of the article. BG: conception and design of the study; analysis and interpretation of data; mak-

ing critical revisions related to the relevant intellectual content of the manuscript; supervision; validation and final approval of the version of the article to be published.

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