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Original Research

Clinical and Radiographic Outcomes after Direct Anterior Approach Total Hip Arthroplasty Using Two Specialized Surgical Tables

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ABSTRACT

Background: Specialized tables for direct anterior (DA) approach total hip arthroplasty (THA) have required an unscrubbed assistant for manipulation of the operative limb. A novel surgical table attachment designed for the DA approach is fully surgeon controlled and partially automated. The purpose of this study is to compare the clinical outcomes in patients who underwent THA through a DA approach with an assistant-controlled vs the surgeon-controlled (SC) table.

Methods: This is a retrospective study of 343 patients who underwent primary THA between January 2017 and October 2017. Two cohorts were established based on the surgical table used. Surgical and clinical data included the surgical time, length of stay, presence of pain (groin, hip, or thigh pain) at latest follow-up, and revision for any reason. Immediate postoperative radiographs were compared with latest follow-up radiographs to assess for leg length discrepancy, stem alignment, and stem subsidence.

Results: One hundred sixty-seven (48.7%) cases were performed using the assistant-controlled table, and 176 (51.3%) cases were performed using the SC table. The surgical time was significantly greater for surgeries using the SC table (70.2 minutes vs 66.1 minutes, $P < .001$). Neither group experienced any intraoperative fractures or postoperative dislocations. There were no significant differences in any other clinical or radiographic outcomes.

Conclusions: Although the surgical time with the self-controlled table was longer by approximately 4 minutes, this discrepancy disappeared with progression through the learning curve. In our experience, the SC table allows for greater autonomy for the operating surgeon and eliminates the need for a full-time employee in the operating room workflow.

Introduction

The direct anterior (DA) approach for total hip arthroplasty (THA) has gained popularity among hip arthroplasty surgeons in the United States over the last decade, with its proponents citing earlier functional recovery and less muscle damage as its main advantages [1-3]. Detractors of the DA approach have cited poor femoral exposure, malalignment of the stem component, and periprosthetic fractures as reasons to avoid this procedure [4]. Femoral exposure is indeed considered the most challenging aspect of this approach, with malalignment and undersizing of the femoral stem being the most common technical exposure–related complication, which predisposes to stem subsidence and periprosthetic fractures [1,4].

To address the difficulties in femoral exposure, the use of a dedicated surgical table allowing for extension of the operative limb and rigid positioning of the femur has been advocated [5-13]. Although the DA approach can also be performed on a standard operating room (OR) table, the setup requires bilateral draping of the lower extremities, an extra scrubbed assistant to position both extremities throughout the procedure, and sometimes the use of a table-mounted femoral elevator, making it a less-attractive option in the eyes of some surgeons [2,8,14]. The dedicated surgical table allows for the range of motion of the operative extremity in all planes including extension and therefore facilitates femoral

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exposure. Although a scrubbed assistant is not required, an unscrubbed assistant is still necessary to manipulate the table. Alternatively, a surgeon-controlled (SC) table allows the operating surgeon to independently adjust the leg position manually via foot pedal without the need for an assistant, reducing the surgical team to a minimum of the operating surgeon and a surgical assistant [8,9]. The use of such a table, however, adds to an already well-described learning curve for the DA approach [15,16].

The purpose of this study is to compare the clinical outcomes after THA through a DA approach between patients who underwent surgery on either an assistant-controlled (AC) or an SC table. We hypothesize that clinical (eg, intraoperative complications, postoperative pain, readmissions, revisions) and radiographic outcomes (eg, stem alignment, subsidence, limb length discrepancy) will be similar between both tables.

Material and methods

This is a retrospective study of all consecutive patients who underwent primary THA by the senior author (R.D.) at one institution utilizing a DA approach with either an AC or an SC table between January 2017 and October 2017. Patients were divided into 2 cohorts for comparison: (1) the AC table cohort and (2) the SC table cohort. On any given surgical day, 2 ORs were used to allow the surgeon to perform cases in 2 rooms sequentially and bypass turnover time. Each OR contained either the AC table or the SC table, and patients were randomly assigned to either room without the knowledge of which table would be available in each room. The release pattern was identical for both surgical tables being evaluated in this study. Implant choice was made on a case-by-case basis and not in relation to the table used. The records and existing data are deidentified and are part of our institutional quality improvement program; therefore, the present study was exempted from human-subjects review by our institutional review board.

Surgical technique

For all surgeries in this series, a standardized intraoperative anesthesia protocol was used that included short-acting nonopiate spinal anesthetic, intravenous fentanyl, propofol, midazolam, dexamethasone, and acetaminophen. Once anesthesia induction was complete, the patient was placed supine on the AC table (Hana®, Mizuho OSI, Union City, CA) and brought distally about a radiolucent perineal post. Both feet were placed in well-padded traction boots attached to leg spars. After the patient was prepped and draped, an incision of approximately 8 cm was carried out over the anterior aspect of the hip, and blunt muscular dissection was carried out until the hip joint was reached. The femoral neck cut was marked fluoroscopically and then undertaken under direct visualization, and the femoral head was removed from the acetabulum using a corkscrew device. After acetabular preparation, the cup was impacted into position under fluoroscopic imaging to account for appropriate version, inclination, and seating of the cup. For additional release of the medial aspect of the femoral neck capsule, the femur may be externally rotated; for the superolateral femoral neck capsule, the femur can be placed into extension and adduction. The femur is then externally rotated, extended, and adducted. A cobra retractor is placed over the tip of the greater trochanter, which provides for good exposure. An electronic femoral elevator is available for use with the AC table, but its use had been previously abandoned by the senior author. The proximal femur is then sequentially broached up to the templated size, a trial reduction is performed, and fluoroscopic imaging is used to indicate appropriate positioning of all trial implants and restoration of leg length and offset. Final implants are placed, and final fluoroscopic imaging is obtained.

The SC table uses a standard OR table in combination with a partially automated, surgeon-operated table attachment (RotexTable®, Condor MedTec, Salzkotten, Germany). The operative leg is padded and fastened into a carbon fiber traction boot, which is then fastened into the SC table attachment. The surgeon controls rotation of the extremity through the drapes via a ratcheted lever with 3 settings. The neutral setting allows for free rotation of the extremity and is used for the majority of the case. Turning the lever anteriorly locks the leg into an internally rotated position, and turning the lever posteriorly locks the leg into an externally rotated position. A foot pedal activates an automated mechanism that controls hip flexion and extension. Gross traction is also locked through the drapes via a switch mechanism; extension of the hip is disabled under gross traction to prevent neurovascular injury. After femoral neck cuts, the extremity is held in slight flexion at the hip and at the knee and in slight external rotation ("Figure-of-4" position) for femoral head removal. Acetabular preparation is performed in the usual fashion under fluoroscopy. The lever is then ratcheted posteriorly, locking the leg in external rotation for femoral preparation. The pedal is used to bring the hip into the desired degree of extension, and adduction is achieved via manual control. After femoral preparation, the hip is brought out of extension, the ratchet mechanism is placed in neutral, and gentle traction and internal rotation is used to reduce the hip. The extremity is placed in extension and external rotation to assess anterior stability and is brought back to neutral to assess posterior stability.

Data collection

Descriptive patient characteristics and surgical data collected using our electronic data warehouse included the gender, age, body mass index, race, American Society of Anesthesiologists score, smoking status, surgical time, and length of stay. Surgical and clinical data were extracted via a manual chart review, including presence of postoperative pain (categorized as groin, hip, or thigh pain) that was evaluated at latest follow-up and revision for any reason.

Immediate postoperative plain anterior-posterior radiographic images of the hip were compared with radiographic images at latest follow-up to assess for stem alignment (neutral, varus, valgus) and for quantitative evidence of stem subsidence. Radiographic analysis was performed by 2 trained observers (J.G. and J.P.), both of whom agreed on the methodology that would be used throughout the measurement process. To ensure consistency, they together performed alignment and subsidence measurements for the first 10 patients in the study cohort. The degree of varus or valgus angulation was defined as the angle formed between the central shaft of the stem and the medial or lateral endosteal cortices, respectively. As previously described in literature, a stem was categorized into varus or valgus alignment if the angle deviated $\geq 5^\circ$ from neutral [8,17,18].

For subsidence measurements, radiographic calibration of each radiograph was performed using the known implanted femoral head size. A 90° angle was formed between the long axis of the femoral stem and the most superior aspect of the femoral stem shoulder. A line parallel to the horizontal arm of the perpendicular angle was drawn and brought to the level of the superior tip of the greater trochanter. The distance between these 2 parallel lines was recorded. Stem subsidence was calculated as the difference between the immediate postoperative radiographs and the latest follow-up radiograph. A cutoff of 3 mm was used to denote subsidence.

Statistical analysis

The means and standard deviations were used to describe all continuous variables, and frequency distributions were used to describe categorical variables. Fisher's exact test and 2-sample *t*-tests were used to test for significance. Finally, a regression analysis was performed to control for factors, including the surgical table used, affecting subsidence at latest radiographic follow-up. β Coefficients are interpreted as the change in subsidence in millimeters relative to the reference group for that category. A *P*-value threshold of less than .05 was considered statistically significant. All statistical analyses were performed by a statistician using STATA, version 15.1, (StataCorp, 2017, College Station, TX).

Results

Patient demographics

A total of 343 patients underwent primary THA during the study period and were included in the present study. Of these, 133 (38.8%) patients were male and 210 (61.2%) were female. The mean age and body mass index of the study sample were 65.2 ± 10.8 years and 27.4 ± 4.8 kg/m^2, respectively. The majority of patients (244, 71.1%) had an American Society of Anesthesiologists score of 2, were former or never smokers (324, 94.5%), and were of Caucasian descent (318, 92.7%). Full demographic information for each study cohort is summarized in Table 1. No significant differences were found between both cohorts with respect to any baseline patient characteristics.

Surgical and clinical outcomes

One hundred sixty-seven (48.7%) cases were performed using the AC surgical table, and 176 (51.3%) cases were performed using the SC table. Overall, the surgical time was significantly greater for surgeries in which the SC table was used (70.2 minutes vs 66.1 minutes; $P < .001$). A statistically significant difference was also found between the first third and the last third of cases performed on the SC table (73.6 minutes vs 68.0 minutes, respectively). The average surgical time in the last third of cases performed on the SC table was found to be statistically equal to the average surgical time of AC table cases ($P = .349$). Patients were implanted with either of 2 single-wedge prosthesis designs by different manufacturers (Accolade II®, Stryker Corporation, Kalamazoo, MI; Anthology®, Smith & Nephew, London, UK). There were no differences in the distribution of stem designs between both cohorts ($P = .510$). The length of stay between both cohorts was similar as well (AC table, 0.88 ± 0.86 days vs SC table, 0.76 ± 0.70 days; $P = .141$).

No patients in either cohort experienced an intraoperative fracture. Postoperatively, among those who underwent THA on an AC table, there were a total of 30 (18.0%) patients who experienced significant postoperative pain, broadly categorized into groin (5, 3.0%), hip (20, 12.0%), and thigh (5, 3.0%) pain. In the SC cohort, there was a total of 30 (17.0%) patients who experienced postoperative pain: 3 (1.6%) instances of groin pain, 14 (8.0%) of hip pain, and 13 (7.4%) of thigh pain. These distributions were similar between both cohorts. No patients in either cohort experienced a postoperative dislocation. One (0.6%) patient in the AC cohort experienced a displaced periprosthetic femoral shaft fracture and underwent open reduction internal fixation and revision of the femoral component to a modular revision stem. One (0.6%) patient in the SC cohort sustained a nondisplaced periprosthetic femoral shaft fracture that was osteoporosis related; the fracture healed uneventfully without operative intervention and did not result in any lasting thigh pain. There were a total of 4 (2.4%) revisions in the AC group—2 for periprosthetic joint infections requiring irrigation and debridement with head and liner exchange, one for the previously mentioned periprosthetic fracture, and one due to aseptic loosening of the femoral component. There was one (0.6%) patient with periprosthetic joint infection who underwent irrigation and debridement with head and liner exchange in the SC group. Full surgical and clinical outcome data are summarized in Table 2.

Table 1
Patient demographics (n = 343).

	AC table (n = 167)	SC table (n = 176)	*P*-value
Gender			.825
Male	66 (39.5%)	67 (38.1%)	
Female	101 (60.5%)	109 (61.9%)	
Age (y)			.487
<55	17 (10.2%)	28 (15.9%)	
55-64	46 (27.5%)	45 (25.6%)	
64-74	69 (41.3%)	69 (39.2%)	
75+	35 (21.0%)	34 (19.3%)	
BMI			.367
Normal (18.5-24.9)	47 (28.7%)	60 (35.7%)	
Overweight (25-29.9)	74 (45.1%)	71 (42.3%)	
Obese (>30)	43 (26.2%)	37 (22.0%)	
ASA score			.304
1	10 (6.0%)	6 (3.4%)	
2	113 (67.7%)	131 (74.4%)	
3 or 4	44 (26.4%)	39 (22.2%)	
Race			.535
White	153 (91.6%)	165 (93.8%)	
Nonwhite	14 (8.4%)	11 (6.3%)	
Smoking status			.413
Current smoker	7 (4.2%)	12 (6.8%)	
Former smoker	65 (38.9%)	74 (42.1%)	
Never smoked	95 (56.9%)	90 (51.1%)	

ASA, American Society of Anesthesiologists; BMI, body mass index.

Radiographic outcomes

Average subsidence for the AC table group was 1.28 ± 1.56 mm at an average radiographic follow-up of 37.8 ± 22.9 weeks. For the SC group, average subsidence at a radiographic follow-up of 37.9 ± 22.28 weeks was 1.40 ± 2.17 mm. Overall, 24 of 167 (13.8%) stems in the AC group and 18 of 176 (10.2%) in the SC group demonstrated radiographic subsidence >3 mm at latest imaging follow-up. There was no difference in subsidence between groups ($P = .323$). There were 12 (7.2%) stems found to be in varus and 1 (0.6%) in valgus in the AC group; in the SC group, there were 13 (7.4%) stems in varus and 1 (0.6%) in valgus ($P = .999$). Three patients in the AC group were found to have a leg length discrepancy ≥3 mm, compared with 1 (0.6%) patient in the SC group ($P = .287$). Full radiographic outcome data are summarized in Table 3.

Table 2
Surgical and clinical outcomes (n = 343).

	AC table (n = 167)	SC table (n = 176)	*P* Value
Surgical time (min)	66.1 (9.7)	70.2 (10.0)	<.001
Stem type			.510
S&N Anthology	72 (43.1)	69 (39.4)	
Stryker Accolade	95 (56.9)	106 (60.6)	
Length of stay (d)	0.88 (0.86)	0.76 (0.70)	.141
Postoperative pain	30 (18.0%)		.162
Groin	5 (3.0%)	3 (1.6%)	
Hip	20 (12.0%)	14 (8.0%)	
Thigh	5 (3.0%)	13 (7.4%)	
None	137 (82.0%)	146 (83.0%)	
Periprosthetic fracture	0 (0.0%)	1 (0.6%)	.999
Revisions	4 (1.2%)	1 (0.6%)	.362

Table 3
Radiographic outcomes (n = 343).

	AC table (n = 167)	SC table (n = 176)	*P* Value
Average total subsidence (mm)	1.28 ± 1.56	1.40 ± 2.17	.280
Subsidence ≥3 mm	24 (13.8%)	18 (10.2%)	.323
Stem alignment			.999
Neutral	154 (92.2%)	162 (92.1%)	
Varus	12 (7.2%)	13 (7.4%)	
Valgus	1 (0.6%)	1 (0.6%)	
Limb length discrepancy ≥3 mm	3 (1.8%)	1 (0.6%)	.287

Discussion

Proponents of the DA approach have advocated for the use of a dedicated surgical table similar to that used in lower extremity fracture care, which allows for extension of the lower extremity at the hip to facilitate femoral exposure. These tables have traditionally required a trained assistant (often a physician extender or a nurse) to manipulate the limb intraoperatively. The purpose of this study was to explore outcomes after THA through a DA approach performed on a newly available fully SC table attachment specialized for DA THA. Our analysis compared a random sample of patients undergoing DA THA on an AC table, which was previously our standard of care, with the new SC table. Neither group experienced any intraoperative complications or postoperative dislocations. Stem subsidence was statistically equal between groups, as were the number of stems that subsided more than 3 mm or fell into varus or valgus. The surgical time was statistically greater for surgeries that used the self-controlled table by approximately 4 minutes. We did find, however, that this difference no longer became statistically significant by the last third of the cases (first third, 73.6 minutes vs last third, 68.0 minutes) in the series because of progression through the learning curve of the SC table. Despite the learning curve, the senior surgeon felt that the pelvis was positioned in the same location on both tables without requiring any changes to the fluoroscopic workflow as compared with the AC table.

Various authors have published their outcomes after surgeries in which a traditional AC fracture table was used [6,11,19]. In a study by Siguier et al. [19], 926 patients underwent THA through the DA approach on a Judet orthopaedic table. They found a dislocation rate of 1.0% (10/1037 hips), with 3 patients requiring revision surgery for recurrent dislocation. One patient experienced a non-displaced distal external malleolar fracture in the setting of severe osteoporosis after manipulations on the orthopaedic table. Matta et al. [6], in their study on 437 patients, similarly found a very low overall dislocation rate of 0.6% (3/494 hips), with no patients requiring revision surgery for recurrent dislocation. There were 9 (1.8%) instances of intraoperative fractures (3 greater trochanter fractures, 2 femoral shaft fractures, and 4 calcar fractures) that occurred during canal preparation, as well as 3 (0.6%) ankle fractures that the investigators speculated were due to the external rotational force used for the dislocation maneuver. Sariali et al [11]. observed 27 (1.5%) dislocations in 1764 patients who underwent THA, as well as 29 (1.6%) intraoperative complications: 21 femoral neck fractures, 7 femoral false reaming routes, and 1 greater trochanter fracture. Jewett and Collis [10] reported a higher rate of trochanteric fractures (2.3%) than in other series, although the authors speculated that this was due to the use of a specialized bone hook used to aid femoral elevation and placed tension on the posterior superior hip capsule, which is attached to the lateral greater trochanter. Importantly, in all of the previously mentioned studies, the intraoperative fractures occurred early during the study period, after which they were no longer seen. All authors agreed that the use of a specialized table improved femoral access, with some adding that it decreased the necessity for secondary incisions and reduced potential muscle trauma from forceful retraction. Ankle fractures, although possible, are very rare occurrences, occurred in patients at high risk for osteoporotic fracture and were easily avoided by placing less torque on the foot and ankle during the dislocation maneuver.

Published reports following the use of an SC table for the anterior approach are few and, to the best of our knowledge, have been exclusively from groups in Europe. De Geest et al. [8] examined outcomes after 300 consecutive THA procedures performed in 284 patients through a DA approach with the aid of an SC table attachment similar to the one used in this study. There were only 2 (0.7%) cases of dislocation. There were 9 (3.0%) intraoperative complications (2 femoral perforations, 4 calcar fractures, and 3 greater trochanter avulsion fractures) that occurred during manipulation or preparation of the femur, none of which required operative fixation. They also reported 5 (1.7%) early periprosthetic fractures that they suspected were occult intraoperative fractures. The authors felt that these may have been related to implant design, which was subsequently abandoned. Gebel et al. [9] reported on 100 primary THA patients who were also operated on using the SC table attachment. One (1.0%) patient suffered recurrent dislocation requiring revision, and there were no intraoperative complications. The average hip disability and osteoarthritis outcome score at 3 months postoperatively was 90, significantly greater than the baseline score by 43 points. Approximately 99% of patients had a leg length discrepancy in a range of ±5 mm. Therefore, an analysis of prior literature demonstrates low intraoperative and postoperative complication rates for the DA approach using either an AC or SC fracture table.

The results of our study suggest that an arthroplasty surgeon who regularly performs the DA approach may enjoy the benefits of an SC fracture table without compromising clinical outcomes. Advocates of the flat table have anecdotally cited the complete control of the operative extremity as one reason for avoiding the use of a specialized table. The SC table investigated in the present study allows the surgeon full control and manipulation of the extremity with the added advantage of rigid extremity fixation during femoral preparation, as well as eliminating the need for an additional full-time assistant in the OR. Posterior stability was checked by disengaging the boot of the operative extremity and maximal hip flexion and internal and external rotations to impingement positions. The boot was reattached by the surgeon, and anterior stability was assessed with greater than 45 degrees of hip extension and external rotation. Moreover, as the surgeon becomes more familiar with the technology and is able to establish a consistent workflow between cases, surgical efficiency may improve. The need for communicating instructions to an assistant, which can result in delays if the table operator mishears or has not worked with the surgeon before, can be eliminated. This was evidenced by the last third of SC table cases seeing an improvement in the surgical time of over 5 minutes when compared with the first third of cases and being statistically equal to the surgical time of AC table cases. The SC table attachment used in this study also provides considerable convenience as it is portable, attaches to most surgical tables, and can be collapsed in such a way that permits easy storage and maneuverability between ORs. It must be taken into consideration that implementing new technology in any surgical procedure is associated with a learning curve. The DA approach is already associated with a learning of anywhere from 40 to 200 cases, after which the surgical time and rates of intraoperative complications such as femoral fractures and perforations decrease [6,9,20,21]. The authors accordingly recommend that surgeons interested in using the SC table attachment already be well versed in performing the DA approach with an AC fracture table.

There are limitations to this study that should be considered. The retrospective nature of this study represents an area where bias may have been introduced. All of the cases included in this study were performed by a single surgeon who exclusively uses the DA approach for THA at a high-volume orthopaedic specialty hospital. Therefore, the results may not be generalizable to surgeons who perform this procedure at a lower volume and are not as familiar with its technical nuances. In addition, radiographic follow-up time was limited. Despite this, previous literature has demonstrated that long-term fixation and diminished risk of progressive subsidence occurs during the first 3-6 postoperative months [20,21]. This time period is well covered by the present study. In addition, we lack long-term data to determine if femoral- or acetabular-sided failures are higher in one group than in the other.

Conclusions

Surgeons who routinely perform a DA approach for THA can expect similar clinical outcomes using a SC table compared with an AC table. No short-term outcome differences were observed between the 2 cohorts. Although the surgical time with the SC table was longer by approximately 4 minutes, this difference is not clinically significant and disappears beyond the learning curve. The SC table allows for greater hands-on feedback during the procedure and a significantly smaller institutional financial investment due to the reduced manpower required. Based on these results, we have abandoned the use of the AC table in favor of the SC table described.

Conflict of interest

R.I. Davidovitch receives royalties from Radlink and Schaerer Medical, is a paid consultant for Exactech, Inc, Medtronic, Radlink, and Schaerer Medical, and holds stock in Radlink; R. Schwarzkopf receives royalties from Smith & Nephew, is a paid consultant for Smith & Nephew and Intellijoint, holds stock in Intellijoint and Gauss Surgical, is the principal investigator of and receives research support from Smith & Nephew and Intellijoint, receives financial or material support from Smith & Nephew, is a member of the editorial/governing board of *JOA and Arthroplasty Today*, and is a board member of the AAOS AAHKS; all other authors declare no potential conflicts of interest.

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