Three-dimensional pelvis computed tomography-assisted Taylor approach for spinal anesthesia in hip arthroplasty: a retrospective study

Saecheol Oh, MD, Phd¹, Yoojung Park, MD², Hana Kwon, MD³, Eunjin Eom, MD³, Dal-ah Kim MD³

¹Department of Anesthesiology and Pain Medicine, Daejeon St. Mary’s Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea.

²Department of Anesthesiology and Pain Medicine, Saint Vincent’s Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea.

³Department of Anesthesiology and Pain Medicine, Incheon St. Mary’s Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea.

Running Title:
CT-assisted Taylor Approach

Corresponding author:
Dal-ah Kim, MD
Department of Anesthesiology and Pain Medicine, Incheon St. Mary’s Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea.
56, Dongsu-ro, Bupyeong-gu, Incheon, (Zip code: 21431)
E-mail: 20900040@cmcnu.or.kr  Tel: 010-9213-2360  Fax: 032-280-5416

Previous presentation in conferences
The Anesthesiology Annual Meeting 2019 by American Society of Anesthesiologists
Oct 19-23, 2019 at Orange County Convention Center, Orlando, Florida, United States of America

Conflict of Interests
The authors declare no conflicts of interest.

Funding
The authors have no sources of funding to declare for this manuscript.

Acknowledgements
Not applicable

IRB number
DC19RESI0047
Three-dimensional pelvis computed tomography-assisted Taylor approach for spinal anesthesia in hip arthroplasty: a retrospective study

Running title: CT-assisted Taylor approach
Abstract

**Background:** The needle insertion in the Taylor approach of spinal anesthesia is challenging as the L5–S1 space is difficult to locate on surface anatomy. In this study, we wanted to suggest that 3D pelvis CT can assist the anesthesiologist in locating the needle insertion point. By comparing the success rate of 3D pelvis CT assisted-Taylor approach to other approaches in the existing literatures, we would like to report this technique as an alternative method of subarachnoid block in L5-S1 space.

**Methods:** For this retrospective observational study, we reviewed the records of hip arthroplasty using the 3D pelvis CT-assisted Taylor approach. The virtual two-dimensional plane was created with a midline and intercristal line on the posterior view of the 3D pelvis CT. Another imaginary guidance line was created from the crossing point of the two lines to the ideal skin insertion point of Taylor approach. The primary outcome was the success rate. Secondary outcomes are the angle between the intercristal line and the guidance line, the length of the guidance line and the distance from the ideal needle insertion point to the L5-S1 space within the midline.

**Results:** We reviewed the records of the 276 patients who underwent hip arthroplasty using 3D CT-assisted Taylor approach. From the 276 patients only 25 patients had been failed with the 3D CT-assisted Taylor approach in L5-S1 subarachnoid block. The success rate of 3D CT-assisted Taylor approach was 90.9%. The needle insertion point was identified with the results of measurement from the pelvis 3D-CT, $5.9\pm0.6\text{cm}$ on a line $65.5\pm5.8^\circ$ off the intercristal line. The target of L5-S1 space intended to be displayed on the skin was $2.7\pm0.6\text{cm}$ away from the needle insertion point. Moreover, the number of spinal deformities was not related to the success rate.

**Conclusions:** A 3D pelvis CT-assisted Taylor approach of spinal anesthesia can be an alternative method of subarachnoid block in L5-S1 space with the acceptable success rate.
Keywords: Anesthesiologists; CT; Femoral neck fractures; Hip arthroplasty; Men; Pelvis; Spinal anesthesia; Women.
Introduction

Performing spinal anesthesia in elderly patients is challenging in some cases. Spinal deformities due to aging, postoperative surgical scars, and metallic instrumentation during spinal surgery are major obstacles to the success of spinal anesthesia. Gupta et al. concluded Taylor’s approach could provide a reliable and less traumatic alternative to midline approach for lumbar puncture in deformed spine [5]. The Taylor’s approach of spinal anesthesia, which is performed in the L5–S1 interlaminar interspace, can solve this problem.

In the Taylor approach, a spinal needle is inserted in the cephalomedial direction through a skin wheal raised 1 cm medial and 1 cm caudal to the lowermost prominence of the posterior superior iliac spine (PSIS) [1]. However, it is challenging for a beginner to identify patient’s surface anatomy for localizing the needle insertion point which needs to be reached to the L5–S1 space (target). The needle insertion point is supposed to be situated near the “skin dimples,” which corresponds to the lowermost prominence of the PSIS. However, not all elderly patients have remarkable skin dimples on their lower back. In addition, it is difficult to estimate the location of the target (L5–S1) space. The “cephalomedial direction” is all the information a novice anesthesiologist needs rely on to imagine its position. Three-dimensional imaging study could give us the lengths and angles to be applied in a patient’s surface anatomy. The lengths and angles were displayed on the patient’s skin with the sterile marking pen. These processes prompted us to focus on the three-dimensional (3D) pelvis computed tomography (CT).

Anesthesiologists utilizes the measurements from the radiologic studies to decide the needle insertion depth and direction for the spinal anesthesia. When we had planned a Taylor approach for the spinal anesthesia, the pelvis 3D CT had benefited us in identification of the needle insertion point and direction towards the target space. Three dimensional bony structures allowed us to identify the anatomical landmarks easily.
We assumed that the success rate of Taylor approach would be acceptable when the anesthesiologist uses the 3D CT to find out the needle insertion point. We compared our success rate to other studies to prove this hypothesis. Zhang et al. reported the success rate of an elevated lateral recumbent position (ELP) and the regular lateral recumbent position (LRP) with the paramedian approach to the subarachnoid space [6]. Successful dural puncture within 2 attempts of the ELP and the LRP had the success rate of 97.8% and 82.8% respectively [6]. Gupta et al. reported failure rate of 15% with the conventional Taylor’s approach [5]. Our primary outcome was the success rate of 3D CT-assisted Taylor approach, and the secondary outcomes are the mean value of the angles and lengths leading to the needle insertion point. Additionally, we analyzed whether patient factors such as body mass index (BMI), scoliosis, kyphosis, and spinal instrumentation would have a negative impact on the success of this technique.
Materials and Methods

This is a retrospective observational study in a single center. After obtaining approval from the Institutional Review Board (19RESI0047) of our institution, medical records of 280 patients had been assessed the eligibility for this study who underwent hip arthroplasty in existence of 3D pelvis CT from March 2018 to May 2019. All the procedures were conducted in accordance with the Helsinki Declaration-2013.

Four cases were excluded from the review (Fig. 1). Their conditions were not suitable for the subarachnoid block. Exclusion criteria were (1) INR over 1.5, (2) warfarin treated within 5 days, (3) platelet number of below 100,000 microliters of blood, (4) patient refusal, (5) noncooperation due to confused mental status. Only one anesthesiologist had tried 3D pelvis CT assisted-Taylor approach for the spinal anesthesia. Success of the 3D CT assisted-Taylor approach was approved with the requirements of two conditions, (1) free flow of cerebrospinal fluid following maximum of 5 trials of dural puncture, (2) no complaints about pain relating to the surgical incision. Number of trials is defined as skin puncture numbers. Angles and lengths for the identification of needle insertion point was measured from the 3D pelvis CT and Imaginary target distance from needle insertion point was estimated from the 3D pelvis CT. Data on BMI were collected, and spinal deformities such as compression fracture, kyphosis, scoliosis, metallic instrumentation, and vertebroplasty were analyzed using a simple L-spine radiograph interpreted by the radiologists.

Clinical practice of 3D pelvis CT- assisted Taylor approach in the operating room.

Informed consent was obtained from patients who are expected to schedule a hip arthroplasty. The 3D pelvis CT of the patients scheduled for surgery was prescribe by the surgeon regardless of anesthetic procedure. We had determined the needle insertion point and the target (L5-S1) space for the Taylor approach (Fig. 1) using the posterior view of the 3D pelvis CT. The needle insertion
point was determined by the following procedure.

Among the posterior views of the 3D pelvis CT, we selected the image where the symphysis pubis met the midline. ① The needle insertion point for the Taylor approach (A) was 1 cm medial and 1 cm caudal to the posterior superior iliac spine (PSIS). ② The target (T) is the point where the midline meets the L5–S1 interlaminar space. ③ The intercristal line connects the two iliac crests. ④ The midline was perpendicular to the intercristal line. In the case of spinal scoliosis, the midline drawn on the sacrum was elongated to the lumbar area. ⑤ “B” is the point where the intercristal line meets with the midline. ⑥ “X” is the length between B and A. ⑦ “Y°” is the angle between the intercristal line and B-A line. ⑧ “X cm” and “Y°” form a pair of length and angle representing the location of “A” and ⑨ “t cm” is the length from B to the target (L5–S1) on the midline.

The procedure was performed with the patient in the sitting position on the bed after intravenous administration of midazolam 0.5–2 mg and fentanyl 50–100 µg. All procedures were performed with aseptic method. The intercristal line and midline were drawn. From intersection B, we drew a line that was Y° down the intercristal line using a protractor. We marked "A" for the point of needle insertion, X cm from B. Finally, the target (L5–S1 space: t cm from B) was located (Fig. 2). A 3.5-inch spinal needle is inserted toward "T" through "A". If a bone encountered on first needle insertion, the needle is walked off the sacrum into the target (T; L5-S1 space). After confirming the free flow of cerebrospinal fluid, 20 mg of heavy bupivacaine was administered. After being transferred from the bed to the operating table, the patient was placed in the Trendelenburg position for a few minutes. The level of the block was confirmed by the pinprick test. Once the level of the block reached the T10 dermatome, the patient was switched to the lateral position for surgery. The patient was sedated with propofol infusion at a rate of 150–200 mg/h with an initial bolus of 30 mg. Capnography was used to monitor the patient’s breathing.
One anesthesiologist performed all the procedures in this study.

**Statistical analysis**

The sample size was based on the available data during the study period. Means for continuous variables were compared using the unpaired Student’s $t$-test. The chi-squared test was used to compare categorical valuables; $p < 0.05$ was considered statistically significant. All statistical analyses were performed using SPSS version 15 (SPSS Inc., USA).
Results

We reviewed medical records of 280 patients who underwent hip arthroplasty in existence of 3D pelvis CT from March 2018 to May 2019. Medical records of four patients were excluded from the study because they were applicable to the contraindications of subarachnoid block (Fig. 1).

Primary outcome

The success rate of 3D-CT assisted Taylor’s approach was 90.9%, and the number of trials between the success group and the failure group was 2.4±1.6 and 5.6±1.1 (p<0.01), respectively (Table 1).

Secondary outcome

The needle insertion point A was on a line approximately 65.5±5.8° from the intercristal line (success group: 65.5±4.9°, failure group: 66.6±4.9°) (p=0.96) and 5.9±0.6cm from point B (success group: 5.9±0.7cm, failure group: 5.9±0.4cm) (p=0.81). The target (L5–S1 space) was 2.7±0.6cm (success group: 2.7±0.5cm, failure group: 3.1±0.6cm) (p=0.03) from point B (Table 2).

BMI and spinal deformities such as compression fracture, kyphosis, scoliosis, metallic instrumentation, and vertebroplasty

The BMI was 22.4±3.7 kg/m² and 23.5±3.7 kg/m² (p=0.17) between success group and failure group, respectively. There were compression fractures in 59% of women (men: 32%), kyphosis in 8% (men: 7%), scoliosis in 20% (men: 11%), metal instrumentation in 13% (men: 7%), and
vertebroplasty in 32% (men: 14%). The number of spinal deformities was 1.3 (failure: 1.1) and 0.7 (failure: 0.8) among women and men, respectively, in the success group with no statistically significant difference between the number of spinal deformities and the success rate.
Discussion

According to this study, spinal anesthesia using the 3D pelvis-assisted Taylor approach was successful in 90.9% of hip arthroplasty patients.

Spinal anesthesia is advocated for isolated orthopedic injuries such as femoral neck fracture, as it is known that there is a lower mortality rate, shorter hospital stay, and lower incidence of delirium in the postoperative period for elderly patients [2]. The anatomical arrangement of spinal column is often deformed in elderly patients than young patients. Thereafter, spinal anesthesia in elderly patients is likely to be more time-consuming and has lower success rates than in young patients. Therefore, anesthesiologists have attempted the Taylor approach. The L5–S1 space is not only wider than the other intervertebral spaces [3], but also known as the most suitable space for the spinal block when other interspaces are not easy to approach due to spinal deformities [5].

In our center, the 3D pelvis CT is always prescribed by orthopedic surgeons for their surgical procedure [4]. 3D pelvis CT image provides us more stereoscopic vision than simple X-ray or 2D-CT. Anatomical landmark is more distinctive in 3D pelvis CT than other imaging studies.

The success rate of the 3D pelvis CT-assisted Taylor approach was 90.9% in our study. This figure is comparable with that of other studies. Zhang et al. reported the success rate of an elevated lateral recumbent position (ELP) and the regular lateral recumbent position (LRP) with the paramedian approach to the subarachnoid space [6]. Successful dural puncture within 2 attempts of the ELP and the LRP had the success rate of 97.8% and 82.8% respectively [6]. Gupta et al. reported failure rate of 15% with the conventional Taylor’s approach [5]. There were no significant statistical differences between the number of spinal deformities and the success rate. Contrary to the anesthesiologist’s expectations, the number of spinal deformities had no negative contribution to the success of the 3D pelvis CT assisted-Taylor approach. This could be explained by the fact that the L5–S1 space is the widest despite pathological spinal diseases.
This study has three questions left unsolved. First, the comparison between the 3D pelvis CT-assisted approach and a usual Taylor approach has not been reached enough. Prospective control study is needed to prove that the 3D pelvis CT assisted-Taylor approach is superior to any other approaches. Second, the pelvic CT is done in a supine posture whereas the 3D pelvis CT-assisted Taylor approach is operated in a sitting posture. The difference between those two postures is supposed to have significance of results, the related analysis is further required. Lastly, the entire medical records for the analysis revealed only one anesthesiologist had done the 3D pelvis CT-assisted Taylor approach. The primary outcomes could depend on the anesthesiologist’s skillful proficiency. The fact that the success group had no statistically significant difference between the number of spinal deformities and the success rate empowers this possibility. Further studies are needed to reflect this factor in extracting the primary outcome.

In our conclusion, 3D-pelvis CT-assisted Taylor approach can be an alternative approach useful for locating the spinal needle insertion point and the target (L5-S1) space in hip arthroplasty with the acceptable success rate.
References


Table 1. Demographic data and primary outcome

<table>
<thead>
<tr>
<th></th>
<th>Success Group</th>
<th>Failure Group</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject (n=276)</td>
<td>251 (90.9%)</td>
<td>25 (9.1%)</td>
<td></td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>45/206</td>
<td>7/18</td>
<td>0.22</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>79.2 ± 9.1</td>
<td>79.6 ± 6.2</td>
<td>0.82</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>154.6 ± 9.2</td>
<td>154.1 ± 6.7</td>
<td>0.78</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>53.6 ± 10.0</td>
<td>55.8 ± 9.7</td>
<td>0.29</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.4 ± 3.7</td>
<td>23.5 ± 3.7</td>
<td>0.17</td>
</tr>
<tr>
<td>Number of trials</td>
<td>2.4 ± 1.6</td>
<td>5.6 ± 1.1</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Values are presented as mean ± SD and number.
Table 2. Secondary outcomes used in locating needle insertion points

<table>
<thead>
<tr>
<th></th>
<th>Angle and distance for A*</th>
<th>From B to the target (L5–S1)†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Y° (degree)‡</td>
<td>X (cm) §</td>
</tr>
<tr>
<td>Success (n = 251)</td>
<td>65.5 ± 6.4</td>
<td>5.9 ± 0.7</td>
</tr>
<tr>
<td>Failure (n = 25)</td>
<td>65.6 ± 4.9</td>
<td>5.9 ± 0.4</td>
</tr>
<tr>
<td>Mean</td>
<td>65.5 ± 5.8</td>
<td>5.9 ± 0.6</td>
</tr>
<tr>
<td>p-value</td>
<td></td>
<td>0.96</td>
</tr>
</tbody>
</table>

Values are presented as mean ± SD.

* The needle insertion point for the Taylor approach (A) was 1cm medial and 1cm caudal to the posterior superior iliac spine (PSIS).

† B is the point where intercristal line meets with the midline.

‡ Y is the angle between the intercristal line and B-A line.

§ X is the length between B and A.

II “t cm” is the length from B to the target (L5-S1) on the midline.
Patients who underwent hip arthroplasty with 3D-Pelvic CT

n=280

Excluded criteria

1.5<INR (n=1), Warfarin treated within 5days (n=2), Dementia (n=1)

276 cases

Fig. 1.
Fig. 2.
Fig. 3.