

A review of tip apex distance in dynamic hip screw fixation of osteoporotic hip fractures

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ABSTRACT

Fractured neck of femur is a common problem seen in elderly osteoporotic females, mostly in Western countries, among which are the extra-capsular fractures such as intertrochanteric and pertrochanteric fractures also known as peritrochanteric fractures, and commonly treated with dynamic hip screw (DHS) or compression hip screw (CHS). The DHS is based on tension band principle and allows the screw to slide within the barrel to enable compression of the fracture when the patient begins to bear weight. This principle only works in the presence of intact medial wall and so cannot be successful in a reverse oblique fracture of the proximal femur. However, it is important that the technique of screw placement is precise and should ideally be central in the femoral neck, on both AP and lateral radiographs. This is why the concept of tip apex distance (TAD) is critical to the outcome of fixation and can accurately predict failure or survival of the screw. A systematic review of articles published in PubMed/Medline, from 1991 to 2011 (twenty years), was carried out to critically analyse common practice with regards to DHS fixation of extra-capsular femoral neck fractures, and review the recommendations of previous authors, with regard to the effect of TAD in DHS fixation. Search words used include TAD, DHS, sliding hip screw, femoral neck fractures, peritrochanteric fractures, tension band principle, fracture collapse, screw cut-out, DHS failure, and failure of fixation. At the end of the review, recommendations and suggestions regarding the ideal techniques of placement of DHS screw into the femoral neck will be made in line with current published literature, in order to establish an evidence base for best practice. A total of forty eight (48) published articles were found relevant to the review topic. Most papers suggested that Tip Apex Distance (TAD) is the most important predictive factor for DHS failure, followed by lag screw position, fracture pattern and reduction, patient's age and presence of osteoporosis. Therefore, we recommend proper training of surgeons, as well as attention to detail while performing DHS for intertrochanteric neck of femur fractures.

Key words: DHS failure, dynamic hip screw, femoral fractures, intertrochanteric fractures, screw cut-out, tip apex distance

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INTRODUCTION

Low energy hip (neck of femur) fractures are commonly seen in osteoporotic elderly ladies, mostly in Western countries. However, the incidence has been increasing in Nigeria and other developing countries due to increased life expectancy and use of diagnostic facilities such as CT, MRI and Radionuclide (DEXA) scans, which make diagnosis easier to achieve

Dynamic hip screw (DHS) is a procedure commonly performed for intertrochanteric Neck of femur (NOF) fractures, otherwise called extra-capsular fractures. This is a technique, which allows the screw to slide within the barrel, leading to compression of the fracture fragments when the patient bears weight. It also depends on the presence of intact medial wall in the region of the lesser trochanter, to be successful. DHS failure rate has been previously reported as 8%-13%,¹ but the rate has come down to 6.8%, according to a more recent study.² This usually happens when the head collapses in varus position. Other studies have previously recommended the essential role of adequate reduction of the fracture, as well as central placement of the wire on both AP and Lateral views of the radiograph.³

Baumgartner *et al*, initially came up with the concept of Tip Apex Distance in 1995,⁴ and later in 1997 confirmed the

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importance of good surgical technique in the treatment of trochanteric fractures using the TAD as a clinically useful way of describing the position of the screw.⁵ The tip apex distance (TAD) should be less than 25 mm to prevent DHS cut-out or failure, which most often happens if the screw is placed too anterior or too superior. The TAD is the sum of the distance from the tip of the screw to the apex of the femoral head on AP and lateral views⁴ [Figures 1 and 2].

A compromise may be accepted in slightly posterior and inferior positions, if difficulties are encountered, as these positions have less association with screw cut-outs, compared to superior and anterior placement of the screw, which are associated with a high cut-out rate⁶ [Figures 3 and 4].

Also, a second wire can be passed superior and parallel to the central one, in order to prevent the head of femur from spinning around and devitalizing it during screw insertion, which is more likely to happen in basicervical

fractures. Subsequently, an antirotation cannulated screw can be inserted through the superior wire and left in place to hold the head.

Other causes of failure are osteoporosis, and poor patient selection, as DHS is not ideal for unstable and reverse oblique fractures. Previous studies have shown that intertrochanteric hip fractures with associated posteromedial comminution and extension into the femoral neck should not be treated with a DHS, which is associated with a high failure rate.⁷ The technical ability of the operating surgeon may also determine the outcome, because sometimes the most junior surgeons are left to struggle alone during the reduction and operation. Baumgaertner *et al*,⁵ recommended use of 135° fixed angle side plate, rather than higher ones, which are likely to increase the valgus angle of the femoral neck, and suggested that the outcome of fixation can be influenced by education and good assessment methods [Figures 5–7].



Figure 1: AP radiograph of left intertrochanteric femoral fracture, fixed with a DHS

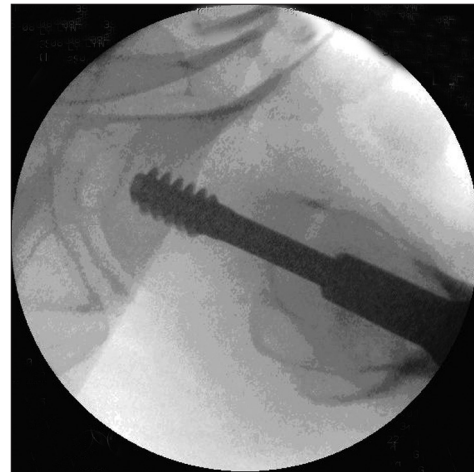


Figure 2: Lateral radiograph of the same patient fixed with a DHS



Figure 3: AP radiograph of left hip showing technique of wire placement into the femoral neck

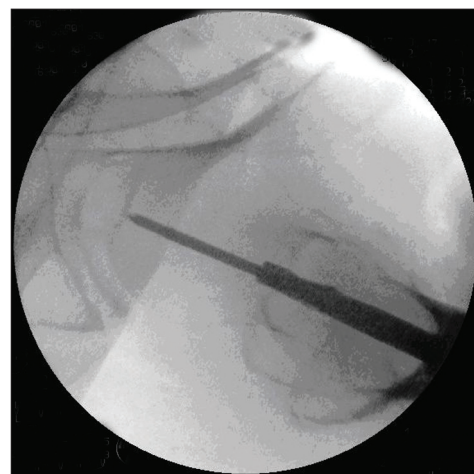


Figure 4: Lateral radiograph showing position of the wire in the antero-posterior plane

A PubMed/Medline search using the relevant search words between 1991 and 2011, revealed forty eight (48) published articles in relation to TAD and DHS failure or screw cut-out, and were considered to be relevant to the

review. Tables 1 and 2 shows a breakdown of the number of relevant articles by the year of publication.

Methods of quantifying lag screw placement

Tip apex distance is usually calculated from the AP and lateral hip radiographs, according to Baumgaertner’s

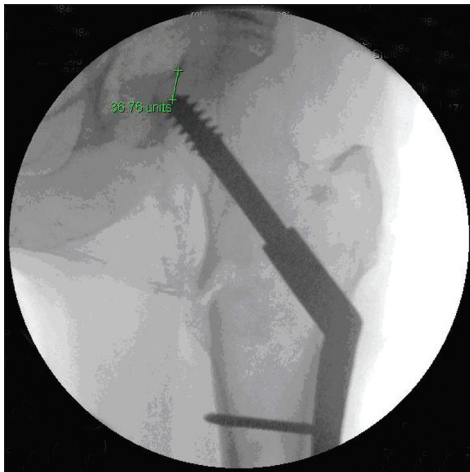


Figure 5: TAD on the AP radiograph of the hip

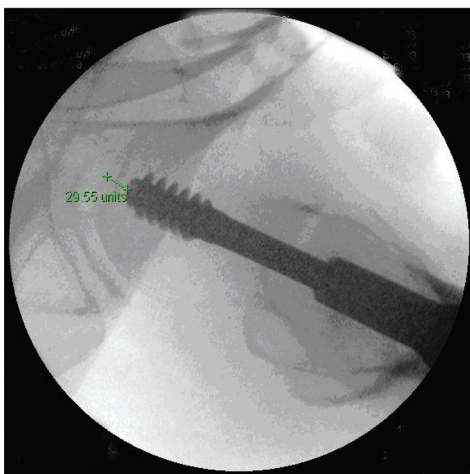


Figure 6: TAD on the lateral view of the hip

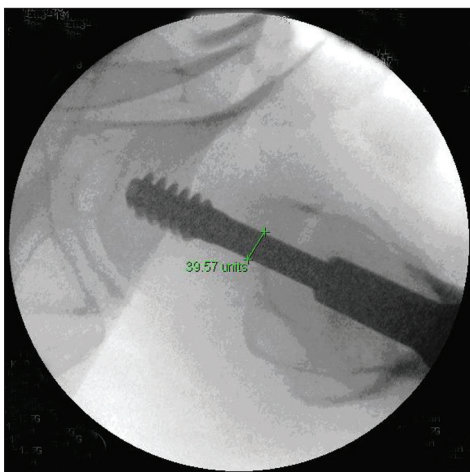


Figure 7: Demonstrating the diameter of the lag screw

Table 1: Number of relevant articles by the year of publication

Year of publication	Number of relevant articles
2011	5
2010	8
2009	10
2008	4
2007	1
2006	1
2005	7
2004	2
2003	1
2002	0
2001	1
2000	0
1999	1
1998	1
1997	2
1996	2
1995	1
1991	1
Total	48

Table 2: Breakdown of the number of relevant articles by the journal of publication

Journal	Number of relevant articles
Injury	9
International Orthopaedics	6
JBJS (Br)	4
JBJS(Am)	3
Orthopaedics	3
Journal of Orthopaedics and Trauma	2
Orthopaedic and Traumatology Surgery Research (OTSR)	2
Acta Orthopaedica Belgica	2
Z. Orthop Unfall	2
Journal Orthopaedic Surgery	1
Clinical Orthopaedic Surgery	1
Int. J Computer Assis Radiol Surgery	1
J. Orthopaedic Traumatology	1
Int. J. Medical Robot	1
Surgical Innovations	1
J. Orthopaedics Residents	1
Acta Orthop Trauma Surgery	1
Student Health Technol. Information	1
Clinical Biomechanics	1
Acta Chir Orthop Traumatol Cech	1
Medical Eng Physics	1
Medical Journal of Malaysia	1
Rofo (Germany)	1
Zhongguo Xiu Fu (china)	1
Total	48

formula,⁴ but the picture archiving and communication system (PACS) has recently been introduced as a useful tool for accurately measuring the TAD, which is easily reproducible, and makes audit easier in future.⁸ Other methods of quantifying the accuracy of lag screw placement in hip fracture fixation include the Parker's ratio method of lag screw placement.⁹

The importance of screw position in DHS fixation of femoral fractures cannot be over-emphasized. TAD greater than 25 mm is accepted as a strong predictor of screw cut-out in patients with intertrochanteric femoral fracture by dynamic hip screw.¹⁰ Peripheral placement of the screw in the femoral head has been found to increase the tip apex distance. However, posterior and inferior placements of screw give more support to the posteromedial cortex and calcar femoral in unstable fractures, and reduce the risk of screw cut-out.¹⁰ The cut-out rate is quoted to be 1%-6% of all DHS cases performed in some studies.¹¹

Effects of lag screw position

The effects of Lag-screw position on modes of DHS fixation failure in intertrochanteric fractures, has recently been investigated.¹² DHS fixation failure was attributable to lag-screw cut-out in the supero-lateral edge of the femoral head in 13 of 18 cases of failed DHS. It was therefore, concluded that the position of the lag screw has a definite effect on the type of fixation failure. However, Hsueh and colleagues² recently evaluated the risk factors of screw cut-out in 937 patients, and revealed a cut-out rate of 6.8% (64 patients). They found the Tip Apex Distance to be the most important predictive factor for cut-out, followed by screw position, fracture pattern, reduction and patient age. This has previously been described.¹³

This evidence was also supported by Guven and colleagues,¹⁰ in their paper on the importance of screw position in intertrochanteric femoral fractures treated with DHS, where they concluded that peripheral screw placement in the femoral head increases the TAD, with the attendant risk of subsequent failure. They however, suggested that posterior and inferior positioning of the screw may actually support the posteromedial cortex and calcar femorale in unstable fractures, therefore giving more stability to the fixation.¹⁰ Other workers have reviewed the effect of femoral neck-shaft angle (NSA) in extra-capsular fracture fixation with DHS, on the TAD and suggested that there was no effect of NSA on the TAD in DHS fixation.¹⁴

Computer-assisted techniques of lag screw placement

In order to improve the accuracy of guide-wire and screw placement, computer-assisted surgery using Surgix has been introduced as a new intra-operative guiding system, and this has been shown to greatly improve the accuracy of

wire and screw positioning, and reduces radiation exposure to the surgeons and scrub team.¹⁵

A similar technique described earlier was shown to be more precise than conventional technique, and requires fewer drill tracks in the femoral head and neck, and greatly minimizes the amount of radiation exposure to the surgical and scrub teams.¹⁶

A two dimensional fluoroscopy-based navigation system for insertion of DHS has also been described recently and was found to reduce the amount of radiation exposure, theatre time and fewer drill tracks.¹⁷ However, further studies and trials are required before these techniques become routine practice.

Effects of limb positioning during DHS insertion

Kumar and colleagues looked at the significance of hip rotation on measurement of TAD in a synthetic femur, taken in neutral and varying degrees of hip rotation and positions (adduction and abduction).¹⁸ They found statistically significant differences in the TADs on AP and Lateral radiographs, and suggested that to avoid putting the screw through the joint, the hip should be placed in internal rotation, otherwise if the screw is placed in external rotation or abduction, there may be a danger of putting it straight into the joint.¹⁸

Surgical education has been demonstrated to be an important factor in accurate DHS placement during hip fracture surgery. Introducing the concept of Tip Apex Distance to surgeons has been shown to improve the accuracy of Lag screw placement during fixation of an extracapsular fracture, and this has been shown to reduce the cut-out rate post-operatively,¹⁹ and was first advocated by Baumgaetner in 1997.⁵

Analysis of screw micro-migration

An Analysis of the micro-migration of the sliding hip screw (SHS), using point-based registration, was recently described.²⁰ This method assesses micro-migration of the screw using computerized tomogram (CT) scans acquired at different times postoperatively (0, and 3 months), and revealed that the micromigration assessment compared favourably with semi-automated image-based results. Hopefully, this technique will become routine in the future assessment of DHS fixation failure.²⁰

Previous studies have evaluated the migration resistance of DHS lag screw under simulated walking conditions, and revealed that the hip is loaded in a multiplanar dynamic manner during normal gait, and this greatly affects screw migration and subsequent collapse of the femoral head in varus.²¹

Minimally invasive techniques of DHS insertion

Minimally invasive techniques of DHS insertion have

recently been introduced, and found to be associated with shorter hospital stay, less blood loss, and quicker compared to the conventional technique, and offers the same stability of fixation.²² However, other workers did not find any significant differences between the two techniques, with regards to postoperative complications and screw positioning, but the minimally invasive technique may have better advantages intraoperatively compared to the conventional technique.²³

A double blind randomized controlled clinical trial of minimally invasive DHS fixation of intertrochanteric fractures was recently carried out. There were 66 patients in the study, 35 randomized to the minimally invasive group, 31 in the conventional DHS group.²⁴ The outcome measures were wound size, drop in haemoglobin, need for blood transfusion, pain score, need for analgesia, elderly mobility scale score, hip screw position, TAD, union rate, time to healing and overall complication rate.²⁴ Results revealed that the two groups had similar preoperative and clinical data. There were no significant differences in fracture position, screw position, TAD, union rate, healing time and overall complication rate. It was concluded that the minimally invasive technique is effective and safe and greatly reduces the amount of blood loss, pain, and rehabilitation period, without sacrificing adequate reduction, screw position, stability of fixation or healing time.²⁴ A similar study has recently been carried out and similar results were described.²²

New devices for fracture fixation

Newer devices have been introduced, in order to reduce the risk of fixation failure in femoral neck fractures. However, it has been shown that accurate placement of the Lag screw can be achieved for both DHS and cephalomedullary nail implants, and should therefore not be a selection criterion for the implant required for adequate fixation of pertrochanteric fractures.²⁵ However, there is a trend towards a more favourable TAD in women for both implants, compared to men.²⁵

A prospective randomized controlled study comparing screw versus blade in the treatment of low energy trochanteric fractures was recently carried out in three hundred and thirty five patients randomized into a screw group (DHS and Gamma nail), and a blade group (DHS blade and PFNA), and it was observed that both groups performed equally well with regards to implant positioning and functional outcomes.²⁶

Barton and colleagues carried out a randomized controlled trial of treatment of extra-capsular fractures (AO/OTA 31-A2) with either gamma nail or DHS. Their primary outcome measure was re-operation within the first postoperative year. They also looked at mortality, length of hospital stay, transfusion rate, change in mobility, and residence, as well as overall quality of life, and concluded that DHS should remain

the gold standard for treatment of this type of extra-capsular fracture, as it was found to have similar outcomes with the gamma nail, but significantly cheaper.²⁷

A radiological and clinical assessment of functional outcomes in patients treated for pertrochanteric fractures was also recently carried out to compare DHS, percutaneous compression plate (PCCP), and PFNA, and the results suggest that PCCP is superior to the others with regards to speed of operation, X-ray screening time, and subsequent failure.²⁸

Roerdink and colleagues undertook a biomechanical comparison of the dynamic locking blade plate (DLBP), with DHS and twin hook.²⁹ This study was done in a synthetic femur and revealed that DLBP has three times more rotational stability than a DHS and twice that of a twin hook. However, there was no major difference in the cut-out rates of the different implants studied.²⁹

In another study, involving analysis of human cadaveric femurs, it was revealed that migration occurred in all the dynamic hip screws (DHS) performed, compared to half in the DHS-blade cases.³⁰ The chance of implant survival was observed to be higher with the blade compared to the DHS, although the blade has a much higher construct deformation. This implies that the DHS-blade had a better implant anchorage than DHS, which might reduce the rate of screw cut-out.³⁰ A previous study suggested that the pull-out forces of the DHS blade were significantly lower than that of screw, with the former having greater rotational stability compared to the latter.³¹

Little and colleagues have previously compared the effects of Holland intramedullary nail with the DHS and concluded that although DHS can be inserted quickly with less exposure to radiation, the Holland nail is better overall, because it results in less blood loss and the need for transfusion, and allows patients to mobilize faster and return to their normal activities.³² Previous studies have shown that the intramedullary gamma locking nail is biomechanically better than DHS in the treatment of subtrochanteric or very osteoporotic fractures.³³

Additional devices with DHS

Cho and colleagues looked at the effect of additional fixations for dynamic hip screw (DHS) in treating unstable pertrochanteric fractures, and suggested that with use of devices such as antirotation screw, cerclage wiring of unstable bone fragments, and trochanter stabilizing plate (buttress plate), for the unstable pertrochanteric femoral fractures could be properly stabilized with a DHS, until bony union occurs, thus reassuring better outcome for the patient.³⁴ This is also supported by other workers.³⁵

A retrospective review comparing the long-term stability and functional outcomes of basicervical and intertrochanteric fractures was previously carried out

to evaluate the effect of additional derotation screw in basicervical fractures.³⁶ The results however revealed that although the basicervical fractures have greater biomechanical instability, use of a derotational screw with a DHS does not affect fracture stability or clinical outcome.³⁶

Complications of DHS

Many complications of DHS have been described in the literature, and can be intra-operative or postoperative.³⁷ The intraoperative ones include inadequate fracture reduction, breakage of K-wire, improper technique, and fracture of the distal fragment of the fracture. Postoperative complications include screw cut-out, avascular necrosis, progression of coxarthrosis, screw breakage, pseudoarthrosis, faulty placement of the side plate, hemorrhage and infection, among others.³⁷ Proper training and attention to detail while inserting DHS will help to reduce or avoid some of these complications.³⁸

Knobe and colleagues compared the outcomes of DHS and PCCP in pertrochanteric femoral fractures, and revealed that PCCP can be a good alternative to DHS in the treatment of osteoporotic pertrochanteric femoral fractures, due to its superiority in surgical time and outcome.³⁹ They also suggested that the reoperation and cut-out rates were much lower, compared to DHS in the treatment of unstable fractures.³⁹

Laohapoonrungsee *et al.* reviewed 83 intertrochanteric fractures fixed with DHS, and revealed that 68% of the patients had minimal collapse of the fracture, 24% moderate collapse, and 8% had severe collapse.⁴⁰ They also observed that 80% of the moderate and severe collapse categories were associated with osteoporosis and fracture instability, in addition to four failures, two due to lag screw cut-out, and two from side plate pull-out.⁴⁰

It has been previously demonstrated that use of a trochanter stabilizing (buttress) plate, can prevent or even treat early cut-out of DHS lag screw, and this has been shown to be quick, easy and safe solution, especially in unstable intertrochanteric fractures.⁴¹

A meta-analysis of implant-related complications in the treatment of unstable intertrochanteric fractures was carried out to compare dynamic screw-plate (DSP) versus dynamic screw-intramedullary nail devices (DSIN).⁴² Meta-analysis revealed no significant difference in the frequency of implant-related complications between the two groups. The same study also revealed that the rate of screw cut-out was much lower in the DSIN than DSP devices.⁴²

RECOMMENDATIONS AND CONCLUSION

At the time of writing this review article, injury has the highest number of relevant publications (9), followed by international orthopaedics (6), and JBJS (Br) (4), while JBJS (Am)

and orthopaedics have three relevant publications each. Also, during the 20-year review period (1991–2011), 2009 had the highest number of relevant publications (10), with a total of 48 articles related to the review topic during the whole period considered.

Adequate reduction of the fracture has been found to be a key to success of fixation with the DHS, and it is now well established that central lag screw placement in both AP and Lateral placements is an important factor in prevention of DHS failure. However, some people advocate inferior/posterior placement of the screw in getting good purchase between the screw and fracture fragments.

The commonest methods of quantifying adequacy of lag screw placement are the TAD, and Parker's ratio method, which can both be obtained from plain AP and Lateral radiographs. However, the picture archiving and communications system (PACS), is now commonly used to calculate the TAD, and the recommended TAD should be less than 25 mm to avoid screw cut-out, as the TAD has been found to be a strong predictor of lag screw cut-out. Neck shaft angle (NSA), has not been found to have any effect on TAD in DHS. To increase the accuracy of screw placement and also avoid getting into the joint while performing DHS, it is recommended that the hip should be internally rotated.

DHS is only recommended for stable intertrochanteric fractures (with intact medial wall), and should not be used in unstable fractures, reverse oblique pattern, and severe osteoporosis. Other causes of failure include poor patient selection, inadequate reduction, and incompetent surgeon performing the operation at the end of the trauma list, usually the most junior trainee. The outcome of fixation has been shown to be influenced by proper education and good assessment methods.

Computer-aided, navigational and minimally invasive methods of lag screw placement have all recently been introduced, and have been found to increase accuracy of guide wire placement, decrease radiation exposure, number of drill tracks in the femoral head and neck, and also theatre time required to perform DHS, compared to the conventional technique. However, there is a steep learning curve and increased cost of the extra facilities required.

Hip loading in a multiplanar dynamic manner during normal gait, has been observed to affect lag screw migration, and subsequent DHS failure. Use of additional devices such as anti-rotation wire and screw, cerclage wiring of unstable fragments, and buttress plate (Trochanter stabilizing plate) has been advocated in some specific situations.

Several complications of DHS have been described in the literature, and can occur both intraoperatively or postoperatively. The intraoperative complications include failure to achieve adequate reduction of the

fracture, breaking of K-wire, excessive bleeding and fracture of the distal femoral fragment. Postoperative complications include screw cut-out, avascular necrosis (AVN), coxarthrosis, screw breakage, plate pulling off from the femur, pseudoarthrosis, hemorrhage, and infection. Therefore, proper training and attention to detail has been recommended, in order to prevent or at least reduce the rate of complications.

Several new alternative devices have been introduced and tried for the treatment of intertrochanteric fractures of the femur, in order to reduce or eliminate the risk of fixation failure using DHS. These include cephalomedullary nail implants, Gamma nail, PFNA, PCCP, twin hook, DHS blade, and dynamic screw plate (DSP).

Although some of these new devices have theoretical and biomechanical advantages over DHS, overall, they have not been found to be superior to DHS in terms of failure rate and functional outcomes, in the treatment of intertrochanteric fractures. Therefore, DHS still remains the gold standard for the treatment of stable intertrochanteric fractures in suitable patients. However, intramedullary devices are generally better for subtrochanteric or very osteoporotic fractures, as they are biomechanically more stable than DHS.

REFERENCES

- Bannister GC, Gibson AG, Ackroyd CE, Newman JH. The fixation and prognosis of trochanteric fractures: A randomised prospective controlled trial. *Clin Orthop Relat Res* 1990;254:242-6.
- Hsueh KK, Fang CK, Chen CM, Su YP, Wu HF, Chiu FY. Risk factors in cutout of sliding hip screw in intertrochanteric fractures: An evaluation of 937 patients. *Int Orthop* 2010;34:1273-6.
- Thomas AP. Dynamic hip screws that fail. *Injury* 1991; 22:45-6.
- Baumgaertner MR, Curtin SL, Lindskog DM, Keggi JM. The value of the tip-apex distance in predicting failure of fixation of peritrochanteric fractures of the hip. *J Bone Joint Surg Am* 1995;77:1058-64.
- Baumgaertner M, Solberg B. Awareness of Tip-Apex Distance reduces failure of fixation of trochanteric fractures of the hip. *J Bone Joint Surg [Br]* 1997;79-B:969-71.
- Nordin S, Zulkifli O, Faisham WI. Mechanical failure of Dynamic Hip Screw (DHS) fixation in intertrochanteric fracture of the femur. *Med J Malaysia* 2001;56(Suppl D):12-7.
- Kyle RF, Ellis TJ, Templeman DC. Surgical treatment of intertrochanteric hip fractures with associated femoral neck fractures using a sliding hip screw. *J Orthop Trauma* 2005;19:1-4.
- Johnson LJ, Cope MR, Shahrokhi S, Tamblyn P. Measuring tip-apex distance using a picture archiving and communication system (PACS). *Injury* 2008;39:786-90.
- Parmar V, Kumar S, Aster A, Harper WH. Review of methods of quantifying lag screw placement in hip fracture fixation. *Acta Orthop Belg* 2005;71: 260-3.
- Güven M, Yavuz U, Kadiloglu B, Akman B, Kilincoglu V, Unay K, *et al.* Importance of screw position in intertrochanteric femoral fractures treated by dynamic hip screw. *Orthop Traumatol Surg Res* 2010;96:21-7.
- Windolf M, Braunstein V, Schwieger K. Is a helical shaped implant a superior alternative to the dynamic hip screw for unstable femoral neck fractures? A biomechanical investigation. *Clin Biomech (Bristol, Avon)* 2009;24:59-64.
- Wu CC, Tai CL. Effect of lag-screw positions on modes of fixation failure in elderly patients with unstable intertrochanteric fractures of the femur. *J Orthop Surg (Hong Kong)* 2010;18:158-65.
- Pervez H, Parker MJ, Vowler S. Prediction of fixation failure after sliding hip screw fixation. *Injury* 2004;35:994-8.
- Walton NP, Wynn-Jones, H, Ward MS, Wimhurst JA. Femoral neck-shaft angle in extra-capsular proximal femoral fracture fixation; does it make a TAD difference? *Injury* 2005;36:1361-4.
- Herman A, Dekel A, Botser IB, Steinberg EL. Computer-assisted surgery for dynamic hip screw, using surgix, a novel intraoperative guiding system. *Int J Med Robot* 2009;5:45-50.
- Mayman D, Vasarhelyi EM, Long W, Ellis RE, Rudan J, Pichora DR. Computer-assisted guidewire insertion for hip fracture fixation. *J Orthop Trauma* 2005;19:610-5.
- Muller MC, Belei P, de la Fuente M, Strake M, Weber O, Burger C, *et al.* Evaluation of 2D fluoroscopy-based navigation system for insertion of the Dynamic Hip Screw (DHS): An experimental study. *Rofo* 2011;183:536-42.
- Kumar AJ, Parmar VN, Kolpattil S, Humad S, Williams SC, Harper WM. Significance of hip rotation on measurement of 'Tip Apex Distance' during fixation of extracapsular proximal femoral fractures. *Injury* 2007;38:792-6.
- Parmar V, Kumar AJ. The importance of surgical education in the accuracy of implant placement during hip fracture fixation. *J Orthop Traumatol* 2009;10:59-61.
- Raudaschl P, Fritscher K, Roth T, Kammerlander C, Schubert R. Analysis of micro-migration of sliding hip screws by using point-based registration. *Int J Comput Assist Radil Surg* 2010; 5: 455-60.
- Ehmke LW, Fitzpatrick DC, Krieg JC, Madey SM, Bottlang M. Lag screws for hip fracture fixation: Evaluation of migration resistance under simulated walking. *J Orthop Res* 2005;23:1329-35.
- Ho M, Garau G, Walley G, Oliva F, Panni AS, Longo UG, *et al.* Minimally invasive dynamic hip screw for fixation of hip fractures. *Int Orthop* 2009;33:555-60.
- Tao C, Guoyou Z, Xianlong Z. Review: Minimally invasive versus conventional dynamic hip screw fixation in elderly patients with intertrochanteric fractures: A systematic review and meta-analysis. *Surg Innov* 2011;18:99-105.
- Wong T-C, Chiu Y, Tsang W-L, Leung W-Y, Yeung S-H. A double-blind prospective, randomised, controlled clinical trial of minimally invasive dynamic hip screw fixation for intertrochanteric fractures. *Injury* 2009;40:422-7.
- Lindsey RW, Ahmed S, Overturf S, Tan A, Gugala Z. Accuracy of lag screw placement for the dynamic hip screw and the cephalomedullary nail. *Orthopaedics* 2009;32:488.
- Stern R, Lubbeke A, Suva D, Miozzari H, Hoffmeyer P. Prospective randomised study comparing screw versus helical blade in the treatment of low-energy trochanteric fractures. *Int Orthop* 2011;35:1855-61.
- Barton TM, Gleeson R, Topliss C, Greenwood R, Harries WJ, Chesser TJ. A comparison of the long gamma nail with the sliding hip screw for the treatment of AO/OTA 31-A2 fractures of the proximal part of the femur: A prospective randomized trial. *J Bone Joint Surg Am* 2010;92:792-8.
- Knobe M, Munker R, Sellei RM, Schmidt-Rohlfing B, Erli HJ, Nethard FU. Unstable peritrochanteric femur fractures. Failure rate, lag screw sliding and outcome with extra and intramedullary devices (PCCP, DHS and PFN). *Z Orthop Unfall* 2009;147:306-13.
- Roerdink WH, Aalsma AM, Nijebanning G, Van Walsum AD. The dynamic locking blade plate, a new implant for intracapsular hip fractures: Biomechanical

- comparison with the sliding hip screw and hook plate. *Injury* 2009;40:283-7.
30. Wildolf M, Muths R, Braunstein V, Gueorguiev B, Hanni M, Schwieger K. Quantification of cancellous bone-compaction due to DHS blade insertion and influence upon cut-out resistance. *Clin Biomech (Bristol, Avon)* 2009;24:53-8.
 31. Al-Munajjed AA, Hammer J, Mayr E, Nerlich M, Lenich A. Biomechanical characterisation of osteosyntheses for proximal femur fractures: Helical blade versus screw. *Stud Health Technol Inform* 2008;133:1-10.
 32. Little NJ, Verma V, Fernando C, Elliott DS, Khaleel A. A prospective trial comparing the Holland nail with the dynamic hip screw in the treatment of intertrochanteric fractures of the hip. *J Bone Joint Surg Br* 2009;90:1073-8.
 33. Haynes RC, Poll RG, Miles AW, Weston RB. An experimental study of the failure modes of the Gamma locking Nail and AO Dynamic Hip Screw under static loading: A cadaveric study. *Med Eng Phys* 1997;19:446-53.
 34. Cho SH, Lee SH, Cho HL, Ku JH, Choi JH, Lee AJ. Additional fixations for sliding hip Screws in Treating unstable peritrochanteric femoral fractures (AO Type 31-A2): Short-term clinical results. *Clin Orthop Surg* 2011;3:107-13.
 35. Liu C, Li Q, Yang J, Jin A. Treatment of intertrochanteric fractures with dynamic hip screw and femoral neck anti-rotation screw. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi* 2011;25:334-6.
 36. Su BW, Heyworth BE, Protosaltis TS, Lipton CB, Sinicropi SM, Chapman CB, *et al.* Basicervical versus intertrochanteric fractures: An analysis of radiographic and functional outcomes. *Orthopaedics* 2006;29:919-25.
 37. Hrubina M, Skotak M, Behounek J. Comparisons of dynamic hip screw treatment for proximal femoral fractures. *Acta Chir Orthop Traumatol Cech* 2010;77:395-401.
 38. Parker MJ. Failure of femoral head fixation: A cadaveric analysis of lag screw cut-out with the gamma locking nail and the AO dynamic hip screw. *Injury* 1998;29:569.
 39. Knobe M, Munker R, Schmidt-Rohlfing B, Sellei RM, Schubert H, Erli HJ. Surgical outcome in peritrochanteric femur fracture: The impact of osteoporosis, comparison between DHS and percutaneous compression plate. *Z Orthop Unfall* 2008;146:44-51.
 40. Laohapoonrungrsee A, Arpornchayanon O, Phornputkul C. Two hole side-plate DHS in the treatment of intertrochanteric fracture: Results and complications. *Injury* 2005;36:1355-60.
 41. Lee PC, Yu SW, Hsieh PH, Chuang TY, Tai CL, Shih CH. Treatment of early cut-out of a lag screw using a trochanter supporting plate: 11 consecutive patients with unstable intertrochanteric fractures. *Arch Orthop Trauma Surg* 2004;124:119-22.
 42. Audige L, Hanson B, Swiontkowski MF. Implant-related complications in the treatment of unstable intertrochanteric fractures: Meta-analysis of dynamic screw-plate versus dynamic screw-intramedullary nail devices. *Int Orthop* 2003;27:197-203.

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