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**Name of Journal:** *World Journal of Orthopedics*

**Manuscript NO:** 79981

**Manuscript Type:** ORIGINAL ARTICLE

*Retrospective Study*

**Taper-wedge stem suitable for anterior approach total hip arthroplasty: Adequate biomechanical reconstruction parameters and excellent clinical outcome at mid-term follow-up**

Trevisan C *et al.* Anterior approach total hip arthroplasty

Carlo Trevisan, Antonino Salvatore Lombardo, Gianluca Gallinari, Marco Zeppieri, Raymond Klumpp

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**Abstract**

**BACKGROUND**

The direct anterior approach (DAA) for total hip arthroplasty (THA) is a less invasive and muscle-sparing approach that seems to improve early function and patient satisfaction. Several studies, however, have reported high complication and revision rates due to the technical difficulties related to the femoral preparation.

**AIM**

To evaluate the usefulness and safety of a new stem equipped with a morphometric design and a size-specific medial curvature in DAA for THA.

**METHODS**

This retrospective study was based on 130 patients that underwent mini-invasive DAA procedures for THA using the Accolade II stem. A total of 144 procedures were included

in the assessment, which was based on postoperative complications, survival rates, functional parameters, and patient related outcomes.

## RESULTS

Overall complications were recorded in 6 procedures (4.2%). There were no complications related to the stem implantation and no intraoperative fractures. Only one patient was revised for deep infection. On radiographs, biomechanical hip reconstruction was satisfactory and no stem showed any subsidence greater than 2 mm. Full osseointegration based on Engh scores was seen in all of the implanted stems. Median Harris hip score at final follow-up was 99 points (range 44-100 points), which resulted excellent in 91.3% of patients. The median values of the osteoarthritis outcome score ranged from 87.5 to 95.

## CONCLUSION

The mid-term positive outcomes and low complication rate in our consecutive series of patients support the safety and suitability of this new stem design in DAA for THA.

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**Key Words:** Total hip arthroplasty; Orthopedics; Direct anterior approach; Orthopedic surgery; Stem implantation; Accolade II stem

Trevisan C, Lombardo AS, Gallinari G, Zeppieri M, Klumpp R. Taper-wedge stem suitable for anterior approach total hip arthroplasty: Adequate biomechanical reconstruction parameters and excellent clinical outcome at mid-term follow-up. *World J Orthop* 2022; In press

**Core Tip:** The direct anterior approach can provide a less invasive and muscle-sparing technique for total hip arthroplasty. New stems used in the direct anterior approach have been designed to reduce complication rates, and enhance postoperative morphologic and

functional outcomes. The Accolade II stem is equipped with a morphometric design and a size-specific medial curvature, which can be advantageous for this type of surgery.

## INTRODUCTION

13 Total hip arthroplasty (THA) is one of the surgical procedures with the highest levels of safety, efficacy, and clinical satisfaction<sup>[1]</sup>. In the last decade, there have been numerous improvements in techniques and technologies, which have given rise to better clinical outcomes and less need for early surgical THA revisions<sup>[2,3]</sup>. New technology, methods and implants, however, need to be carefully tested and assessed in long term studies on large cohorts to determine the clinical usefulness and safety before widespread use.

15 The direct anterior approach (DAA) for THA has been a debatable issue in current literature. Several studies supporting this surgical technique have reported that this less invasive and muscle-sparing approach can improve early functional and patient-reported outcomes. Others studies, however, have reported the limitations of using this approach, which include high complication and revision rates, usually dependent on long and difficult surgeon learning curves<sup>[4,5]</sup>. The technical difficulties in the DAA have been reported to be linked with the implantation of undersized stems<sup>[6]</sup> and early femoral failure<sup>[7]</sup>.

5 The design of the femoral stem used in surgery can be an additional contributing factor in postoperative early aseptic loosening. 5 Lindgren *et al*<sup>[8]</sup> found that stems with an "anatomic" design 5 were more likely to loosen when implanted through an anterolateral approach. 4 Janssen *et al*<sup>[9]</sup> reported that cementless femoral stems with a proximal shoulder tend to be associated with early aseptic loosening when inserted through an anterior or anterolateral approach, while an anatomically shaped stem may be preferred with these approaches. 4

The choice of a suitable stem to be used in an anterior approach should preferably consider a reduction in possible complications rates related to the difficulties of femoral exposure. A new second-generation cementless stem (Accolade II) with its short length and smooth tapered tip could be considered a good candidate when using the DAA for THA. This new stem was created to better adapt to the anatomy of the femoral canal thanks to a more anthropomorphic dimension ratio between its proximal and distal portions and to the variation, size to size, of the radius of curvature of its medial side<sup>[10]</sup>.

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The aim of our study was to evaluate the feasibility, utility and safety of this second-generation cementless stem (Accolade II) for the DAA. The assessment in our study was based on data regarding complications, survival of the implanted prostheses, biomechanical hip reconstructions, radiographic evolutions, functional results, and patient-related outcomes.

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## **MATERIALS AND METHODS**

### ***Study design***

This retrospective observational study analyzed consecutive patients that underwent THA with DAA using the Accolade II stem (Stryker Orthopedics) in the Department of Traumatology and Orthopedics at a public Italian hospital located in Seriate, Bergamo between November 2013 and March 2019. The analysis was based on data obtained from outpatient reports, medical records, and radiographs. The investigation was performed in accordance with the tenets of the Declaration of Helsinki and informed consent was obtained from all participants before surgery. The study was in compliance with Institutional Review Boards and the Health Insurance Portability and Accountability Act requirements of the hospital. The study was approved by the Ethics Committee of Bergamo (n. 144/19, August 5, 2019).

Hip-fractured patients and patients with a final follow-up of less than 12 mo were excluded. All the surgical procedures were performed *via* a mini-invasive DAA without a traction table. A preoperative radiological 2D plan, using TraumaCad® software, and intraoperative fluoroscopy evaluation of trials for stem positioning were performed for each patient. The stems were used in combination with an uncemented Trident HA-coated cup (Stryker orthopedics). In all cases, a highly cross-linked polyethylene on Biolox Delta femoral head bearing was used.

One hundred forty-eight subjects (161 hips) were treated in the time interval considered. Seventeen patients were lost to follow-up. At the last outpatient follow-up visit, these patients were stable from a clinical and radiographic point of view. Four patients died for reasons unrelated to their hip surgery. Thirteen patients, contacted by

phone, refused to come to the follow-up visit for logistical or work reasons. They all reported that no other surgical revisions were performed on the operated hip.

### **Data collection**

<sup>10</sup> Body mass index (BMI), American Society of Anesthesiologists (ASA) Score, Charlson Comorbidity Index (CCI)<sup>[11]</sup>, and Charnley classification were calculated for each patient<sup>[12]</sup>. The postoperative outcome assessments included data based on complications, implant survival, and clinical and radiological outcomes. Complications and adverse events were coded according to the Hip Society THA Complications workgroup<sup>[13]</sup>. Clinical outcomes were obtained at the last follow-up visit. Functional results were evaluated by the Harris Hip Score (HHS)<sup>[14]</sup>. Patient-related outcomes were assessed by the Hip disability and Osteoarthritis Outcome Score Italian version LK 2.0 (HOOS)<sup>[15]</sup>.

<sup>6</sup> Standardized pre- and post-operative anteroposterior radiographs of the pelvis and the lateral view of the operated hip were used for the radiological assessment. Occurrence of radiolucent lines, osteolytic changes, or cortical hypertrophy were recorded using Gruen's zones for the stem and the DeLee Charnley zones for the cup<sup>[16,17]</sup>. Stem subsidence was calculated using the method reported by Grant *et al*<sup>[18]</sup>. Femoral component fixation and stability were assessed by the Engh score<sup>[19]</sup>. Adequate radiographs to measure the biomechanical parameters for hip reconstruction as described by Asayama *et al*<sup>[20]</sup> and Schmidutz *et al*<sup>[21]</sup> were available in 104 hips. Acetabular cup positioning was evaluated by referring to the safe zones defined by Lewinnek *et al*<sup>[22]</sup>.

### **Statistical analysis**

<sup>7</sup> Data regarding quantitative variables included mean, standard deviation, range and/or median, and qualitative variables as a percentage. The student *t*-test for independent samples was used to compare continuous variables in normally distributed data amongst groups. <sup>21</sup> The Wilcoxon rank-sum test was used for data not normally distributed. The



<sup>1</sup> implant survival probabilities were computed using Kaplan–Meier analysis (revision of any component for any reason as the terminating event or at the end of the follow-up period). The statistical analysis <sup>1</sup> was performed using the STATA11 software package (Statistic Data Analysis, StataCorp, College Station, TX). *P* values lower than 0.05 were considered significant.

## RESULTS

<sup>19</sup> One hundred and thirty patients were included in the study. Surgery was carried out bilaterally in 14 cases for a total of 144 hips that underwent DAA for THA. One hundred and twenty cases were performed by a senior experienced surgeon; twenty-four cases by two other surgeons in their learning curve.

<sup>3</sup> The demographic and clinical data of the patients are shown in Table 1.

### *Complications*

Complications were recorded in 6 procedures (4.2%). Analytical data are reported <sup>3</sup> in Table 2.

No significant differences in terms of complications were observed between the senior surgeon and the training surgeons (5 complications out of 120 procedures *vs* 1 complication in 24 procedures-*n.s.* Fisher exact test).

No intra-operative complications and no dislocations were reported.

### *Survivorship*

At 69 mo, the cumulative survival of the stem and cup (that did not require surgical revisions) was 98.6% (95%CI: 90.7-99.8). Only one implant was revised due to deep infection (0.7%). No failures were observed for aseptic loosening.

### *Component positioning*



Stem alignment averaged  $-0.3^{\circ} \pm 1.9^{\circ}$ ; 97 out of 104 stems (93.3%) were within  $3^{\circ}$  of varus/valgus. The mean cup inclination was  $38^{\circ} \pm 5.7^{\circ}$  and the mean anteversion was  $15^{\circ} \pm 5.2^{\circ}$ . Eighty-eight out of 104 cups (84.6%) were within the Lewinnek safe zone.

No significant differences were seen between the senior surgeon and the training surgeons regarding stem alignment and cup position.

### *Hip center of rotation, femoral offset and abduction lever arm reconstruction and leg length*

When compared to the contralateral side, hip center of rotation (CoR) was postoperatively elevated by  $3.7 \text{ mm} \pm 4.3^{\circ}$  and medialized by  $3.4 \text{ mm} \pm 4.5^{\circ}$  on average. Femoral offset (FO), abduction lever arm (ALA), and leg length (LL) after surgery are shown in Figure 1. FO increased in 83 out of 104 cases (79.8%); when compared to the contralateral side, only 8 out of 104 cases (7.7%) showed a decrease of FO greater than 15%. Compared to the contralateral side, the leg length of the operated hip was longer by  $2 \text{ mm} \pm 6.1 \text{ mm}$  on average. In 56.7% of cases, leg length discrepancy was within  $\pm 5 \text{ mm}$ .

### *Radiographic outcomes*

No lines of radiolucency or lysis were observed around any of the implanted acetabular components. One stem showed an area of lysis in Gruen zone 1 and radiolucencies in zones 3, 4, and 5 at 24 mo. This patient was asymptomatic with an Engh score of 15.

No stem showed any subsidence greater than 2 mm. The Engh score provided results between 15 and 26 suggesting osseointegration of all implanted stems. Distal femoral cortical hypertrophy (DFCH) was observed around 32 femoral stems (22.2%) (Figure 2). Gruen zone 3 was the most affected (28 cases), followed by zones 2 and 5 (respectively 13 and 11 cases). None of the patients involved were symptomatic nor showed any functional impairment. HHS and HOOS total scores were not significantly different between those with DFCH and those without it (respectively  $95.8 \pm 9.6$  vs  $97.4 \pm 2.9$  and  $86.9 \pm 16.6$  vs  $89.5 \pm 9.9$ , Wilcoxon rank-sum test).

### *Functional outcomes and patient-related outcome*

The HHS median at final follow-up was 96.2 points (range 44-100 points). The score was excellent in 119 patients (91.5%), good in 5 (3.8%), fair in 3 (2.3%) and poor in 3 (2.3%).

The patients with poor HHS included 3 Charnley class C females with disabling chronic low back pain. HOOS results at final follow-up for all patients are presented in Figure 3. Median values range from 87.5 to 95.

Two multivariate analysis was performed to identify potential risk factors for a poor outcome using HHS and total HOOS at final follow-up as independent variable and age, gender, BMI, ASA, CCI and Engh Score as dependent variables. Regarding HHS, male gender was a significant positive factor whilst age, ASA and CCI were significantly inversely correlated with the score. Age and ASA were also significantly inversely correlated with final HOOS total score.

### **DISCUSSION**

The results of our study showed that the Accolade stem is suitable, safe, and efficient when used in the DAA for THA. The overall complication rate was low even for surgeons during the learning curve. None of the complications were related to the difficulties of exposure of the femur during the surgical procedure, intraoperative fractures or stem subsidence. Failures due to infection was very rare, with only one of the 144 cases that showed failure for periprosthetic infection at a mean follow-up of 35 mo.

Femoral exposure and preparation through the DAA is a complex part of the operation. Meneghini *et al*<sup>[7]</sup> found that the revisions due to early femoral failure were more common in patients who had undergone the DAA. In this regard, the design of the stem can play an important role during surgery, and data from the literature suggests that the shape of the stem can induce specific problems. Janssen *et al*<sup>[9]</sup> found that there was a stem-approach interaction, in which shoulder stems showed a greater likelihood of early aseptic loosening when the anterolateral or the anterior approach was used.

Studies have reported that longer stems or those with particular designs were associated with more perioperative complications, especially periprosthetic fractures.

Dietrich *et al*<sup>[23]</sup> found an odds ratio of 1.98 for intraoperative fractures when a Quadra-H stem was used compared to the Fitmore and AMiStem. Tamaki *et al*<sup>[24]</sup> and Greco *et al*<sup>[25]</sup> reported an increase in femur complication rate using the Taperloc Microplasty short stem with full profile taper concerning the standard length Taperloc. Rivera *et al*<sup>[6]</sup> reported that the Fitmore stem was associated with a higher probability of undersizing when implanted by DAA.

New stem designs may reveal new problems with other surgical approaches as well, as suggested by the data from Tootsi *et al*<sup>[26]</sup>, which reported a 5% incidence of intraoperative femoral fracture in 222 THA performed using the novel SP-CL® implant. With regards to the Accolade II, the morphometric design with a size-specific medial curvature and optimized length potentially renders this stem suitable for DAA. Our radiographic results on the reconstruction of the biomechanics of the operated hip also seem to promote the design of this stem. Stem positioning and the reconstruction of FA, ALA, and LL resulted comparable to those reported by Schmidutz *et al*<sup>[21]</sup>. This study compared a short-stem hip with a conventional stem implanted with a minimally invasive anterolateral Hardinge approach in the supine position. The achieved degree of precision of the joint reconstruction was such as not affecting patient-related outcomes<sup>[27]</sup>.

The performance of the Accolade II stem has also been described in other studies. Pierce *et al*<sup>[28]</sup> reported the results of 68 hips implanted at a high-volume institution using an anterolateral approach. No stem complications were shown, with an all-cause survivorship of 99.2% at a mean follow-up of 3.5 years. Kolisek *et al*<sup>[29]</sup> examined 202 Accolade II femoral stems implanted in 4 different hospitals with a 2-year follow-up. They reported two surgical complications related to stem implantation, which included a posterior trochanteric avulsion and a periprosthetic fracture. Aseptic and all-cause survival rates of 100% and 99.5% were reported. Berndt *et al*<sup>[30]</sup> reviewed 151 THA procedures with the Accolade II/Trident implant system using DAA. With regards to complications, this study reported one intraoperative stem perforation and one aseptic stem loosening at 45 mo with a total implant survival of 96.9% at 5 years.

Our study showed that all patients had favorable radiographic outcomes. The Engh scores suggested that all stems were well integrated and showed a low incidence of radiolucency lines (reported in 1 of the 115 hips). These results are indicative of a satisfactory fit and fill of the femoral canal and adequate adhesion of the circumferential porous coating to the surrounding bone<sup>[31]</sup>.

A better "fit and fill" of the Accolade II stems when compared to the previous models has been reported in a preclinical study by Faizan *et al*<sup>[32]</sup>, which showed a more uniform proximal-distal grip in a large sample of femoral sizes. Studies by Issa *et al*<sup>[10]</sup> reported a significant improvement in both proximal and distal fixation in the current version. Numerous evidences affirms that excellent "fit and fill" correlate with better clinical-functional results<sup>[33-35]</sup>. Our data confirm the excellent results in HHS and HOOS in addition to the absence of radiological subsidence in the stems.

We detected DFCH in 22% of our stems, but this did not appear to influence the implant survival and functional and subjective outcomes. Previous studies have shown that DFCH prevalence ranges from 6% to 56% in different cementless stem designs without determining any functional impairment<sup>[36,37]</sup>.

Our study has several limitations. The data is based on a retrospective study in which the lack of complication related to the stem may be due to the relatively limited number in the cohort. Similar types of study in literature, however, have reported incidence rates of perioperative fractures ranging from 1 to 7 cases<sup>[23,25]</sup>, which was not seen in our cohort. Moreover, our study was based on a rather short follow-up (3.5 years), thus does provide information regarding the long-term success rates of this stem.

## **CONCLUSION**

The design of the stem can have an effect on the risk of adverse events in DAA for THA. Studies are needed to confirm the safety and success rates when new models are proposed for implantable stems for THA are desirable. Our preliminary data shows that the Accolade II stem tends to provide a low complication rate and satisfactory biomechanical reconstruction. The mid-term positive outcomes concerning survivorship,

functional scores, and activity levels in our consecutive series of patients support the safety and suitability for DAA of this new stem design, which can be a long-term predictor of success. Further multicenter studies with longer follow-up are needed to confirm these preliminary positive results.

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## **ARTICLE HIGHLIGHTS**

### ***Research background***

The direct anterior approach for total hip arthroplasty is a less invasive and muscle-sparing approach that seems to improve early function and patient satisfaction.

### ***Research motivation***

To study the results of this surgery in a cohort of patients.

### ***Research objectives***

To report outcomes, advantages and indications for this surgery.

### ***Research methods***

Analysis of outcomes after surgery.

### ***Research results***

Result outcomes were good. Complication rates were relatively low.

### ***Research conclusions***

The mid-term positive outcomes and low complication rate in our consecutive series of patients support the safety and suitability of this new surgery.

### ***Research perspectives***

New models to enhance surgery can improve outcomes.

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7 Carlo Trevisan, Antonio Rocca, Gianluca Gallinari, Stefano Piscitello, Raymond Klumpp. "Targeting the safe zones for cup position without fluoroscopic guidance in total hip arthroplasty: does the surgical approach affect the outcomes?", European Journal of Orthopaedic Surgery & Traumatology, 2021

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8 [www.wjgnet.com](http://www.wjgnet.com)

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---

9 Joost AAM van den Hout, Koen LM Koenraadt, Robert Wagenmakers, Stefan BT Bolder. "The Accolade TMZF stem fulfils the demands of modern stem design: Minimum 5-year survival in a cohort of 937 patients", Journal of Orthopaedic Surgery, 2018

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---

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- 17 [docksci.com](http://docksci.com) 9 words — < 1%  
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- 
- 18 S. Giannini, M. Cadossi, M. Mosca, G. Tedesco, A. Sambri, S. Terrando, A. Mazzotti. "Minimally-invasive treatment of calcaneal fractures: A review of the literature and our experience", Injury, 2016 8 words — < 1%  
Crossref
- 
- 19 Sarah Graham, Mauricio Solano, James Sutherland-Smith, Amy F Sato, Louise Maranda. "DIAGNOSTIC SENSITIVITY OF BONE SCINTIGRAPHY FOR EQUINE STIFLE DISORDERS", Veterinary Radiology & Ultrasound, 2015 8 words — < 1%  
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- 
- 20 Tyler Paras, Benjamin Raines, Kevin Kohut, Soheil Sabzevari et al. "Clinical outcomes of reverse total shoulder arthroplasty for elective indications versus acute 3- and 4-part proximal humeral fractures: a systematic review and meta-analysis", Journal of Shoulder and Elbow Surgery, 2022 8 words — < 1%  
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