Oxford City Publishers

Case Reports in Orthopaedic Surgery Journal

Original Research | Vol 3 Iss 4

Description and Evaluation of an Intraoperative Image Guided Modification of Baumgartner's Technique to Optimise and Document the Tip-apex Distance During Dynamic Hip Screw Surgery

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Received: October 08, 2024; **Accepted:** October 27, 2024; **Published:** November 15, 2024

Abstract

Background: Dynamic Hip screw (DHS) is a common procedure undertaken following intertrochanteric fractures of the femur representing 67% of all surgically treated intertrochanteric fractures in 2023 in the United Kingdom. Tip Apex Distance (TAD) has been introduced by Baumgartner et al, in 1995 and has become the gold standard for DHS lag screw positioning in the femoral head to avoid cut-out and failure. Several techniques have been described for intraoperative TAD evaluation.

Methods and Aim: In this study, we introduce a useful modification to the originally described Baumgartner technique in order to optimise the TAD of the lag screw during the DHS surgery. We evaluate, describe, and provide intraoperative imaging and compare it with alternative techniques described in the literature.

Results: We describe a modified technique for the intraoperative measurement of the lag screw TAD by referencing to the standard threaded portion of the DHS guide wire which is 9 mm in length. After the guide wire central insertion close to the femur apex, the lag screw tip should cross the threaded part of the guide wire achieving a TAD less than 18 mm. To our knowledge, this is the first study to describe this technique with intraoperative imaging as well.

Conclusions: Authors recommend using this modification to the Baumgartner original guide wire technique to decrease the rate of DHS cut-out and failure. The technique is a simple and reliable intraoperative technique, not requiring a special digital system nor the presence of a non-scrubbed surgical assistant in theatre. It also avoids the possible inaccuracy when depending only on the surgeon's eye.

Keywords: Dynamic hip screw; Tip apex distance; Measurement; Technique

Background

Dynamic hip screw (DHS) is a commonly undertaken Orthopaedic procedure used to manage intertrochanteric fractures of femur. It represents 67% of all surgically treated intertrochanteric fractures in 2023 in the United Kingdom [1]. The mean failure rate of DHS is reported at 6.8% with the commonest reason being screw cut-out [2]. There are two main factors affecting the DHS failure rate. The first is Parker's ratio which depends on the lag screw position in the femoral head and neck [3]. The second is the Tip Apex Distance (TAD) which is the sum of the distance from the tip of the lag screw to the apex of the femoral head on anteroposterior (AP) and lateral radiographs after controlling for magnification. The TAD should be less than 25 mm in order not to have an increased risk of cut-out of the screw [4-9]. Several techniques have been described for the intraoperative TAD measurement [4,5,10,11]. These described techniques, however, depend either on a digital radiology system [4], the presence of non-scrubbed surgeons in theatre room, or to be gauged by surgeon's eye [5]. The original technique described in Baumgartner's study was to ensure the combined distance, on AP and lateral views, from the tip of the guide wire to the femoral head apex was less than 1.5 times the length of the threaded portion of the guide wire [4]. We describe a modification of this technique to ensure an optimum lag screw TAD achievement. The lag screw guide wire should be placed close to the femoral head apex on both views, without femoral head penetration. After the lag screw is inserted, it has to overlap the threaded portion of the guide wire as the threads standard length on the guide wire is 0.9 mm. Therefore, the tip apex distance of the definitive lag screw will be less than 18 mm in combined AP and lateral views.

Methods and Aim

In this study, we describe and provide an intraoperative imaging to evaluate this modification of Baumgartner's technique to adequately measure and document the TAD of the lag screw during the DHS surgery and determine if it can be used reliably, without requiring any specialised digital system nor solely dependent on surgeon's eye. We also review and compare it with alternative described techniques.

Technique

This technique was done during a standard dynamic hip screw operation for intertrochanteric fracture. The threaded portion of a standard AO (Arbeitsgemeinschaft für Osteosynthesefragen) DHS guide wire is 9 mm in length (Figure 1). The fracture is reduced using a traction table. Standard lateral hip approach was done. The guide wire is inserted using a predetermined angled guide, aiming to be central within the neck and femoral head in both AP and lateral views as recommended by Baumgartner. The guide wire tip should be placed close to, but importantly not perforating through, the femoral head apex. A second temporary anti-rotation guide wire can be utilised when required (Figure 2).

Following a routine triple ream and tap, the lag screw is inserted over the guide wire and once the screw tip has crossed the threaded part of the guide wire (Figure 3), as described above, the TAD to the guide wire tip will be less than 18 mm.

If the guide wire penetrated the head of femur or was removed, it can be adjusted or reinserted through the lag screw (Figure 4). If the lag screw was not centred over the femoral head apex, the guide wire can be placed centrally in the femur head before closure to check the TAD (Figure 5). Final images should be taken before removing the wire which allow adequate documentation in operative notes.

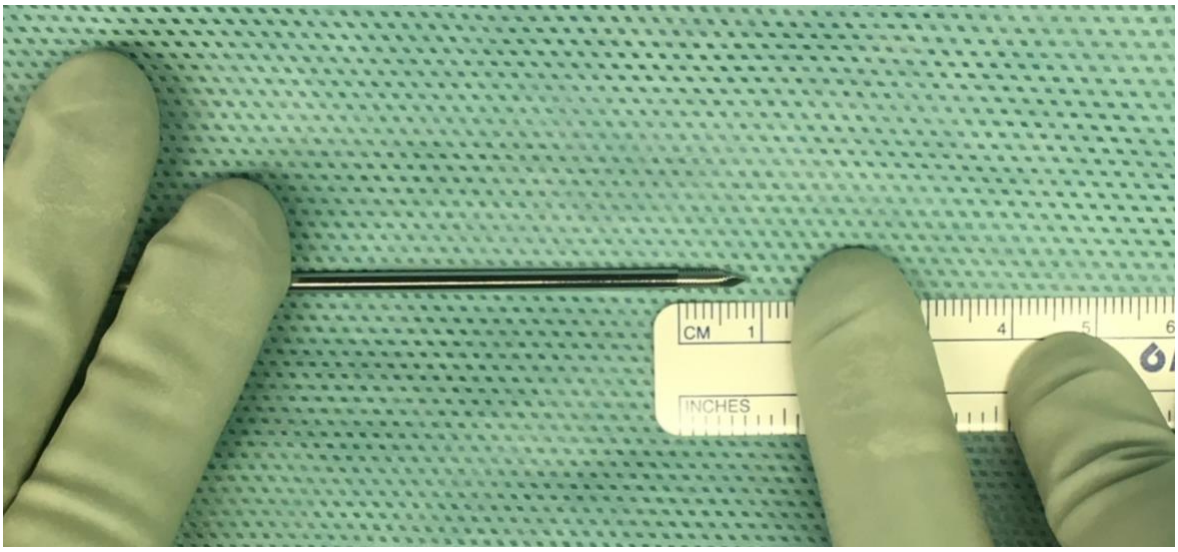

Figure 1: Measurement of the AO threaded guide wire before placement (9 mm).

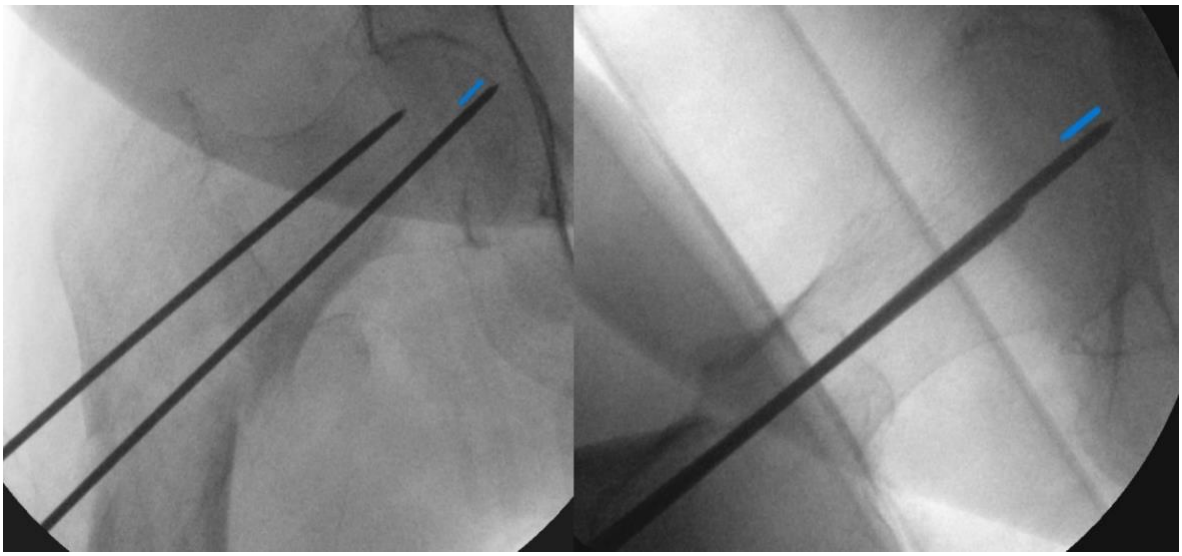

Figure 2: Guide wire should be inserted central in the neck and femoral head in both Anteroposterior (AP) and lateral views and engaged in the subchondral bone with a second anti-rotational wire.

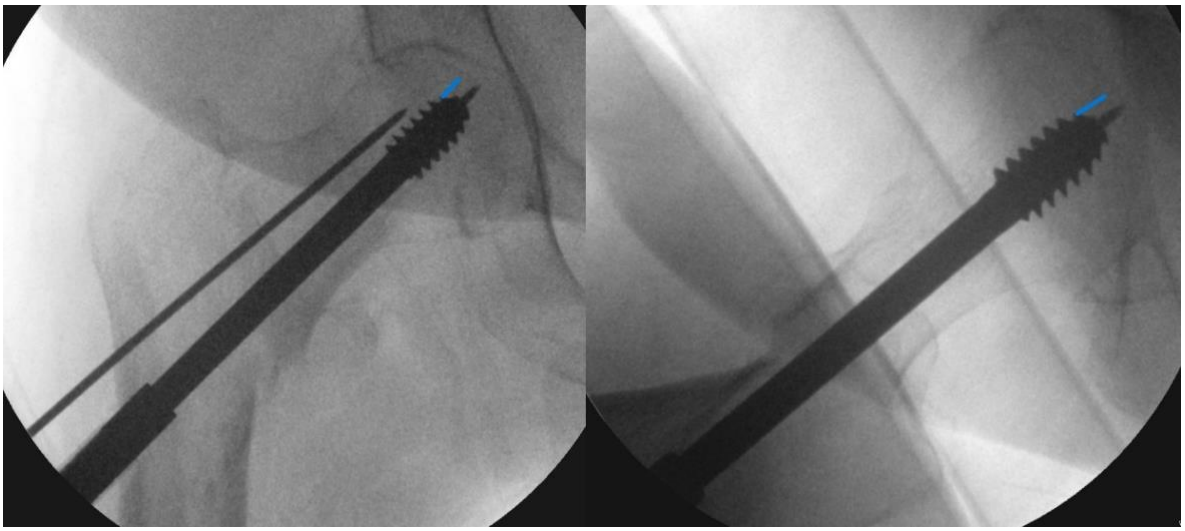

Figure 3: Lag screw is inserted over the guide wire with the tip crossing the threaded portion of the guide wire in AP and lateral views.

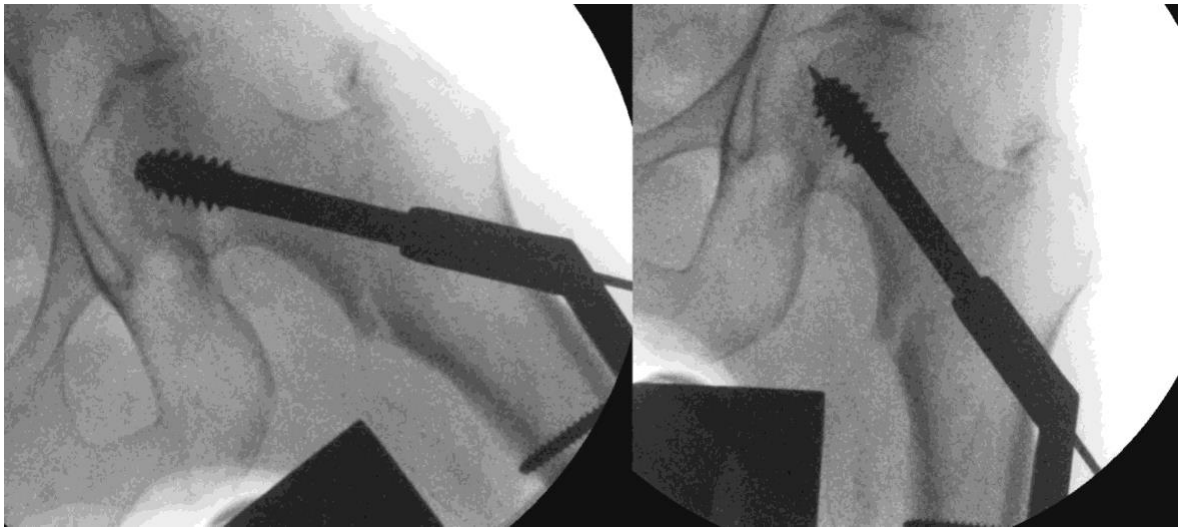

Figure 4: Insertion of the guide wire to check the TAD after the lag screw is applied.

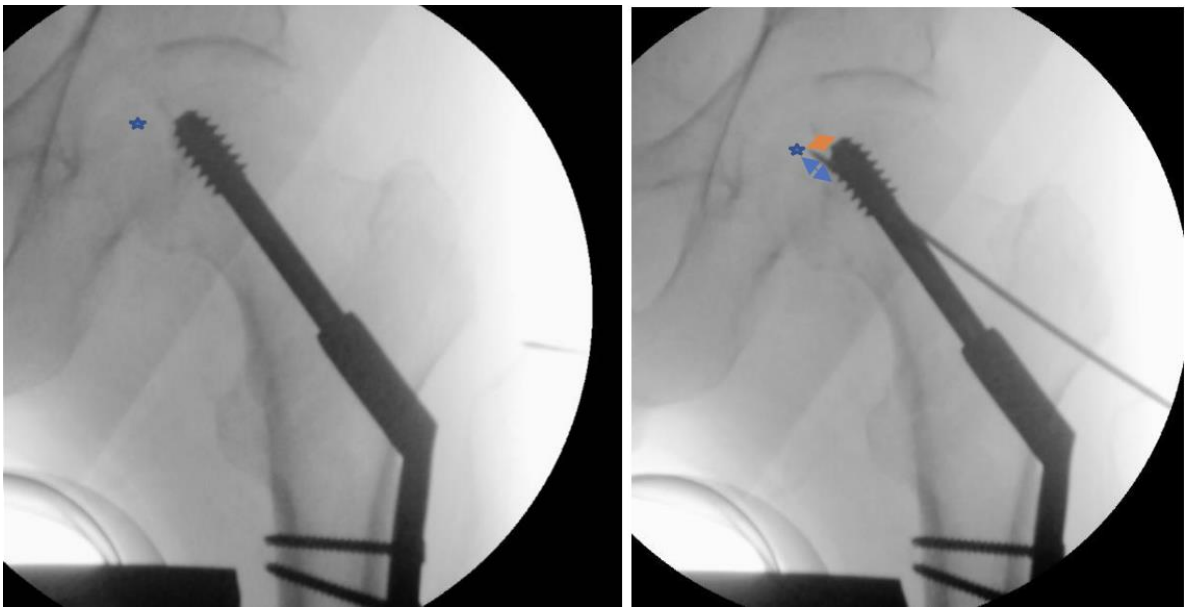

Figure 5: Using a guide wire to measure the TAD if the lag screw is not in the centre of the head. (Blue star: centre of the head, Blue arrow: the wire threaded portion, orange arrow: TAD, orange arrow is less than blue arrow confirming the TAD is less than 0.9 mm in the AP view).

Discussion

Dynamic hip screw procedure has gained worldwide popularity since the mid-1970s [4]. Until 1990, the failure rate was reported to reach 16.8% [11,12] but following the introduction of the lag screw TAD principle and its application, the failure was reported to be 6.8% [11].

In 1995, Baumgartner et al, described the first technique for intraoperative evaluation of TAD by direct measurement from printed hard-copy radiographs. He suggested using the threaded portion of the guide wire as an indication of scale. However, it wasn't presented with intraoperative radiograph imaging in the study but, it was a described technique [4].

In 1997, Baumgartner et al, compared 198 patients treated with DHS before TAD principle to 118 patients following introduction of it and found significant improvement of cut-out failure from 8% to 0% (p=0.0015). The study has described again the intraoperative technique of measuring the TAD using the guide wire but with no intraoperative imaging as the previous study. However, it was explained with an illustration figure (Figure 6) [5].

In 2008, Johnson et al., described the use of computer assisted digital system of image capture where the intraoperative images can be calibrated to measure the TAD (Figure 7) [10]. Although it is a useful technique, this system will only be applicable in hospitals where the image intensifiers can be calibrated. Most operating rooms do not have the technology to perform computerized measurement on X-rays taken during surgery [13].

In 2014, Wijeratna et al., described the use of the DHS lag screw width as a reference as it measures 12.5 MM, which is s equal to the maximum TAD in each imaging view (Figure 8) [11]. This technique however requires the presence of a non-scrubbed assistant in theatre to measure the TAD (Figure 9), or to be gauged by the surgeon's eye [11]. Furthermore, in 2015, Wright et al, selected 20 image pairs of DHS operations to demonstrate different level surgeon's eye ability to calculate TAD, and he found out that the accuracy of 'surgeon's eye' in measuring the TAD is declining with the level of experience, recorded at 82.5% for consultants, 83.8% for registrars and 71.1% for Senior house officers [14].

In this study, we have modified the original suggested Baumgartner technique as described in 1995 with a further detailed description, and this is the first study to our knowledge to describe this technique and provide intraoperative imaging with it.

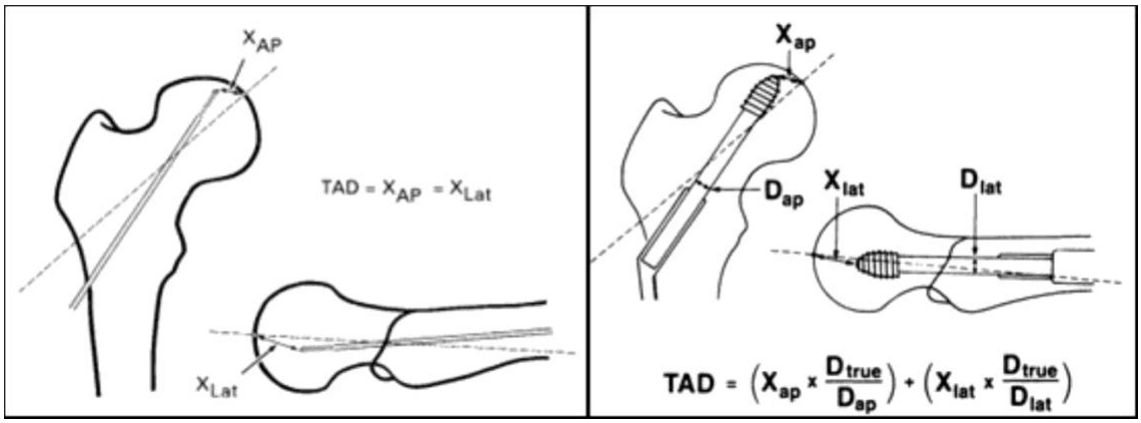

Figure 6: Baumgartner technique and formula where the distance is measured form the tip of the guide wire should be less than 1.5 times the threads [4,5].

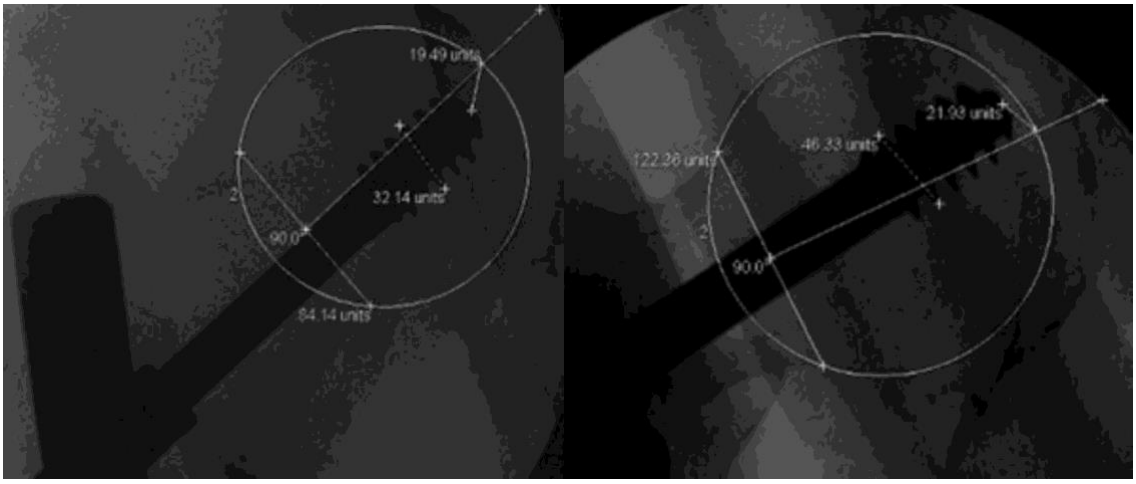

Figure 7: The use of computer assisted digital system where the intraoperative images can be calibrated to be able to measure the TAD [10].

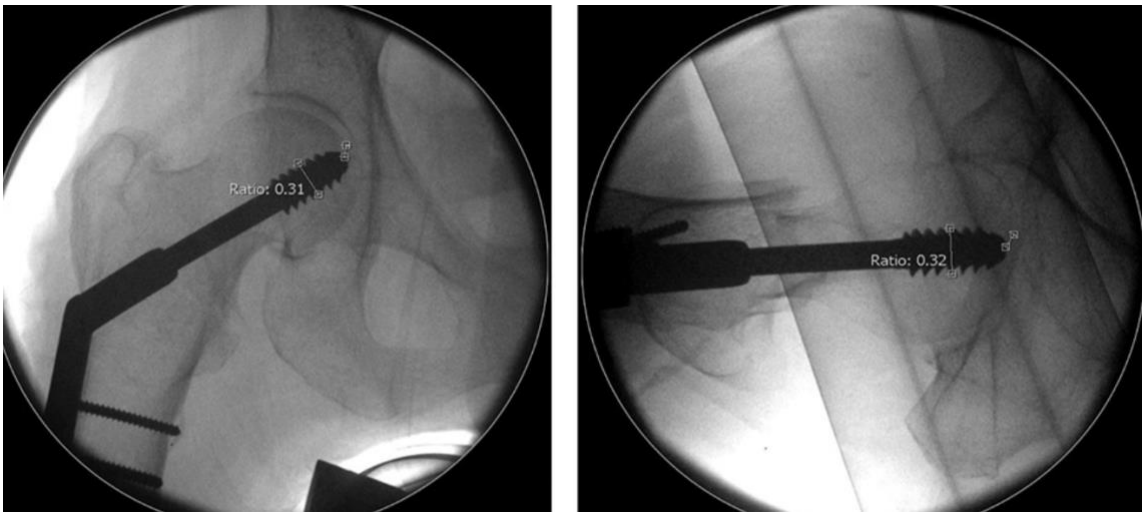

Figure 8: The use of the lag screw width diameter as a reference for the lag screw TAD [11].

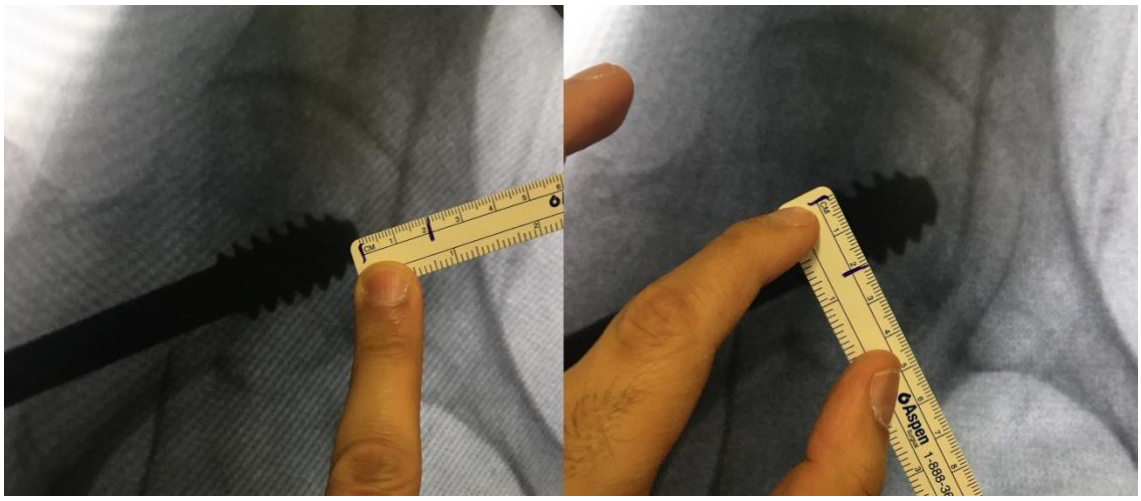

Figure 9: The application of the lag screw diameter technique requires the presence of a non-scrubbed surgeon.

Conclusion

Authors recommend using this modification to the Baumgartner original guide wire technique to decrease the rate of DHS cut-out and failure. The technique is a simple and reliable intraoperative technique, not requiring a special digital system nor the presence of a non-scrubbed surgical assistant in theatre. It also avoids the possible inaccuracy when depending only on the surgeon's eye.

Funding: No funds were received in support for this study.

Conflict of Interest: All authors declare that they had no conflict of interest.

Acknowledgments: We are grateful for Baumgartner efforts who first described the TAD which was a turning point in the principles of the DHS surgery.

Future Study: Retrospective data collection of the last 2 years of all the DHS procedures done in our hospital, and review the failure rate, then applying the technique described in this study with prospective data collection for the next two years to compare the failure rate.

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