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Intertrochanteric fractures in the elderly by dynamic helical hip system (DHHS) & the conventional dynamic hip screw: A comparative study

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Abstract
Background: Intertrochanteric fractures are one of the fragility fractures occurring mostly in patients older than 70 years of age. The most common mechanism of failure of fixation devices like dynamic hip screw (DHS) is the head and neck fragment cutting off the hip screw, due to severely osteoporotic bone in the elderly. Overcoming this problem remains a big challenge in current orthopaedics practice. The Dynamic Helical Hip System (DHHS) has been designed to overcome these very shortcomings of the conventional DHS.
Aim: To compare the clinical and radiological outcomes of osteoporotic intertrochanteric fractures managed with two different designs of implants and to verify the advantage, if any, of the Dynamic Helical Hip System (DHHS) over DHS, specially cut-out of the implant from femoral head-neck with subsequent varus collapse.
Methods: 60 geriatric patients with osteoporotic intertrochanteric fractures were treated with either the conventional DHS or DHHS. All the patients were randomly distributed in one of the two groups. The present study is a prospective randomised clinical trial.
Results: There were 04 cases of failure of DHS in our series compared with only 01 case of failure in DHHS series.
Conclusion: In the management of osteoporotic intertrochanteric fractures DHHS was found to be the superior implant in performance compared to the conventional DHS in terms of screw cut out.

Keywords: Intertrochanteric fractures, dynamic hip screw, dynamic helical hip system, osteoporotic, fragility fracture

Introduction
Intertrochanteric fractures are considered one of the three types of hip fractures. An intertrochanteric hip fracture occurs between the greater trochanter, where the gluteus medius and minimus muscles (Hip extensors and abductors) attach and the lesser trochanter, where the iliopsoas muscle (Hip flexor) attaches. The intertrochanteric region of the hip, represents a zone of transition from the femoral neck to the femoral shaft [1]. Half of all hip fractures are intertrochanteric. The mortality rates associated with these fractures varies from 10% to 30% within the first year of injury. In general, there is a slightly greater mortality rate for intertrochanteric fractures than for intracapsular hip fractures; this is because of the advanced age of patients who suffer intertrochanteric fractures.

The current treatment of intertrochanteric fractures is surgical intervention [2]. In patients managed conservatively the fracture heals with unacceptable shortening, rotation and/or angulation of the extremity, resulting in decreased mobility and subsequent handicap, impairment and disability [3, 4]. With a few exceptions, surgical intervention is used to treat essentially all intertrochanteric fractures [5].

Intertrochanteric fractures are considered as one of the fragility fractures. Fragility fractures are fractures sustained by a fall from standing height or less in the elderly with osteoporotic bones. An ever increasing number of people are living in their 70's and 80's. This has enormous social and financial implications for the society and for the health care system of the country.

Restoring the pre injury level of functional status is the final goal in surgical management of such patients [6]. The experience with fixed-angle nail-plate devices indicated the need for a device that would allow controlled fracture impaction [8]. The sliding nail-plate devices gave rise to sliding hip screw devices. The nail portion was replaced by a blunt-ended screw with a large outside thread diameter. Numerous series have reported excellent results with the sliding hip screw for intertrochanteric fracture fixation [5, 7, 9]. Treatment failures such as loss of fixation, symptomatic joint penetration, aseptic necrosis, malunion and nonunion occurred in 25% of the Jewett nail cases and 6% of the Richards screw cases [7-9].

The most common mechanism of failure of fixation devices like dynamic hip screw today is the head and neck fragment cutting off the hip screw, due to severely osteoporotic bone in the elderly. Overcoming this problem remains a big challenge in current orthopaedics practice. The Dynamic Helical Hip System (DHHS) has been designed to overcome these very shortcomings of the conventional Dynamic Hip Screw (DHS). The present study is a prospective randomised clinical trial. Following are the variables that determine the strength of the fracture fragment-implant assembly:

1. Bone quality
2. Fragment geometry
3. Quality of reduction
4. Implant design
5. Implant placement [10, 11]

Of these five elements of stable fixation, the surgeon can control only the quality of reduction, the choice of implant and its placement [12, 13].

O'Neill F *et al*. conducted a study titled -Dynamic hip screw versus DHS blade: a biomechanical comparison of the fixation achieved by each implant [14]. They biomechanically investigated whether the standard DHS or the DHHS achieves better fixation in bone with regard to resistance to push-out, pull-out and torsional stability. The results showed that the DHHS outperformed the DHS with regard to resistance to push-out and rotational stability. They concluded that the DHHS was the superior implant in this study. Similarly, there have been many other biomechanical studies as well which have consistently shown the superiority of the DHHS over the DHS [15-17].

Unlike biomechanical studies there have been only two randomised clinical trial (RCT) studies published till date that compare the clinical efficacy of the DHHS and DHS. In 2011, Richard Stern *et al*. published a study which was a prospective randomised study comparing screw versus helical blade in the treatment of low-energy trochanteric fractures [18, 19]. The authors concluded that both a screw and a blade performed equally well in terms of implant placement in the femoral head and outcome.

Aim

This study was undertaken with the following aims and objectives:

1. To objectively compare the clinical and radiological outcomes of intertrochanteric fractures in the elderly managed with two different designs of implants and to verify the advantage, if any, of the Dynamic Helical Hip System (DHHS) over Dynamic Hip Screw (DHS) with special emphasis on screw migration within the femoral head and cut-out of the implant with subsequent varus collapse.
2. To establish key prognostic factors that can be used as clinically useful tools to predict cut out of the implant from the femoral head resulting in implant failure.
3. To compare, using standard hip scoring systems, the difference in the functional outcome in the two groups of patients i.e. those treated with DHS and those with the DHHS.

Materials and Methods

The present study consists of 60 elderly patients with intertrochanteric fractures and having radiological evidence of osteoporosis who were treated with either the conventional DHS or the DHHS between 2019 to Nov 2024 in the tertiary care hospital Kalyani at Visakhapatnam. The patients were randomly distributed in the two groups equally and p values were calculated from the data obtained by preoperative and postoperative assessment of patients.

The fractures were classified according to the Boyd and Griffin classification. All the 60 cases were followed up at regular intervals with average follow up of 20 months. The study was conducted with due emphasis for clinical observation and statistical analysis of results was done after surgical management of intertrochanteric fractures of femur with DHS/DHHS.

Inclusion criteria

1. Age > 60 years
2. Boyd and Griffin Types I, II, IV (AO type 31- A1, 31-A2)
3. No other associated injury
4. Radiological evidence of osteoporosis

Exclusion criteria

1. Age < 60 years
2. Boyd and Griffin Type III (AO type 31-A3) (reverse oblique type)
3. Previously operated cases of intertrochanteric fracture
4. Associated ipsilateral or contralateral pelvic injuries
5. Old neglected fracture

Data Collection

Patients with intertrochanteric fracture were admitted to the hospital and all the necessary clinical details were recorded in the performa prepared for this study. After the completion of the hospital treatment, patients were discharged and called at regular intervals for follow up at outpatient level for serial clinical and radiological evaluation.

Management of Patients

Patients were admitted in the Orthopaedic wards and detailed Pre Anaesthetic check-up was done. DVT prophylaxis (Inj LMWH 40/60 mg sc) was given to susceptible patients i.e. patients with multiple co-morbidities and likely late ambulators.

DHHS - Technical Details

The DHHS is mainly indicated for osteoporotic patients. It claims to reduce the rate of screw cut out compared to the standard DHS Screw.

- Material-Titanium
- Blade Length 65-115 mm-Outer Diameter 12.5 mm
- LCP DHS Plate allows better fixation on the shaft - Tapered plate end
- Barrel Angle 130-150 Degrees -Barrel Length 25 and 38 mm (Short/long barrel)

- 1 to 20 Holes plate-Thickness of plate 5.8mm
- Option of Locking and cortical screw 5.0 and 4.5mm respectively

Design Advantages of DHHS are as follows

1. The shape of the blade leads to improved rotational stability of the femoral head-neck fragments, reducing the risk of cut-out, delayed union and varus angulation in unstable trochanteric fractures. (Fig 1)
2. The specially designed tip of the blade allows for compaction of the bone when the blade is inserted. This compaction leads to better anchorage of the implant in the femoral head, beneficial in osteoporotic bone. (Fig 2)
3. Insertion of the Helical Blade doesn't require over-drilling of the femoral head. This preserves precious cancellous bone in femoral head as the helical blade is gently hammered after initial drilling with its triple reamer. The DHS on the other hand leads to cylindrical loss of cancellous bone from the head. (Fig 4)
4. The weight bearing surface of the Helical Blade is greater compared to the DHS screw and can therefore take greater loads. A larger surface means less pressure from the implant onto the bone and less risk of implant cut out. (Fig 2)
5. The Titanium composition of the blade has near ideal modulus of elasticity and causes less stress shielding and better stress distribution.

All the patients were operated in the standard manner for Intertrochanteric fractures using C-Arm image intensifier and fracture traction table. The DHHS has it's own specific instrumentation. (Fig 3) The average operating time with the DHS was 63 minutes compared with DHHS which was 70 minutes. The average blood loss was about 350ml.

Post-Operative Management

Isometric exercises were started as a part of physiotherapy protocol. Toe touchdown weight bearing was allowed usually on 1st post-op day and hip and knee range of motion exercises were encouraged. Sutures were generally removed on 14th post-op day. Hip abduction exercises were begun after wound healing. Weight bearing as tolerated was allowed and gradually the weight borne by the affected limb was increased by the patient. Full weight bearing was usually allowed at 06 weeks but was modified according to the condition of the patient.

Patients were followed at 06, 12, 18, 24, 36 weeks post-operatively in the orthopaedics OPD. Radiographs were taken at every follow-up on OPD basis; all radiographs were analysed for fracture classification, initial blade placement in the femoral head using a coordinate system based on the centre of the head as described by Baumgaertner change of blade tip position within the head postoperatively based on the same coordinates and telescoping of the screw/ helical blade within the barrel of the side plate [20, 21]. In general, higher the Tip Apex Distance (TAD) greater are the chances of screw cut out [22, 23]. Radiograph measurements were adjusted for magnification using the known diameter of the blade (12.5 mm).

Blade/screw tip migration within the femoral head is a good prognostic indicator for screw cut out, implant failure and varus collapse of the fracture fragments. Excessive telescoping of the screw/helical blade within the barrel is detrimental to the final outcome and will usually result in implant failure. Hence fracture collapse has to be controlled both by direction and the amount of collapse.

Preoperative data

1. Age
2. Sex
3. Fracture classification

Postoperative data

1. TAD
2. Telescopy
3. Screw/Blade position
4. Harris Hip Score

All the data thus generated was subjected to statistical analysis that served two purposes:

1. To ensure that the two groups are homogenous in every respect as far as possible.
2. To monitor and compare the postoperative performance of the implants (DHS/DHHS) *in vivo* and the functional outcomes of the patients.

Independent variables were patient related factors and every effort was made to make the two groups as homogenous as possible. These variables were age, sex and fracture classification.

Age

Mean age of the patients in the DHHS group was 74 and in the DHS group was 72 years, with a p value of 0.311, hence this was not a statistically significant difference.

Sex

80% of the patients in both the groups were females; hence age-sex distribution in the two groups ensured elderly female population having sustained fragility fractures. Here the p value was 0.626 and hence the difference was again statistically not significant.

Fracture Classification

Boyd and Griffin classification was used to classify the fractures and type III fractures i.e. revese oblique fractures were excluded from the study. Here the p, value for the variable was 1.000 and hence the difference for fracture pattern in the two groups was statistically non-significant.

Table 1: Statistical comparison of independent variables

Independent variables	p Values
Age	0.311
Sex (Non quantifiable)	0.626
Fracture Classification (Non quantifiable)	1.000

(Age, sex and fracture classification, all values >0.050)

There was no statistically significant difference in age, gender and fracture classification between the two groups. The p values for all these variables were > 0.05. (Table 1)

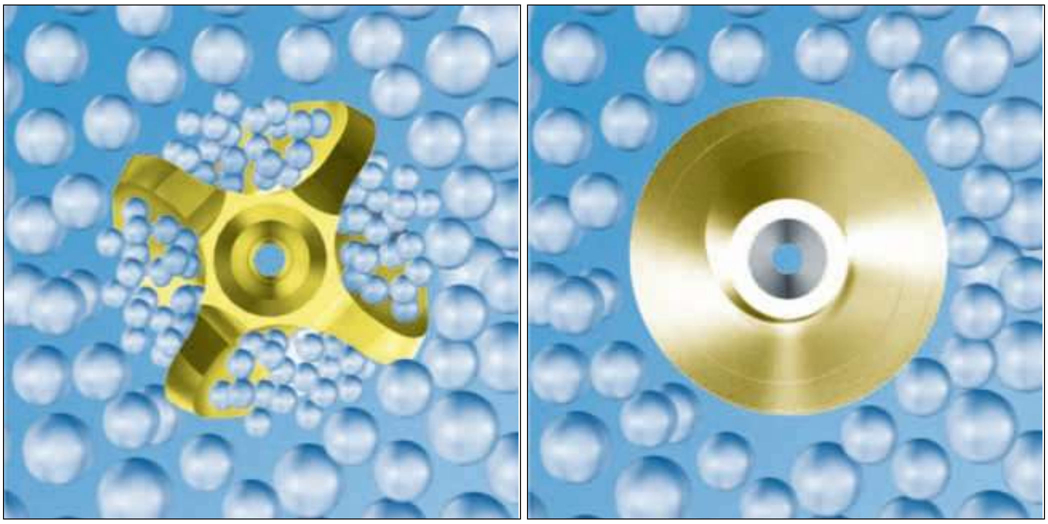

Fig 1: Rotational compaction of cancellous bone produced by the helical blade compared with non-compaction by DHS.

Fig 2: Comparison of Helical Blade and DHS

Fig 3: Armamentarium with full range of implants and instrumentations and 1.5 Nm Torque limiter 'star' drive screw driver used to lock helical blade

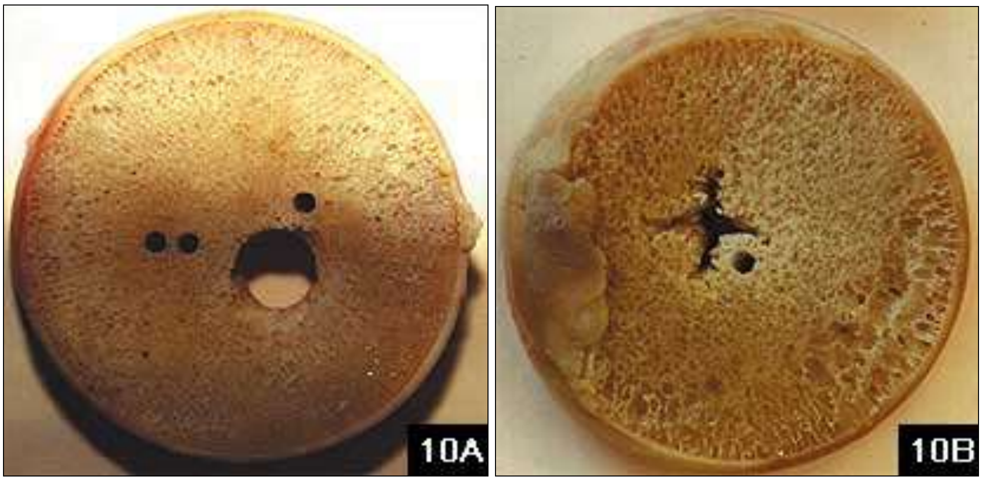

Fig 4: Femoral head cross section demonstrating tracks created by DHS (10A) and DHHS (10B) (81.3/26.7 mm^2)

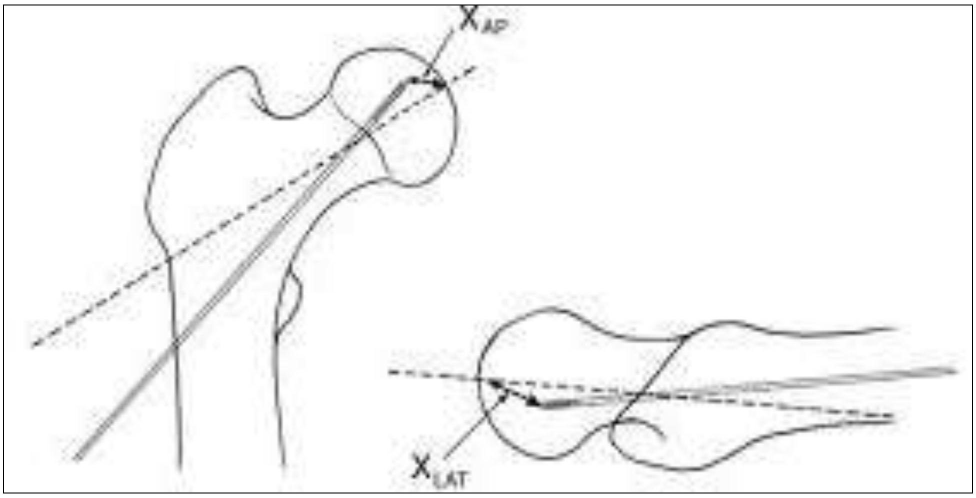

Fig 5: Method of assessing 'TAD' on AP and Lat X rays.

Results

The following observations were made from the data collected during the study of 60 cases of intertrochanteric fractures treated either by the conventional Dynamic Hip Screw (DHS) or the Dynamic Helical Hip System (DHHS). Chi Square analysis of the data was done and p values were obtained (Wherever possible). There were 30 patients in each of the two groups i.e. DHS and DHHS. All the variables were divided into two broad groups i.e. independent and dependent variables. (Table 2)

Table 2: Showing independent and dependent variables

Independent Variables	Dependent Variables
Age	TAD
Sex	Blade/Screw Placement
Fracture Classification (Boyd & Griffin)	Telescopy
	Functional Outcome (Harris Hip Score)
	Quality of Reduction (Non Quantifiable)
	Failure (Cut Through/Cut Out)

Dependent Variables

There were 05 positions for the both the DHHS and the DHS, p value for screw/blade placement (non-quantifiable) was 0.353 i.e. statistically non-significant. This means that in terms of screw placement in the femoral head there was not much difference in the two groups and both the implants enjoyed the same degree of freedom of placement in the femoral head.

The p value for TAD in this study was statistically significant, this was 0.010. The average TAD was 24 mm in the DHHS group and 22 mm in the DHS group (p=0.01) i.e. the DHS could be placed more close within the range of recommended TAD, this might be because of the fact that the DHS has better control of insertion because of screwing motion used (torsional force) for insertion of the implant than hammering (axial force) of the implant as is done in DHHS as also the learning curve with the use of helical blade. (Table 4)

The functional outcome in both the groups was assessed by Harris Hip Score. There were progressive improvements in the scores as shown by the increased activity levels with 45% of the patients in the DHS and 20% in DHHS group having excellent function. 40% patients in DHS group and 60% in DHHS had good function based on Harris Hip Score at the end of follow up period.

Telescopy is the measure of collapse that has taken place with the implant in-situ. This was the distance measured between the base of the screw/blade and the tip of the barrel plate before and after full collapse has taken place. The mean of telescopy in the DHHS group was 8mmm and in the DHS group was 10mm. This showed that more telescoping (Collapse) occurred in the DHS group. The p value in this variable was found to be 0.008 which was statistically significant.

The DHHS group had one failure caused by central protrusion (cut through) of the blade through the femoral head without significant varus collapse or superior migration (Fig 8). The DHS group had 04 failures, all resulting in varus collapse and superior migration of the screw (cut out) (Table 3) (Fig 9,10,11).

Percentage wise this was 13% failure in the DHS group and 3% in DHHS group (Table 4). However, the p value for this variable was 0.177, indicating that for the difference in the cut out/failure to be considered statistically significant a larger sample of patients should be taken.

Table 3: Showing normal and cut-out failure results of DHHS and DHS

	Normal	Cut Through/Cut Out	Total
DHHS	29	01	30
DHS	26	04	30
Total	55	5	60

Table 4: Showing Comparative Results of DHS and Helical Blade

	DHS	DHHS
Screw Cut-Out (%)	13	3
TAD Migration(mm)	>1mm/wk	<1mm/wk
Screw Cut-Through	None	01
Screw Cut Out	04	None
Non Union	None	None

Fig 6: X-rays showing Intertrochanteric fracture Type II fixed with DHHS in AP and Lat view

Fig 7: X-rays showing Intertrochanteric fracture Type II fixed with DHHS in AP and Lat view

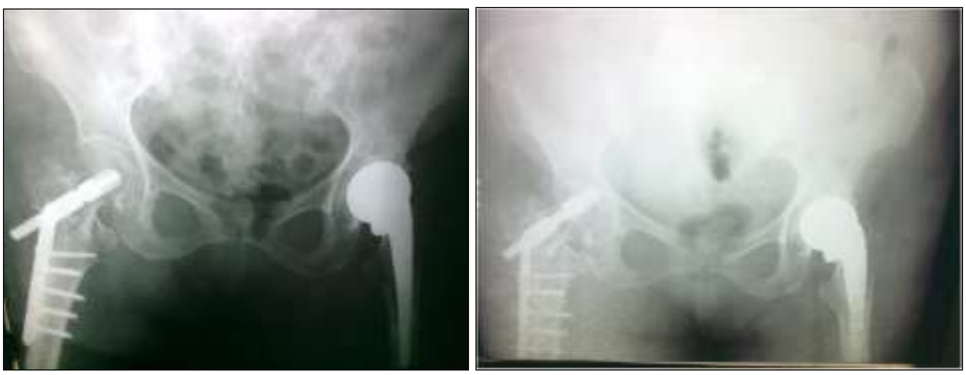

Fig 8: X- ray showing Intertrochanteric Fracture Type IV fixed with DHHS showing excessive Telescopy; 01 month follow-up shows cut-through of the implant

Fig 9: X-ray showing Intertrochanteric fracture type IV fixed with DHS in AP view; 02 months follow-up showing excessive telescoping, cut-out and implant failure

Fig 10: X-ray showing another Example of DHS failure cut-through

Fig 11: X-ray showing Intertrochanteric fracture Type IV fixed with DHS; 01 month follow-up showing cut-through and implant failure

Discussion

Peritrochanteric fractures of the proximal femur are a major cause of morbidity and even mortality in the geriatric age group. Osteoporosis is characterised by reduced bone mass, it predisposes to fragility fractures. Dynamic Hip screw (DHS) has remained the preferred fixation method for intertrochanteric hip fractures. Experience has shown that DHS do not do well in severely osteoporotic bones. Complications such as screw cut-out and over-telescoping are fairly common. Cut-out rates as high as 28% have been reported in various studies [24]. Significant varus collapse has been reported with the DHS. Cut-out of the screw occurs due to repeated motion at the fracture site with resultant bone fatigue, compaction and eventual superior tract cut-out. Also because large column of bone is removed from the head and neck during DHS screw insertion as a result of drilling for screw insertion, leaving the remaining surrounding bone non-impacted and prone to collapse.

The Dynamic Helical Hip System (DHHS) was developed to address fixation in osteoporotic cancellous bone. Insertion of the helical blade does not require over drilling which effectively allows the cancellous bone to be retained within the head and compacted radially during insertion. Insertion in the case of helical blade is by means of gentle hammering rather screwing i.e. axial force is converted to torsional force. This affords improved rotational control of the medial fragment and greater resistance to varus collapse due to bone impaction. In addition, the titanium composition of the helical blade has a lower modulus of elasticity and improves stress transfer to bone further improving purchase in the head. Implant design can significantly affect the fixation strength and cut-out resistance [14-17].

The randomised clinical trial by Richard Stern *et al*. comparing screw versus helical blade in the treatment of low-energy trochanteric fractures [18, 19]. This was a fairly large study where a total of 335 patients were randomised, 172 to a screw and 163 to a blade. The failure rate in their study was 2.9% for DHS and 1.5% for the DHHS. In our study also we had 3% (01 case) failure in the DHHS. Our study is a randomised clinical trial comparative study. In terms of screw cut out the DHHS performed well than the conventional DHS. The DHHS had only one (Fig 8) cut out in the series whereas the DHS had four (Fig 9, 10, 11). No difference in functional outcome between the two implants was found upon completion of this study. (Table 5)

Table 5: Comparison between present study and R Stern *et al*.

	Present Study	Richard Stern *et al.*
Percentage Failure	13%-DHS 03%-DHHS	2.9%-DHS 1.5%-DHHS
Average TAD in Non-failure	22 mm-DHS 24 mm-DHHS	21.9mm
Average TAD in Failure	27.75 mm-DHS 28 mm-DHHS	29.4mm

The most important primary determinants in deciding the outcome of the surgery are surgeon controlled factors i.e. TAD and screw/blade placement in femoral head since all the failures in our study had TAD>25mm and with less favoured positions of the implant.

Our study however has certain shortcomings. These are

1. Small size of the sample in the study is the main limitation, even though the difference in the percentage of the failure cases appears to be significant (3% for DHHS vs 13% for DHS), this could not be proved to be statistically significant owing to the small sample size in the two groups.
2. Secondly, there cannot be a perfect similarity in between the two groups in terms of fracture pattern and difficulty or ease at reduction of the fracture as also the quality of reduction achieved through closed method.
3. There was no objective parameter to monitor osteoporosis in the patients.

Conclusion

There were 04 cases of failure of DHS in our series compared with only 01 case of failure in DHHS series. In this study the DHHS was found to be superior in performance compared to the conventional DHS in terms of screw cut out. All the cases of implant failure were recorded within 03 months of surgery. The TAD was a key prognostic factor in forecasting chances of screw cut out. Average TAD in DHS failure cases was 27.75mm. This was much higher than the group average of 22mm. TAD of DHHS failure was 28mm. The other factor that is a prime determinant of cut out was screw placement in femoral head. None of the failure cases had the desirable placement of centre-centre/inferior-centre of the implant where the best bone stock is available for secure purchase.

Recommendations

In osteoporotic intertrochanteric fracture DHHS is a better implant than the conventional DHS in terms of screw cut-out, fixation failure and subsequent varus collapse of the fracture.Hence, DHHS is recommended over DHS and may be used in osteoporotic intertrochanteric fractures. TAD should be as close to 25mm as possible for both the implants. Implant placement should be centre-centre/inferior-centre in the femoral head where the best bone stock is available for secure purchase

Data availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Ethical approval was obtained from the hospital Ethical committe.

List of abbreviations

DHS= Dynamic Hip Screw DHHS= Dynamic Helical Hip System TAD=Tip Apex Distance

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