



Short Versus Long Cephalomedullary Nailing for the Treatment of Intertrochanteric Hip Fractures in Patients Over 65 Years Old.

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Glossary of Abbreviations

BIDMC: Beth Israel Deaconess Medical Center

MGH: Massachusetts General Hospital

BWH: Brigham Women's Hospital

CPT: Current Procedural Terminology

OTA: Orthopaedic Trauma Association

ASA: American Society of Anesthesiologists

THA: Total Hip Arthroplasty

TKA: Total Knee Arthroplasty

CMN: Cephalomedullary Nail

OMR: Online Medical Record

CI: Confidence Interval

Section 1: Introduction

Proximal femoral fractures are a frequent trauma injury of the elderly population in the US. Hip fractures among the elderly numbered 250,000 in 1990, and are estimated to reach 500,000 by 2040ⁱ. Within the same time frame, the estimated cost of these hip fractures will climb to \$16 billion annuallyⁱ. Proximal femur fractures are common among the elderly population due to increased bone fragility and an increased tendency for unexpected trauma and falls^{ii,iii}. With the number of elderly individuals expected to increase due to the baby boom generation as well as improved healthcare principles resulting in longer life spans, it follows that the number of hip fractures, including intertrochanteric hip fractures, is set to increase as well^{iv,v,vi}. Traditionally, intertrochanteric fractures have been repaired with a sliding screw plate system via a lateral surgical approach. This type of repair generally involves a large surgical incision, significant operating room time, and is often inadequate for complex (unstable) fracture patterns.

With the introduction of the first cephalomedullary nail for intertrochanteric fractures in the 1990s (the Gamma nail by Howmedica, now Stryker) theoretical advantages for cephalomedullary nailing over sliding screw plate were numerous. These advantages included not only faster operating time with a percutaneous approach, which translates into less anesthesia time, less blood loss, and shorter hospital stay, but also improved fracture fixation biomechanics including anatomical alignment, rotational stability, and load bearing^{vii,viii}. There has been a significant increase in the use of intramedullary nails via a less invasive surgical approach for more complex fractures as well as elderly patient populations. In 1993, only 3% of all (stable and unstable) proximal femur fractures were repaired by nailing. In 2006, nearly 67% of all proximal femur fractures were repaired by nailing, with a sliding screw plate system still being indicated in certain stable fractures^{vii}. Additionally, a recent study by Anglen and Weinstein showed an increasing trend among young orthopaedic surgeons toward cephalomedullary nailing over sliding hip screws for fixation of intertrochanteric fractures^{ix}. While the use of sliding hip screw fixation versus cephalomedullary nailing fixation remains a controversial topic, it is beyond the scope of this study.

Cephalomedullary nailing can involve either a short nail (approximately half the length of the femur) or a long nail (the full length of the femur, >300 cm). First generation short nails often involved secondary fractures along the diaphyseal femoral shaft at the distal end of the nail leading to unacceptably high rates of re-fracture and reoperation (8-11%)^{x,xi}. The first generation short nail implants were bulky, rigid, made of stainless steel, and used large locking bolts at the distal tip of the nail. This early design was thought to result in a significant stress riser in the diaphyseal bone as well as potential three-point bending due to the mismatch in shape between the nail and femur^{xi}.

As a result of the high incidence of re-fracture, the standard of care shifted away from the Gamma short nail and toward long nail placement. The long Gamma nail was developed to end in the metaphyseal region of the distal femur, therefore bypassing the diaphyseal stress riser. Early studies, including the work of Greenspan et al, showed improved outcomes in terms of re-fracture when comparing long Gamma nails to first generation Gamma nailsⁱⁱ. Although re-fracture rates were decreased, fracture at the distal tip of the long nail, now in the metaphyseal bone, generally regarded as the weakest part of the bone, was still a known complication.

New, innovative designs were applied to both short and long cephalomedullary nails, resulting in models such as the TFN by Synthes and the Gamma 3 by Stryker. A shift from rigid stainless steel to flexible titanium created a more adaptable implant. Aside from a materials change, short nails were also redesigned with a tapered distal end and a more proximal distal interlocking screw in hopes that both of these adjustments would reduce the impact of the stress riser in the femoral diaphyseal bone. Recent data shows the short nailing procedure requiring less than three-fourths the amount of time of the long nail procedure (44 minutes compared to 64 minutes, respectively)^{xii} secondary to more extensive reaming and the need for distal perfect circles technique. Short nails have also been shown to reduce radiographic time in the operating room due to the ability to lock distally without perfect circles, decreasing the radiation exposure to surgeons during proximal femur repair operations.

Newer implant designs have resulted in lower complications and it is now believed that fracture rates around both nail types are comparable. The aims of this study include to compare outcomes for short versus long cephalomedullary nailing hardware repair for

intertrochanteric femoral fractures as well as analyze and compare morbidity and mortality outcomes associated with intertrochanteric femoral fractures and nailing hardware repair. The innovation of this project lies in its ability to change the standard of care for proximal femoral fractures, an injury that affects a vast number of Americans every year and a number that will likely increase greatly as the baby-boomer generation continues to age. This study also features the innovation of the new third generation short femoral nails, allowing one to analyze the effect of the change in materials from stainless steel to titanium as well as the creation of a tapered end to the nail with the distal locking screw traversing the nail at a more proximal location while also being smaller in size. New generation short nails, if shown to produce similar results in terms of re-fracture and re-operation, can decrease a patient's surgical incision, operating time, and cost. Short nails are also associated with less radiographic time, reducing the radiation exposure of surgeons during the operation, tying in benefits for the surgeon alongside the numerous benefits for the patient. Our hypothesis is that new generation short trochanteric nails are equally effective without a significantly higher re-fracture or reoperation rate when compared to long nails (>300 cm) for the treatment of intertrochanteric hip fractures.

This scholarly project was a joint contribution by James T. Redshaw HMSIV, Conor Kleweno MD, Jordan Morgan, clinical research coordinator, Mitch Harris MD, Edward K. Rodriguez MD, David Zurakowski MD, Mark Vrahas MD, and research mentor Paul Appleton MD. James T. Redshaw was directly responsible for data and chart review including all inclusion and exclusion criteria, radiographic classification of fracture patterns, and assisted with a thorough literature review. The student also assisted with the writing of the manuscript, specifically the introduction and discussion sections. Dr. Conor Kleweno was the chief orthopaedic resident in charge of the project and had final decision making authority on the complete manuscript, chart review, data analysis, and literature review. Jordan Morgan was the research coordinator who assisted with organization components of the project as well as extensive data analysis and methods formatting. Dr. Harris, Dr. Rodriguez, Dr. Zurakowski, and Dr. Vrahas helped to coordinate research efforts at the three level one trauma centers as well as final manuscript contributions. The research mentor, Dr. Paul Appleton, was available for advice and guidance at all steps of the

project, and carefully reviewed the database, data analysis and writing of the scholarly project. The efforts of the collected research team described above resulted in the project reaching publication in the Journal of Orthopaedic Trauma in July 2014 under the title *Short versus long cephalomedullary nails for the treatment of intertrochanteric hip fractures in patients older than 65 years*^{xxi}.

Section 2: Methods

This is a retrospective data analysis that analyzed operative notes, discharge summaries, and clinical follow-up notes for patients who underwent cephalomedullary nailing for proximal femur fractures at BIDMC/MGH/BWH. Data for this study was collected via WebOMR or direct contact with the patient to compare surgical comorbidities and post-operative outcomes. In cases where mortality data could not be obtained through WebOMR, the SSI was utilized.

IRB approval was obtained at all institutions (BIDMC, MGH, BWH). A search of our prospectively gathered trauma database at all three Harvard Orthopedic Trauma Surgery institutions was conducted between 1/1/2004 and 12/31/2010. CPT code 27245 (treatment of intertrochanteric hip fracture with intramedullary nail) were isolated. Patient medical records, operative reports, and digital x-rays were reviewed. All subtrochanteric hip fractures, pathological fractures, and revision surgeries were excluded. Patients younger than 65 years of age and those with less than one year of follow up were also excluded. Data to be collected include Patient age, Gender, Mechanism of injury, OTA Classification of Fractures, Other injuries, Comorbidities in the form of ASA score, Type of nail used, Operative time, Re-fracture, Complications (post-op), and Mortality. All nine of the OTA intertrochanteric fracture types were included.

Any patient with a proximal femur fracture treated by the orthopedic trauma surgery staff at BIDMC, MGH, or BWH was considered for inclusion. Since this is a medical record study, any person who underwent cephalomedullary nailing of a proximal femur fracture by Harvard Orthopaedic Trauma(HOTS) department was eligible. There was no gender, language, or race exclusion for this study. There are no direct benefits to patients. Rather, there is a potential future benefit for how proximal femur fractures will be treated based on the results from this analysis. Since this was a retrospective chart review, there was no direct physical risk to patients involved in the study. Written informed consent was not requested for this study as it is a retrospective chart review.

This study was limited to proximal femur fractures that were repaired using long nails and third generation short nails. Patients were treated with one of the four following nails: Gamma short nail (third generation), Gamma long nail, Synthes short nail or Synthes

long nail according to surgeon preference. Patients who had a re-fracture or major re-operation were included regardless of length of follow-up. Post-operatively, all patients were allowed to be weight-bearing as tolerated with unrestricted hip motion. Patients were discharged to acute care rehabilitation centers, skilled nursing facilities, or to home with services based upon their needs and in consultation with the treating inpatient physical and occupational therapists.

The study is also limited to patients who have at least one year of follow up and are older than 65 years old. Those patients who did not have at least one-year follow-up and we were unable to reach via telephone were considered lost to follow-up. Mortality data on all patients were collected from the social security death index using a web-based internet search engines (www.ancestry.com and www.tributes.com). All subtrochanteric hip fractures, pathological fractures (caused by tumor), isolated greater or lesser trochanter fracture, and revision hip surgeries involving removal of plate hardware followed by cephalomedullary nail implantation were excluded.

The primary outcome of adverse complications will be defined as re-fracture (of femur or distal to nail) and re-admission. Secondary outcomes include major re-operation defined as need for explantation of nail, revision surgery with nail, or conversion to arthroplasty.

Statistical analysis of the study included using all demographic characteristics of the patients as descriptive statistics. The mean and the standard deviation were used for continuous variables, and the frequency (percentage) was used for categorical variables. The two procedure groups were compared with regard to each characteristic with use of a two-sample t test for continuous variables and a chi-square test for categorical variables. A Kaplan-Meier estimator was used to predict survivorship and Cox multivariable regression model was used for multivariate analysis. A p value of <0.05 indicated significance. Statistical analysis was performed with the SPSS version 19.0 (SPSS Inc./IBM, Chicago, IL).

Section 3: Results

A total of seven hundred fourteen patient charts were reviewed between the three participating centers. A total of 698 patients met all of the inclusion criteria detailed earlier. Sixteen patients were excluded according to previously mentioned criteria: five because of pathologic fracture due to malignancy, eight due to the revision nature of the surgery (e.g. fractures inferior to previous placed hardware), two due to segmental fracture patterns, and one because no preoperative x-rays were available to review. Overall, 175 of 698 patients died less than one year after index surgery for a one-year mortality rate of 25%. The mechanism of injury was a fall from standing in 687 patients, fall down stairs in three patients, fall off ladder in three patients, motor vehicle collision in three patients, bicycle accident in one patient, and a pedestrian struck by motor vehicle in one patient.

Among 698 hip fracture patients, 139 were lost to follow-up (20%) and are excluded from analysis to guard against bias of underestimating event rates. Therefore, statistical analysis is based on a total of 559 patients. The patients were split between the three institutions with 197 patients from MGH (35%), 176 from BWH (32%), and 186 from BIDMC (33%). The average age was 84 years old (SD = 8, range: 65-102), with 404 females (72%), 155 males (28%). Eighty percent of patients were either ASA 2 or 3. A total of 25 patients (4.6%) had a previous TKA. In terms of the patients' Orthopaedic Trauma Association fracture classification, 416 were OTA A1/A2 (74%) and 143 were Type A3 (26%). A total of 273 short nails were used, of which 53 were short Gamma nails and 220 were short Synthes nails. All 273 short cephalomedullary nails were locked with a single distal locking screw, except for two Synthes short nails that had no distal interlocks and one short Gamma nail which had 2 distal interlocks. The 425 long cephalomedullary nails included 17 Gamma nails and 408 Synthes nails. In terms of distal interlocking screws in the long nail group, 94 (22%) had no distal interlocks, 243 (57%) had one, and 88 (21%) had two. Of the final 559 patients included in the statistical analysis, there were 219 patients who had a short nail and 340 who had a long nail.

The overall incidence of re-fracture and reoperation was 30 patients out of 559 (5.4%). This included 13 of 219 short nails (5.9%) compared to 17 of 340 long nails (5.0%) ($P = 0.70$, chi-square test). There were 11 of 559 (2.0%) patients who sustained a re-fracture which included 6 of 219 (2.7%) short nails and 5 of 340 (1.5%) long nails ($P=0.35$,

Fisher's Exact test). The average time from primary operation to re-fracture in those 11 cases was 9 months (range 0 to 40). Surgical time was longer in duration for long nails compared to short nails (70 +/- 35 min vs. 52 +/- 22 min, $P < 0.001$, Student t-test). For the subgroup of long nails without a distal interlocking screw, the average operative time was 59 +/- 41min ($P=0.01$ compared with the short nails at 52 +/- 22 min, Student t-test).

There were no differences in failure rates between the three participating hospitals ($P = 0.27$, chi-square test). Mean survivorship defined as freedom from failure including reoperation and/or re-fracture, was 66 months (95% CI: 63-69 months) for the short nail cohort vs. 81 months (95% CI: 78-83 months) for the long nail cohort ($P = 0.53$, log-rank test). Kaplan-Meier estimated 3-year survivorship was calculated at 91% (95% CI: 85-97%) for patients treated with short cephalomedullary nails compared to 94% (95% CI: 90-98%) for those treated with long cephalomedullary nails.

The Cox multivariable regression model indicated that of the eight covariates tested which included age, gender, ASA level, OTA type (A1/A2 vs. A3), number of interlocks, previous TKA, surgical time, and fixation (short vs. long nail), that the only independent risk factors for reoperation or re-fracture were female gender ($P = 0.007$) and previous TKA ($P = 0.05$). All other covariates including age ($P = 0.40$), ASA ($P = 0.62$), OTA type ($P = 0.80$), number of interlocks ($P = 0.67$), surgical time ($P = 0.35$), and short nail versus long nail fixation ($P = 0.61$) were not significantly predictive of failure.

The overall incidence of reoperation, re-fracture or mortality was 202 of 559 (36.1%). This included 80 of 219 short nails (36.5%) compared to 122 of 340 long nails (35.9%) ($P = 0.93$, chi-square test). There were no differences in failure rates (reoperation/re-fracture) or mortality rates between the 3 participating hospitals ($P = 0.28$, chi-square test).

Mean survivorship, defined as freedom from failure (reoperation/re-fracture or mortality), was 46 months (95% CI: 42-51 months) for the short nail cohort in comparison to 56 months (95% CI: 52-61 months) for the long nail cohort ($P = 0.74$, log-rank test). The Kaplan-Meier estimated 3-year survivorship defined as freedom from failure or death was calculated at 62% (95% CI: 55-69%) for patients treated with short nails and 64% (95% CI: 58-70%) for those treated with long nails.

Cox multivariable regression analysis confirmed that among the eight covariates tested including age, gender, ASA level, OTA type (A1/A2 vs. A3), number of interlocks, previous TKA, surgical time, and fixation (short vs. long nail), there were three independent risk factors identified for reoperation, re-fracture, or mortality. These statistically significant risk factors included older age ($P = 0.006$), female gender ($P = 0.025$), and higher ASA level ($P < 0.001$). OTA fracture classification type ($P = 0.60$), number of distal interlocks ($P = 0.09$), previous TKA ($P = 0.67$), surgical time ($P = 0.51$), and short nail versus long nail fixation ($P = 0.27$) were not significant predictors of failure and/or mortality.

Section 4: Discussion, Limitations, Conclusions, & Future Work

To the best of our knowledge, this study is the largest series comparing short cephalomedullary nails to long cephalomedullary nails for the treatment of intertrochanteric hip fractures. This study was designed to compare outcomes for short versus long cephalomedullary nailing hardware repair for intertrochanteric femoral fractures in terms of re-fracture and reoperation not for re-fracture. We found no significant difference between short nail repair compared to long nail repair in regards of re-fracture and major reoperation.

Our study showed an overall incidence of re-fracture of 2%. This included an incidence of 2.7% of re-fracture in short nails and 1.5% in long nails, which was not statistically significant. This incidence is lower than that previously reported in early studies of intramedullary nailing repair for hip fractures based on early, first generation nail designs^{x,xii}. This drop in re-fracture rate is likely secondary to the new design of these intramedullary nails featuring changes in material, curvature, and taper. The new Gamma 3 short nail by Stryker, at a length of 180 mm, features a decrease in mediolateral curvature by 4 degrees, a more flexible titanium composition, and a designed taper from 17 mm proximal diameter to 11 mm distal diameter. Studies looking at these new Gamma 3 nails showed no intraoperative or postoperative fractures in one-year follow up^{xiii}, reinforcing the lower rate of re-fracture found in this series. The only main independent risk factor for re-fracture or reoperation in our series was female gender. This is in line with previous studies which found a 2-3 times higher incidence of primary hip fracture in women when compared to men^{xiv}. When looking at the survivorship of the intramedullary nails excluding mortality, the Kaplan-Meier estimated 3-year survivorship was 91% (95% CI: 85-97%) for patients treated with short nails and 94% (95% CI: 90-98%) for those treated with long nails. For overall survivorship, the Kaplan-Meier estimated 3-year survivorship, defined as freedom from failure or death, was 62% (95% CI: 55-69%) for patients treated with short nails and 64% (95% CI: 58-70%) for those treated with long nails.

As mentioned previously, a shorter surgical time was touted as a theoretical benefit to short cephalomedullary nails for intertrochanteric fractures, especially when considering interventions for extremely sick patients, poor anesthesia candidates, and

poly-trauma patients. This study found a longer surgical time for long (>300 mm) cephalomedullary nails compared to short (180 mm) nails (70 +/- 35 min vs. 52 +/- 22 min, $P < 0.001$, Student t-test). This increase in surgical time is most likely related to additional time needed for the “perfect circles” technique required with long cephalomedullary nails. The perfect circles technique describes the use of intra-operative fluoroscopy to place the distal interlocking screw in the long nails by aligning the lateral and medial hole of the distal interlock fluoroscopically while placing the locking screw percutaneously. This perfect circles technique is avoided with the use of short cephalomedullary nails with the use of custom jig placed externally based on the proximal surgical site that allows for percutaneous placement of a distal interlocking screw without fluoroscopy. This study also showed that even when controlling for the distal interlocks with the long nails, the short cephalomedullary nails operative time was still statistically significantly shorter than long nail procedures (59 +/- 41 min vs. 52 +/- 22 min, $P < 0.001$, Student t-test). In non-emergent situations, the operative time difference of 18 minutes may not be large enough to warrant a clinical paradigm shift in one’s practice. However, this 18-minute difference may carry more weight in situations where exceedingly sick patients or poly trauma patients warrant shorter operative time as well as the cases where distal interlocking screws are a necessity to guarantee rotational control of the fracture pattern.

Our cohort study generated an average time from initial operation to re-fracture of 9 months, or approximately 36 weeks, with a range of 0-40 weeks. This time to re-fracture falls within timelines generated by previously studies by Robinson et al which reported a 30 week average time to re-fracture with the Gamma nail with a range of 3-82 weeks^{xv}. Additionally, our cohort study found a mortality rate of 25% during the first post-operative year. While this rate may appear disturbingly high at first, it is within the anticipated range of 14-36% at one year post-operative previously established in the published literature investigating the surgical fixation of hip fractures^{iv,vi}. This concurrence in one-year mortality helps show that our incidence of re-fracture is not falsely lowered simply due to the sample population not surviving long enough to sustain re-fracture or necessitate reoperation. Moreover, all reported re-fractures occurred within 40 weeks, thus warranting our one-year follow up as adequate.

While this study is the largest case series analyzing prospectively collected data comparing outcomes with the use of short versus long cephalomedullary nails, several limitations were encountered. First, the study had a 20% lost to follow up rate. Because the study's trauma database included three Level-1 centers (BIDMC, MGH, BWH) all within one city, we anticipated it would be unlikely patients would be transferred back to one of these institutions for re-operation. Secondly, the important consideration of osteoporosis was not controlled for between the two groups as bone mineral density levels were not measured and included in our database. However, our two groups demonstrated a similar average age and from that we extrapolate similar bone mineral density levels between the two cohorts. In addition, our study would have benefitted from collecting the post-operative ambulatory status of our patients to allow further analysis on the effect of differing load bearing mechanics on the nail-femur contact surface and on the implant itself. Lastly, while the trauma database utilized was a prospective database, our study was a retrospective review in nature, which brings with it innate limitations. These retrospective confines include utilizing records not designed or collected for this particular study, possible absence of confounding factors from the database since it was collected in the past, and the aforementioned differential loss to follow up.

Our clinical outcomes observation study looking at short versus long cephalomedullary nails was conducted under the assumption that short and long nails differ biomechanically and that newer generation short nails could offer several advantages over long nails while avoiding previously feared complications encountered in earlier designs. Early studies investigating first generation short cephalomedullary nails reported a stress riser at the diaphyseal femur corresponding to the nail's distal tip as a potential cause of the high-rate of re-fracture^{x,xi}. Given the rigid nature of the stainless steel nails as well as the lack of anatomical design, this conclusion was highly probable. However, these issues have been addressed with new generation short cephalomedullary nails which tout a titanium composition yielding a lower modulus of elasticity, a tapered distal tip, and a more anatomic anterior/posterior bow. Additionally, while re-fracture complications were at first reserved for first generation short nails, time and implementation of long (>300cm) nails has shown that these implants can also produce a stress riser at the nail's distal tip. And with long cephalomedullary nails, that distal tip falls in the metaphyseal region of

bone, generally regarded as the weakest region of bone, where perioperative fractures can also arise (Figure 2A and 2B).

Our current study helped illustrate the efficacy and safety of short cephalomedullary nails compared to long nails for surgical repair of intertrochanteric fractures in patients over the age of 65, but it also spurred several ideas for future work in the field. One possible field of study could involve looking at researching mechanical factors such as length, radius, shape, and elasticity of intramedullary nails to help define the biomechanics of these implants in osteoporotic bone. Such a study could build off of previous work illustrating how the mechanical properties of bone change with age, which in turn elevates the risk of fracture^{xvi}, as well as help to further elucidate the anatomical change that occurs with intramedullary nailing^{xvii}, and how these changes tie into the alteration in biomechanics secondary to nailing and its implication on fracture susceptibility. Additional work could also be done with a closer focus on ambulation status secondary to intramedullary nailing. These studies could help hone in clinical decision making regarding implant choice based on patient lifestyle as well as illuminate the biomechanical stresses endured by the implant and femur secondary to the variance in load and work cycles brought forth by various ambulation classes.

Our study looking at short versus long cephalomedullary nails for the surgical fixation of intertrochanteric fractures in patients age 65 or older found no difference in the rate of re-fracture or reoperation when comparing the newest generation of each short and long nail. From our data and analysis we conclude that safe, predictable outcomes for the surgical fixation of intertrochanteric hip fractures are obtainable with both short and long cephalomedullary nails.

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Tables & Figures:

Table 1. Description of causes of nail failure

Long nails	
Periprosthetic fracture	5
Non-union with screw/blade cutout revised to arthroplasty	5
Screw/blade cutout revised to shorter screw/blade	4
Screw/blade cutout (healed fracture) revised to arthroplasty	1
Fall causing traumatic cutout of screw/blade revised to shorter blade	1
Conversion to arthroplasty for progressive rheumatoid arthritis (no implant failure)	1
Totals	17
Short nails	
Periprosthetic fracture	6
Screw/blade cutout revised to shorter screw/blade	3
Screw/blade cutout (healed fracture) revised to arthroplasty	2
Conversion to arthroplasty for avascular necrosis of femoral head s/p radiation (no implant failure)	1
Conversion to arthroplasty for leg length discrepancy (no implant failure)	1
Totals	13

Table 2

Multivariable Cox Regression: Predictors of Outcome after Index Surgery

Variable	Nail Failure (P-value)	Survivorship (P-value)
Age, years	0.40	<0.01*
Gender	0.007*	0.25
ASA level	0.62	<0.001*
OTA type (A1/A2 vs. A3)	0.80	0.60
Number of interlocks	0.67	0.09
Previous TKA	0.04*	0.67
Surgical time, mins	0.35	0.51
Fixation (short vs. long nail)	0.61	0.27

* Statistically significant independent predictor

Figure 1: Flowchart of Patient Selection

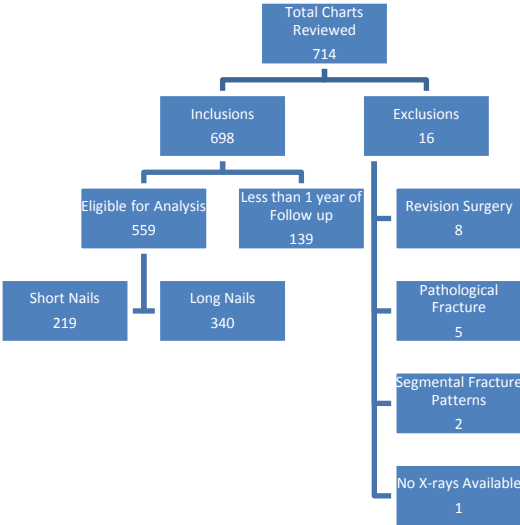


Figure 2A showing periprosthetic fracture distal to long nail



Figure 2B showing periprosthetic fracture distal to long nail



Figure 3 showing periprosthetic fracture distal to short nail



Figure 4 showing screw/blade cutout



Figure 5

Kaplan-Meier Freedom from Nail Failure According to Fixation

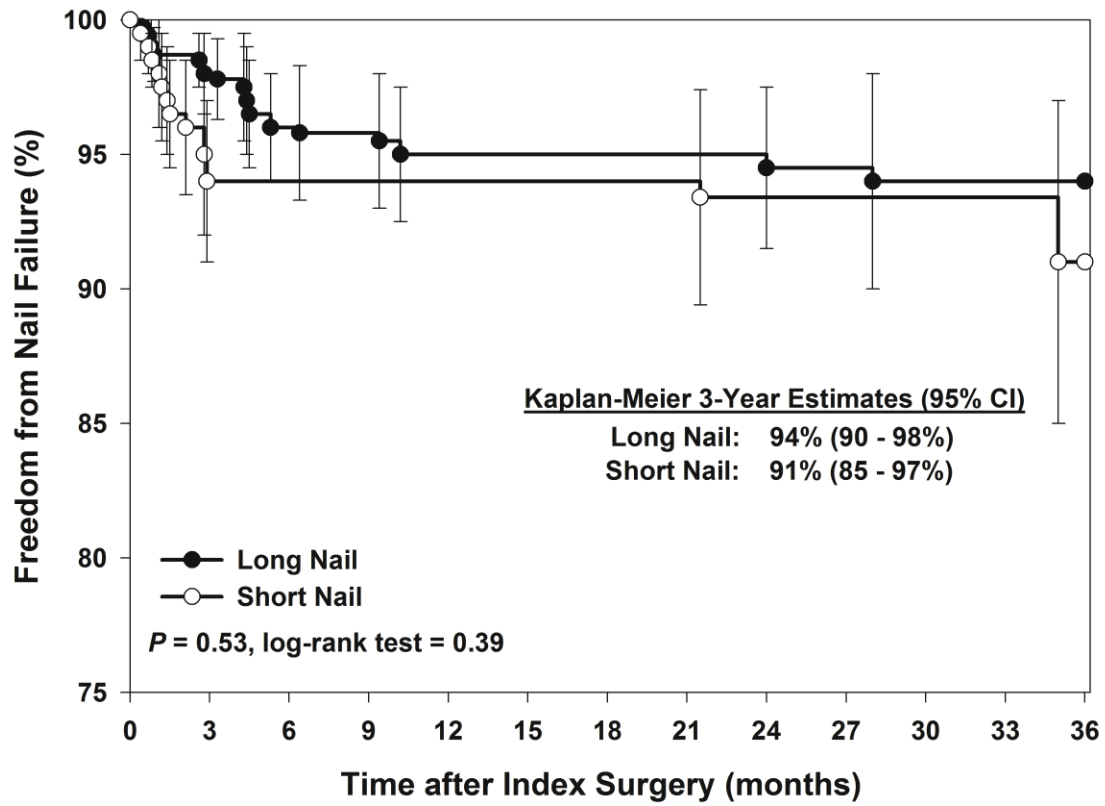


Figure 6

Kaplan-Meier Estimated Patient Survivorship According to Fixation

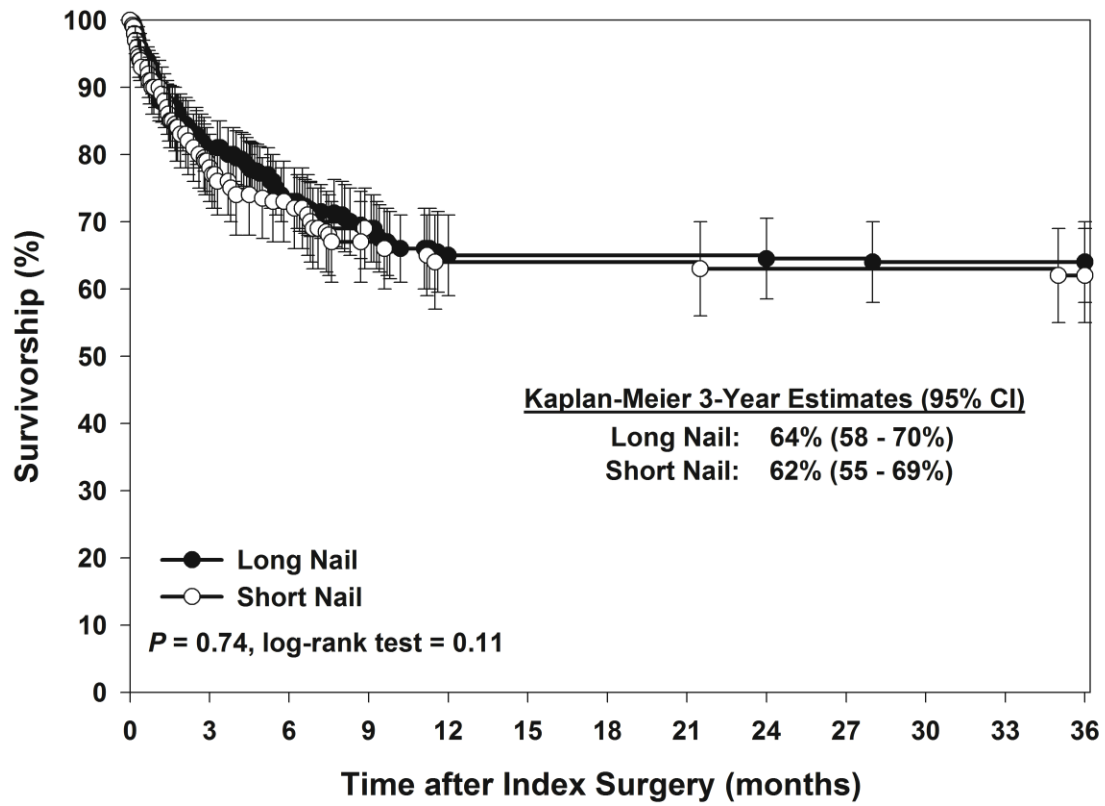


Figure 7 showing post-operative periprosthetic fracture



Figure 8 showing anatomical distinction of inter- versus sub- trochanteric fractures

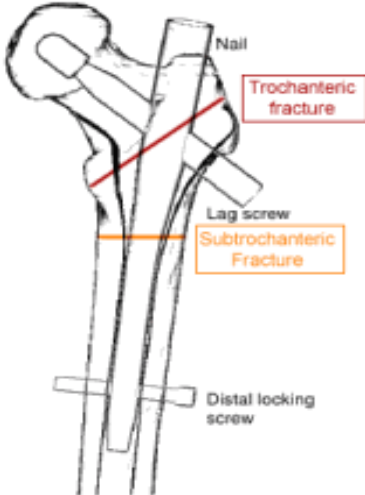
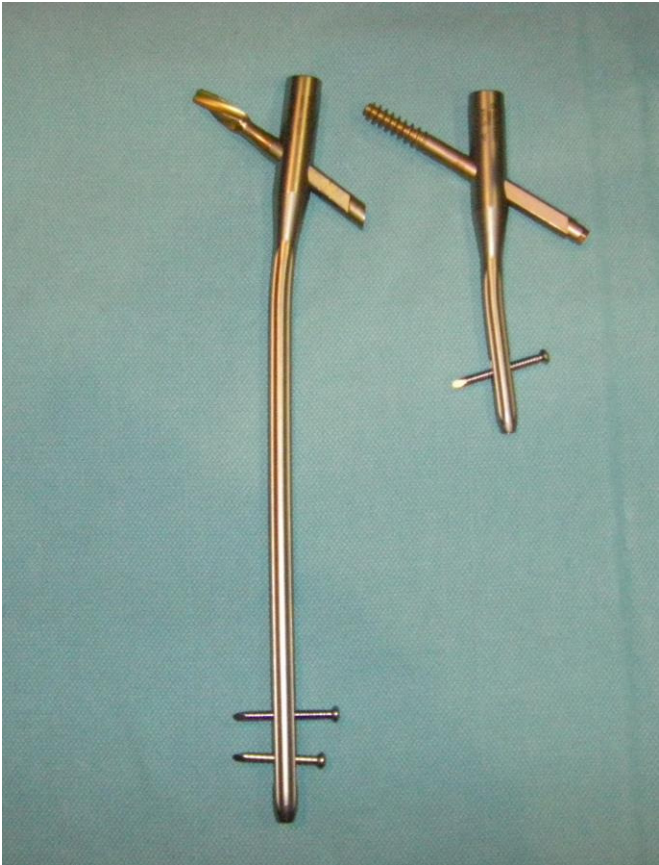


Figure 9 showing side by side comparison of long and short CMN



Appendices:

Appendix A: ASA Classification System^{xx}

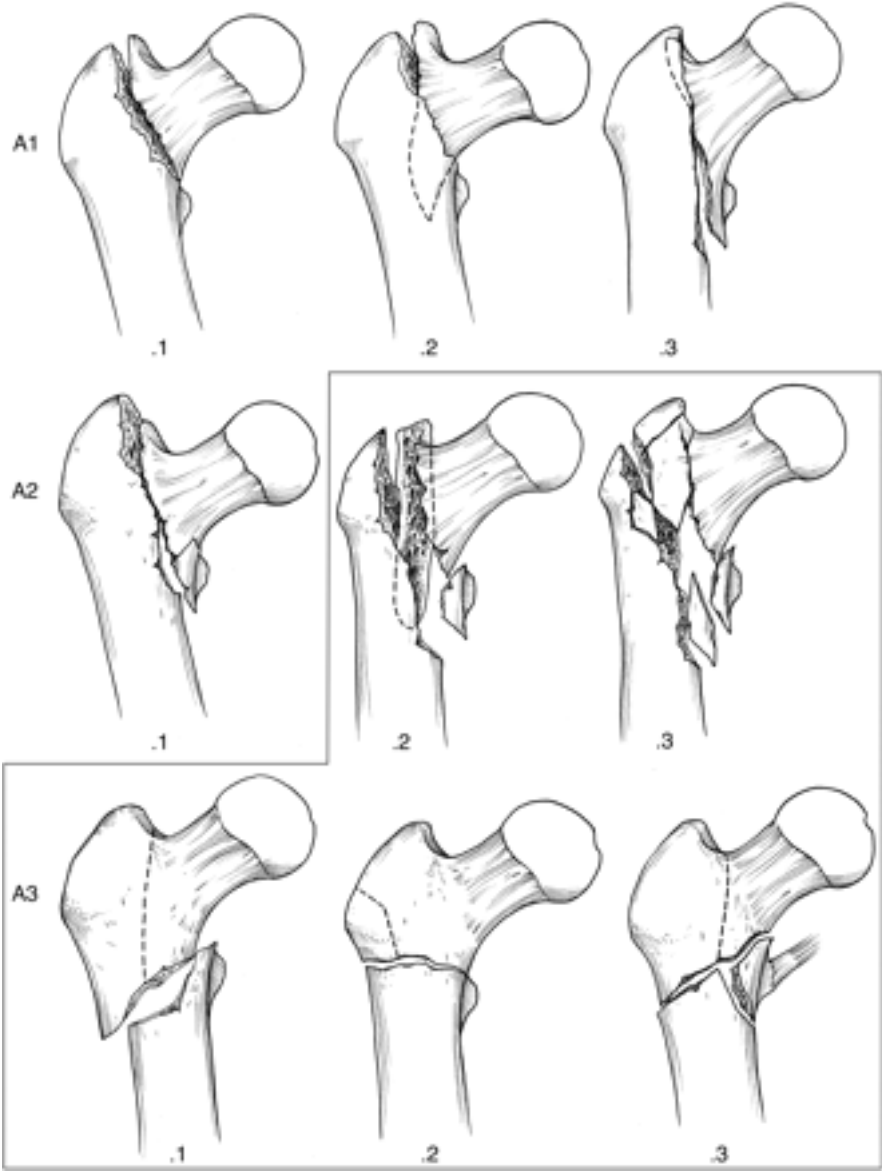
The modern classification system consists of six categories, as described below.

ASA PS Category	Preoperative Health Status	Comments, Examples
ASA PS 1	Normal healthy patient	No organic, physiologic, or psychiatric disturbance; excludes the very young and very old; healthy with good exercise tolerance
ASA PS 2	Patients with mild systemic disease	No functional limitations; has a well-controlled disease of one body system; controlled hypertension or diabetes without systemic effects, cigarette smoking without chronic obstructive pulmonary disease (COPD); mild obesity, pregnancy
ASA PS 3	Patients with severe systemic disease	Some functional limitation; has a controlled disease of more than one body system or one major system; no immediate danger of death; controlled congestive heart failure (CHF), stable angina, old heart attack, poorly controlled hypertension, morbid obesity, chronic renal failure; bronchospastic disease with intermittent symptoms
ASA PS 4	Patients with severe systemic disease that is a constant threat to life	Has at least one severe disease that is poorly controlled or at end stage; possible risk of death; unstable angina, symptomatic COPD, symptomatic CHF, hepatorenal failure
ASA PS 5	Moribund patients who are not expected to survive without the operation	Not expected to survive > 24 hours without surgery; imminent risk of death; multiorgan failure, sepsis syndrome with hemodynamic instability, hypothermia, poorly controlled coagulopathy
ASA PS 6	A declared brain-dead patient who organs are being removed for donor purposes	

ASA Physical Status (PS) Classification System*:

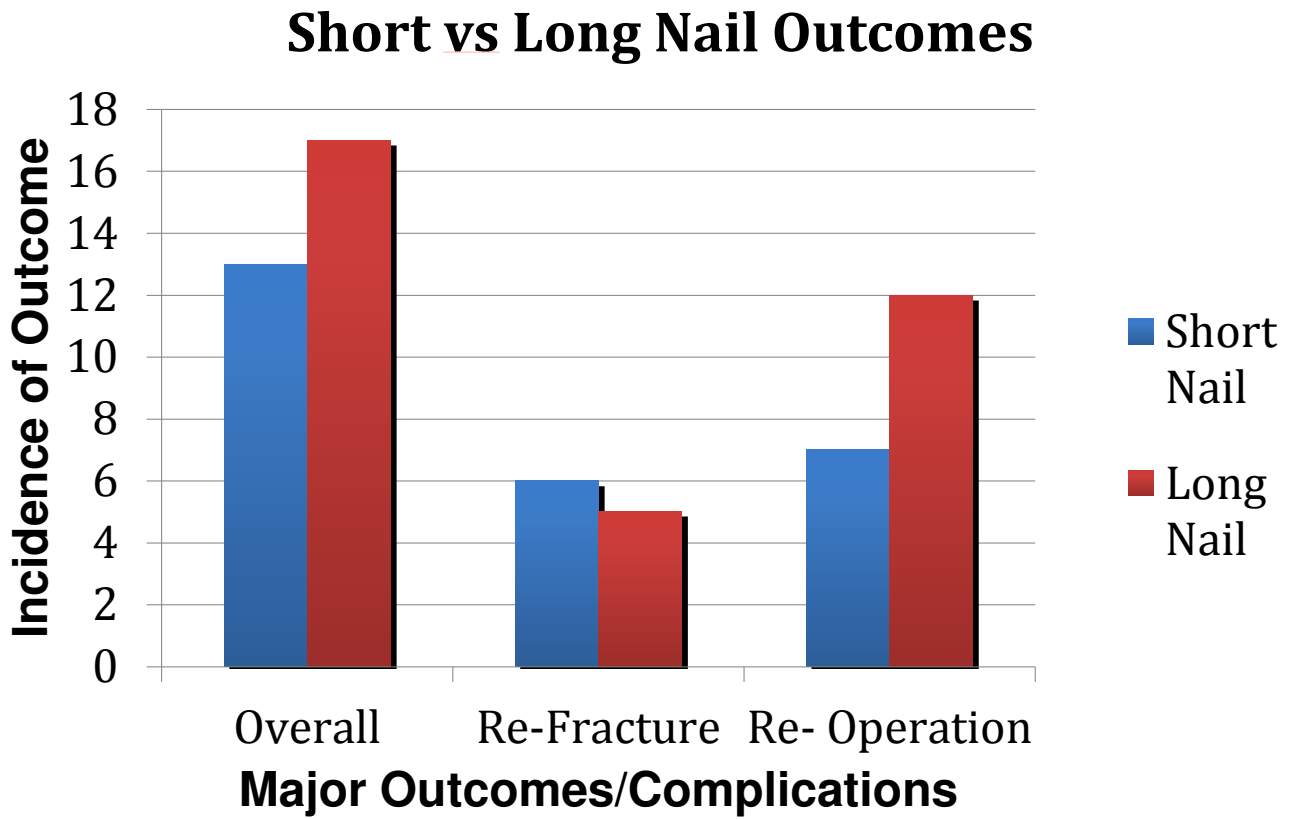
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Appendix B: OTA Intertrochanteric Fracture Classification^{xix}.



*Boxed subtypes represent unstable fracture patterns

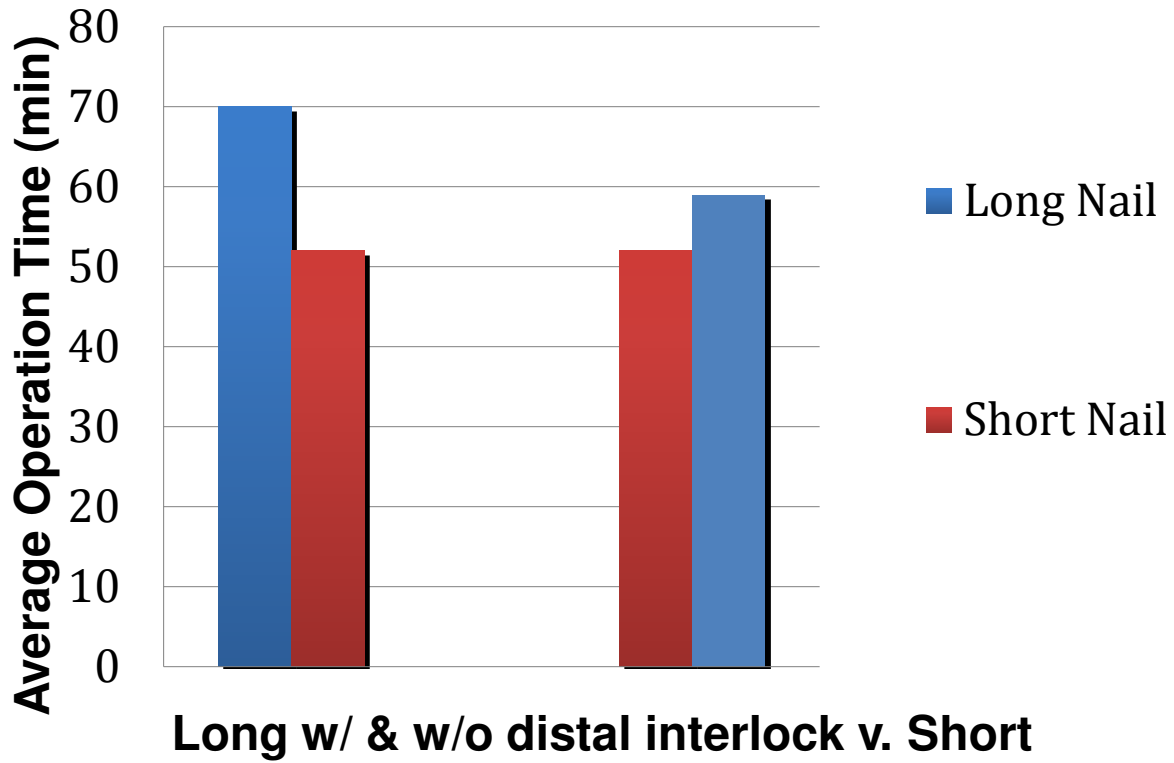
Appendix C: Graphical Representation of Outcomes



There was no statistical difference between short v. long nails in regards to major outcomes (re-fracture and reoperation).

Appendix D: Graphical Representation of Surgical Time

Surgical Time



Long nail surgical fixation had a longer operation time even after controlling for distal interlock.