Medical Research Archives

ESMED
European Society of Medicine

OPEN ACCESS

Published: November 30, 2022

Citation: Lekhi A, Patel K, et al., 2022. Proximal Femur Replacement: Complexities and Learning Points, Medical Research Archives, [online] 10(11). https://doi.org/10.18103/mra.v10i11.2992

DOI
https://doi.org/10.18103/mra.v10i11.2992

ISSN: 2375-1924

RESEARCH ARTICLE

Proximal Femur Replacement: Complexities and Learning Points

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ABSTRACT
Proximal femur replacement (PFR) or Proximal femur reconstruction is a way of salvaging excess bone loss in proximal femur and yet providing a total hip replacement
The article aims to highlight the technical difficulties and comorbidities associated with this complex procedure of proximal femur replacement. We retrospectively evaluated eight complex typical PFR cases performed under the care of same team of two surgeons, from 2013 to 2021, to highlight the various technical difficulties and complications that may be incurred during such a major salvage surgery. This was intended to help prepare the fellows, colleagues and future surgeons to have a plan of action and holistic approach towards the process. Average age of 87.4 years makes it a challenge both pre-operatively and post operatively in view of comorbidities existing in this age, apart from the technical difficulties of PFR. Complications observed were difficult rehabilitation, infection, pulmonary embolism deep vein thrombosis, dislocation, limb-length discrepancies and death. This is a level IV evidence case series with individual case description along with respective radiographs.

Introduction

Proximal femur replacement or Proximal femur reconstruction is a way of salvaging excess bone loss in proximal femur and yet providing a total hip replacement. Literature reviews in past have indicated 10 to 45 % patients suffering moderate to severe complications following a proximal femur trauma surgery and immobility as a major contributing factor for morbidities in the elderly. It allows for faster return to routine function and helps prevent morbidities associated with prolonged in bed immobilisation.[1,2,3,4,5,6]

Many patients undergo revision hip surgery for excess bone loss (traumatic or atraumatic), soft tissue loss, deep infections, peri-prosthetic osteolysis or loosening and peri-prosthetic fracture. It is an effective way from hip replacement and return elderly osteoporotic patients with proximal femur fractures unamenable to straightforward fixation.

Aim

The article aims to highlight the technical difficulties and comorbidities associated with this complex procedure of proximal femur replacement and present similar surgical scenarios, faced whilst managing complex revision and re-revisions involving proximal femur replacement as the salvage method. To fulfil this aim, the planned objective was to retrospectively evaluate the case series of proximal femur replacement available at hand and highlight the various learning points.

Background

The search for literature includes EMBASE, Google Scholar, Cochrane reviews, PubMed library, using the keywords Revision hip arthroplasty+REEF stem, Femur Peri-prosthetic fracture + REEF stem, Diaphyseal engaging femur stem prosthesis, Interlocking femur prosthesis.

In a case series from 2005, published by Klein, Parvizi et al[7], 21 Vancouver B3 type femur periprosthetic fracture patients underwent a proximal femur replacement. The results indicated proximal femur replacement as a viable surgical option in periprosthetic fractures.

Many researcher and hip surgery units have advised proximal femur replacement as an option in significant proximal femur bone loss and also in trauma with uncertain bone quality to support a good fixation.[1,2,5,6,8,9,10] A widely accepted classification system for determining the reconstruction procedure is Paprosky classification.[11] Another classification for bone loss is AAOS (American Academy of Orthopaedic Surgeons) classification for bone loss in femur.[12] Apart from these, broadly observing the involved Gruen zones[11,23] on anteroposterior and lateral femur radiograph views is a useful step in initial surgical planning for femur periprosthetic loosening. Post-operative dislocation is the most common complication given the loss of the bone and deficient abductor mechanism.[13] A 2008 publication by Schoenfeld et al, shows 2 dislocation in primary and 1 in revision groups with PFR. A total of 22 PFR were done in 21 patients.[14] A publication in 2017 by Viste A et al quotes, they had a 15 % dislocation rate in the retrospective review of the 44 patients who underwent PFR between 2000 and 2013. Their Kaplan-Meier analyses indicates 86 percent survivorship free of any revision surgery post PFR at 5 years and 66% years at 10 years.[15] Use of constrained acetabular liners can help reduce the rate of dislocation that is one of the major complications with deficient abductor mechanism in patients undergoing PFR.[16] A study published in 2019 with 21 PFR patients, states a favourable outcome in elderly proximal femur trauma with comminution and poor bone stock.[17]

Methods

We did a retrospective analysis of the eight revision hip arthroplasties with proximal femur replacement (PFR) under the care of same team of two surgeons, from 2013 to 2021. This is a level IV evidence study. The patients with metastasis in pelvis and proximal femur replacement for proximal femur tumours were not included in this set of case series.

The patients underwent hip replacement with a Depuy™ Revision Hip Proximal Femur Replacement system and a ring constrained acetabular liner (Depuy™) where applicable. One patient had a re-revision surgery post PFR for instability, where the original Stanmore- PFR was retained. We used Computed tomography (CT) scan in all these patients for pre-operative planning. It played an important role in assessing bone loss from technically significant landmarks (for example, the Calcar of femur) and also to assess the amenability of viable bone stock to reconstruction and preservation.

The clinical outcome was assessed based on the documented clinical examination in notes, post-operative follow-up radiographs and patient's input in terms of satisfaction and return to routine function. The main criterion for outcome analysis was number of dislocations post-operatively. Other criteria that were assessed, include weight bearing status, limb-length discrepancy, repeat surgery,

infection, implant failure, medical complications, deep vein thrombosis, peri-prosthetic fractures post-surgery and one-year mortality.

Results

The results from this study can be summarised in the following table:

Mean age at surgery	87.4
Average number of previous surgeries	2
Dislocations after PFR	1 after Depuy and 1 after Stanmore PFR (from Previous surgery)
Infections after PFR	2
Peri-prosthetic fracture post PFR surgery	1
Deep Vein thrombosis /Pulmonary embolism	2
Limb Length discrepancy	1
Loosening if prosthesis and Implant Failure	0
Average change in Harris Hip score in the first 6-month post-operative period (2 patients did not attend the score/clinical visits beyond a year)	60 to 72
Average follow up	1 year; 1 on –table death towards the end of procedure
One-year mortality	2

Case 1

This patient underwent proximal femur replacement at another centre and had two episodes of dislocation in the first year post operatively for which a re-revision was planned at the age of 82 years. The original Stanmore-METS™ type PFR was found well fixed and hence retained. The loose cerclage wires were removed and original Marathon™ cup was reamed out and revised to Gryption™ cup with screws. A constrained acetabular liner with a locking ring was installed for providing better stability (Figures 1 and 2). Full weight bearing mobility was achieved post operatively. No episodes of dislocation. He passed away in early January 2017 from heart failure.

Figure 1. Preoperative radiograph (2014) before PFR and the second episode of dislocation in November 2015 with a Stanmore PFR in situ.

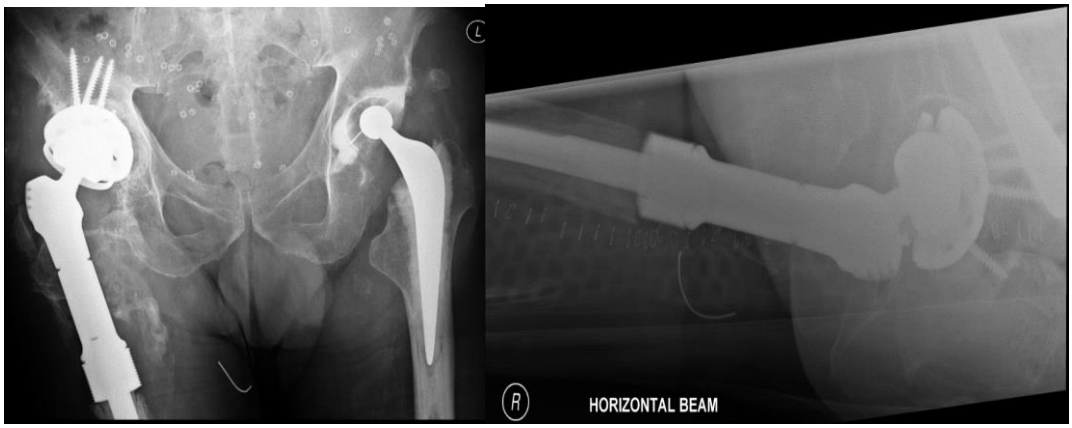

Figure 2. December 2015: Radiograph after Revision surgery with constrained liner and locking ring in situ

Learning points

- Constrained liner use is advisable as salvage option for repeated dislocation with PFR implant in situ
- Pre-operative CT scan plays an impprtant role in assessing proximal femur bone stock and surgical planning

Case 2

This patient had a Vancouver Type C peri-prosthetic repeat fracture with implant failure 2 years post open reduction and internal fixation surgery. It initial management was with further plate fixation, screws and cables that failed.

The patient was admitted with a painful hip and was being planned for intervention in view of a loose acetabular cup. It was managed by PFR in 2012 (age at the time of surgery was 100 years).

Removal of cement from anterior aspect of knee was done in May 2016 for impingement signs. The sequence of events can be correlated to the images in Figures 3,4,5 and 6. The patient went on a cruise trip as well in 2017 and used Zimmer walking-frame to mobilise short distances. For long distance she uses wheelchair. She has been very satisfied with her improved quality of life and is currently 105 years old.

Figure 3. Radiograph after initial THR (Total Hip Replacement) in 2010, which had a peri-prosthetic fracture Vancouver type C, 2 years following index THR.

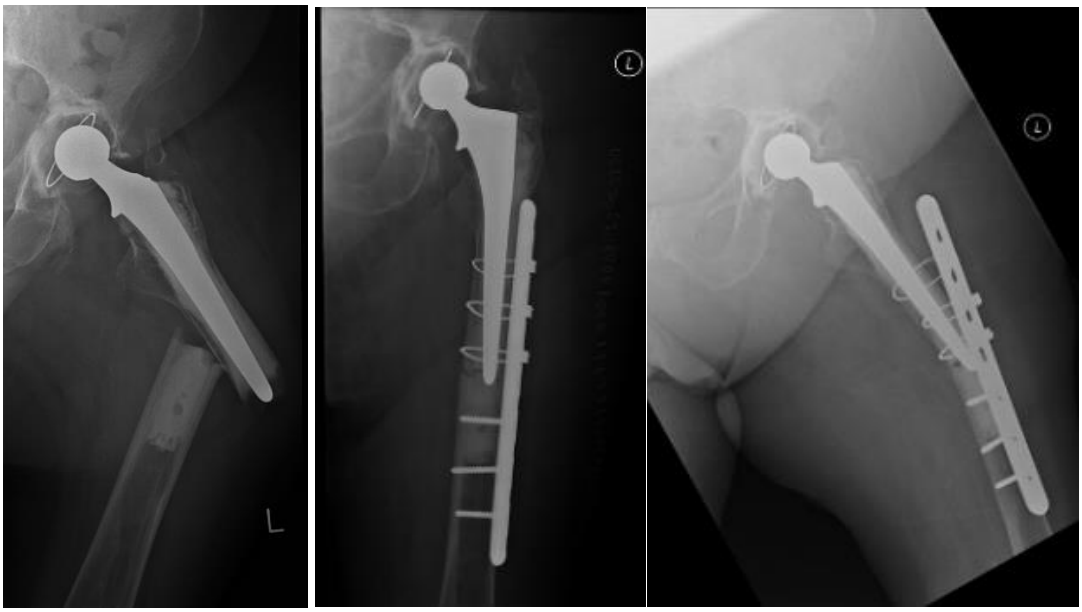

Figure 4. An insufficiency fracture was sustained while standing up from bed- Lymphocytic Peri-prosthetic fracture (as per radiology reports) managed by plate, cables and screws in 2012, followed by implant failure and a repeat fracture. This was then managed with PFR as seen in the follow up radiograph (2016).

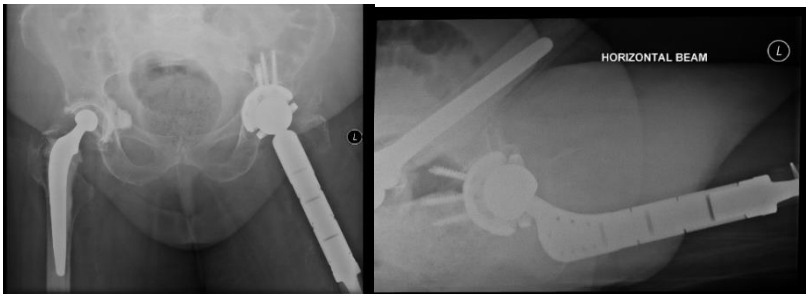

Figure 5. Radiograph from March 2016 upon follow up in clinic

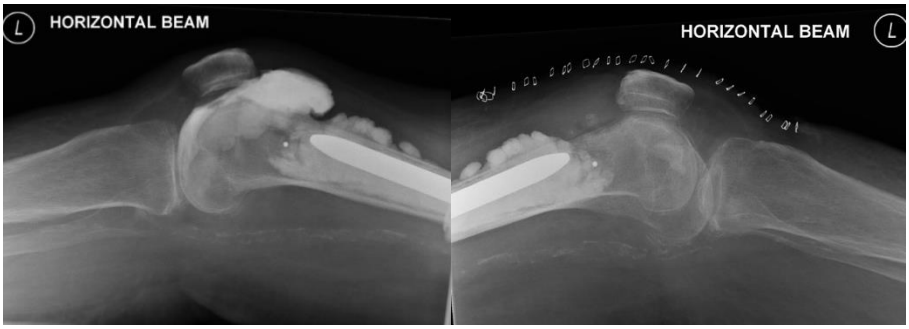

Figure 6. April 2016: Excess cement causing impingement signs, pain and foreign body sensation in anterior knee. Second image showing removal of extruded cement from anterior knee in May 2016

Learning points:
-Implant failure for a peri-prosthetic fracture resulted in need for a complex re-revision that was PFR
- Osteoporotic and insufficiency fractures with minor movements
-Cement extrusion from peri-prosthetic fracture site can cause foreign body sensation and impingement symptoms

Comorbidities:
Hypertension/hypothyroidism/glaucoma/osteoarthritis

Case 3

The patient had her original THR 1987, revised once in 1997, followed by a failed peri-prosthetic fracture (Vancouver Type C) fixation in February 2015. This was re-revised to a PFR in June 2015 (Figures 7 and 8) at the age of 87 years which was

followed by mild abductor weakness post operatively and mobility gradually improved to a tripod frame for mobilising independently.
As per the follow up documentation in February 2017, there was no distal neurovascular deficit in the operated limb and no limp in gait. She used a wheeled-walker frame, had painless hip and was highly satisfied. She passed away at 91 years of age in June 2019 of old age.

Figure 7. June 2015: Pre-operative radiograph with implant failure

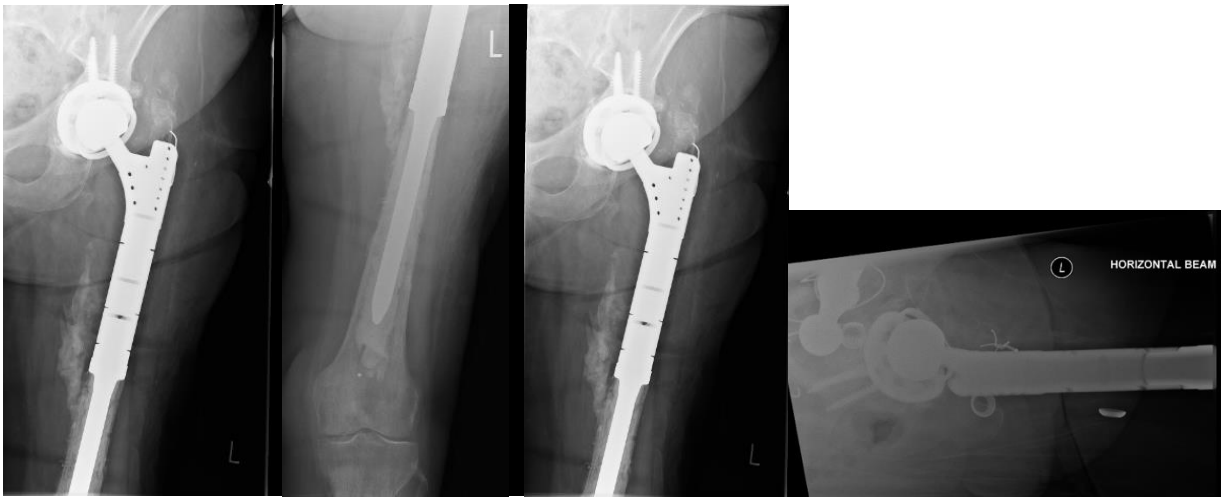

Figure 8. September 2015: Follow-up radiographs and 2017 follow-up radiographs.

Learning points
-PFR may be considered in first revision surgery if poor bone quality and less likely chance of healing -- keeping low threshold for proximal femur replacement in a non-reconstructible proximal femur bone during index periprosthetic fracture
-Mild to moderate abductor weakness is a common complication and associated morbidity with such a complex surgery that may improve partially with continued physiotherapy and efforts by an encouraged and enthusiastic patient

Case 4
This patient had non-union of left sub-trochanteric fracture with failed intramedullary interlocking nail in situ complaining regarding inability to weight bear. She was referred via concerned general practitioner to out-patient clinic. She underwent elective proximal femur replacement at the age of 82 years (Figures 9 and 10). This is the longest follow up available with us, almost nearing a decade.

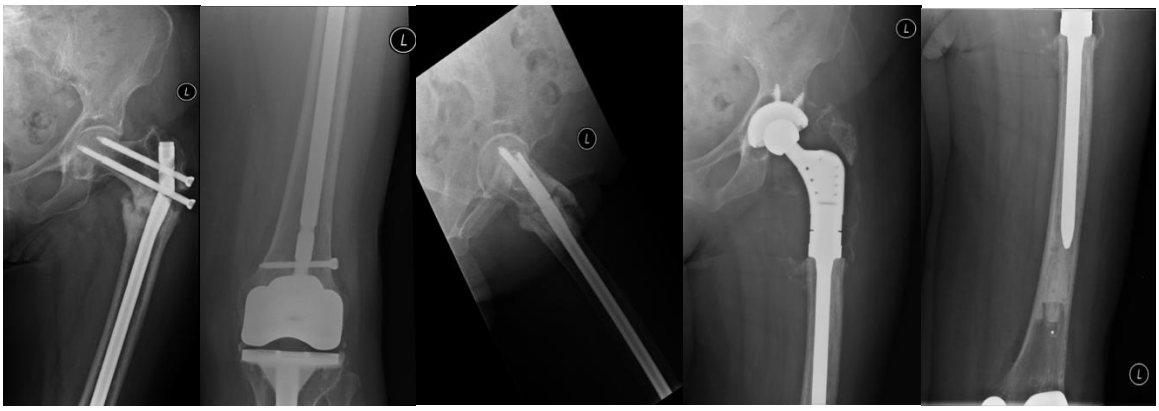

Figure 9. Pre-operative radiograph with implant failure and post-operative radiographs (2012)

Figure 10. 2013 Follow up radiographs and 2021 follow- up (on extreme right) radiograph respectively

Comorbidities: Atrial flutter, osteoporosis, previous CVA with right sided weakness, Zimmer walking-frame for mobility.

Learning points: with good bone stock and abductor repair, proximal femur replacement can serve the purpose without any constrained acetabular liner as well.

Case 5

The patient sustained a right femur Vancouver type C peri-prosthetic fracture (Figure 11) after a fall at home. After detailed consent from patient and the family, a proximal femur replacement was planned, liaising with anaesthesia team. (Patient was 87 years old at the time of surgery)

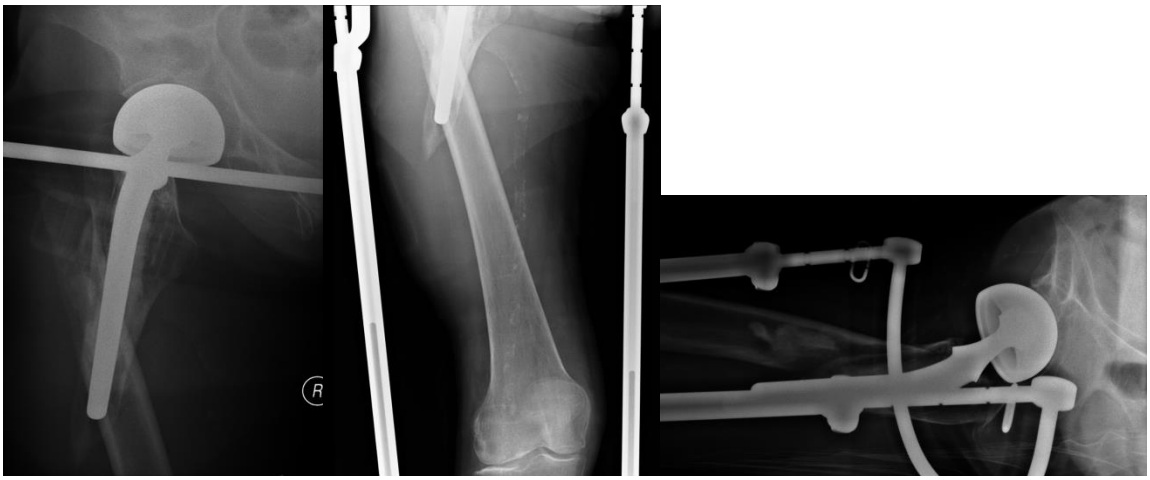

Figure 11. Pre-operative radiograph from 2016

Unfortunately, within 3 minutes of femur cementation- on table cardiac arrest managed by CPR and medications 15 minutes: chances of survival were minuscule and hence locking ring placed but not locked. As per anaesthesia team's advice- quick closure over one drain and clips for skin. Patient passed away towards the end of procedure. Family was duly updated of the events.

Comorbidities: cardiac failure in past
Learning points
- Bone cementation syndrome and cardiac risks are life threatening scenarios.
-High risk and risk to life – detailed informed consent and involvement of next of kin

Case 6

At the age of 83, this female patient underwent a revision hip surgery for peri-prosthetic fracture Vancouver type B3 in right femur and loosened acetabulum cup with acetabular bone loss in situ.
Mechanism of injury: Fell in bathroom onto right hip
She had bilateral total hip replacements in situ for more than 25 years at presentation. Left hip had also been revised for instability and loosening in the past. The patient underwent a complex revision with impaction bone grafting for acetabular bone loss in Charnley's zones I, II and III and Proximal femur replacement with constrained liner (Figures 12,13 and 14).
Right hip cellulitis was observed 3 weeks post operatively and managed with intra-venous antibiotics. There was no intra-articular infection clinically or radiologically with unaffected hip mobility.

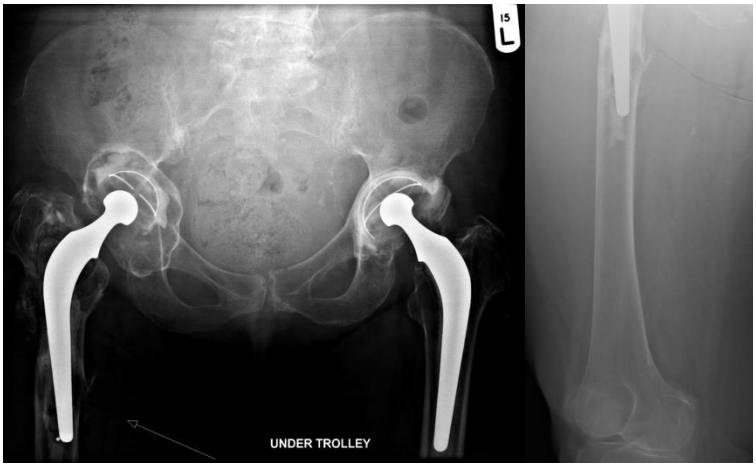

Figure 12. At presentation in September 2019

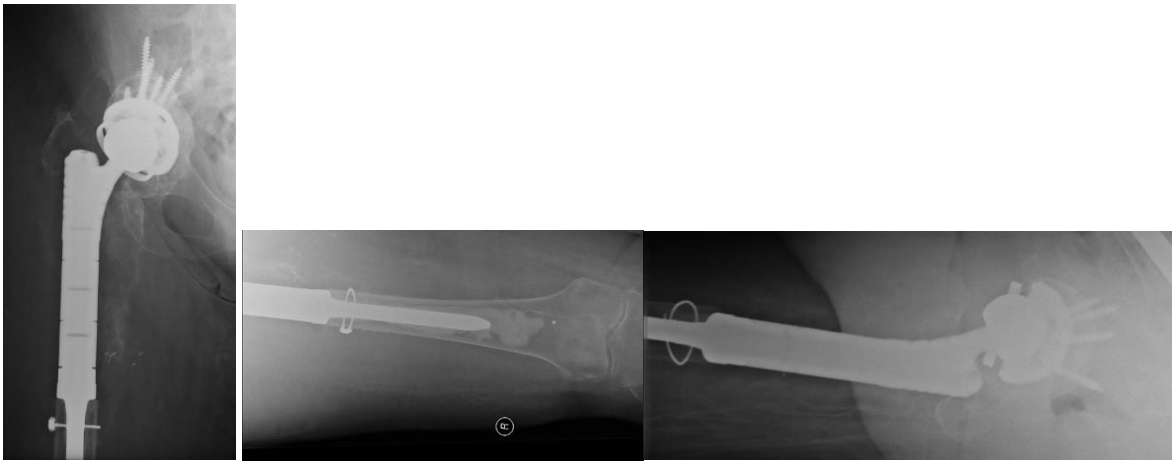

Figure 13. Post-operative radiographs and follow up from November 2019

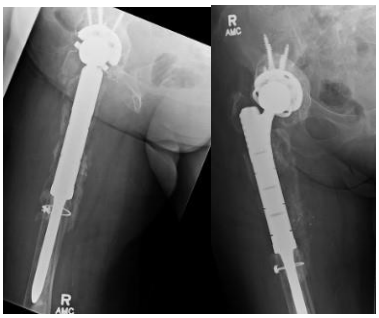

Figure 14. Satisfactory position of implant and well contained impaction bone graft seen in December 2019

At 2 month follow up: Mobilised independently with one walking stick
No dislocation or instability.

Comorbidities: Hypertension, Heart failure (occurred 2 months post-operatively and medically managed)

Learning points:
-Constrained acetabular liners can be used in bone defects managed with impaction bone grafting
-Keeping low threshold for infection management initiation after a major joint surgery.
-Long term medical complications and thromboembolism episodes and looked for at regular intervals in the first post-operative year.

Case 7

This patient underwent a PFR for broken intra-medullary interlocking nail due to non-union of sub-trochanteric left proximal femur fracture at 66 years of age. The procedure was uneventful. She dislocated the prosthesis 18 days post-operatively while bending forward bedside and had a failed closed reduction. The PFR for this patient was not done using a constrained liner in view of high functional demand and relatively young age. Her hip had to be re-revised with a constrained liner and locking ring. Previously attached greater and lesser trochanters had come off the prosthesis as appreciated on re-revision and were re-attached and repaired as possible (Figures 15, 16 and 17). Unfortunately, she was diagnosed with Acute Myeloid Leukaemia (AML) with a poor prognosis. She also developed deep vein thrombosis (DVT) 7 months after the re-revision and managed medically. Unfortunately, she also dislocated the right total hip prosthesis, the fourth time which was managed by closed reduction and hip brace (for 6 weeks) in view of her comorbidities and high risk. She passed away at 67 years of age with AML while on treatment dose for DVT.

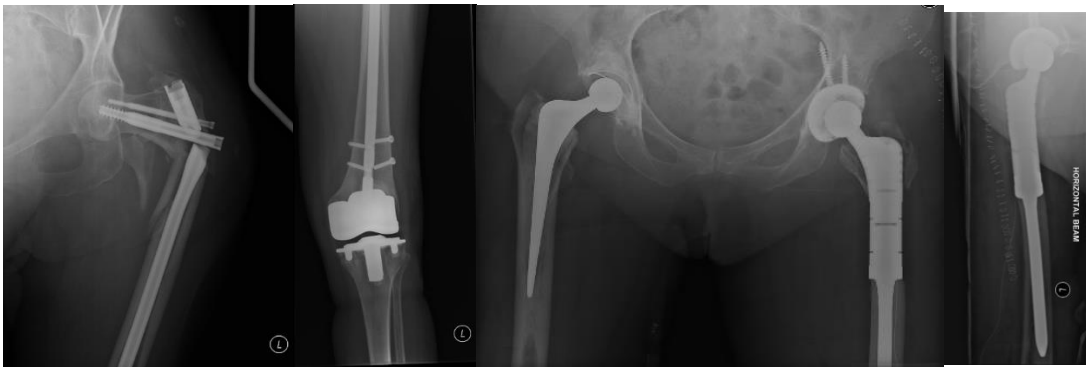

Figure 15. Pre-operative and Post-operative radiographs from October 2013

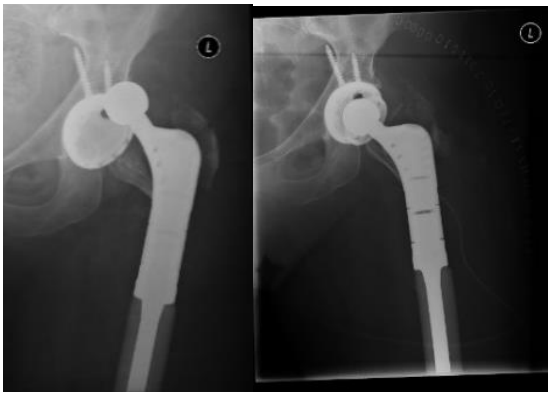

Figure 16. Dislocation in situ 18 days post-operatively and Re-revision to put a constrained liner with locking ring with a new femoral head (November 2013).

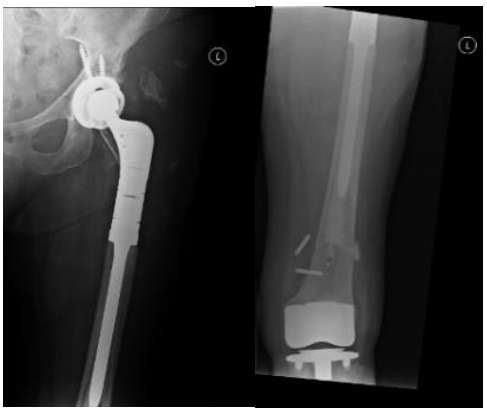

Figure 17. Satisfactory follow-up radiographs from June 2014

Comorbidities:
-AML (poor prognosis), DVT left iliac vein, Rheumatoid arthritis, Sjogren's syndrome (with dry mouth)
Learning points

-Constrained liner serves a better salvage option while performing proximal femur reconstruction in patients with lack of abductor soft tissue and poor bone quality. It may be placed even with intact greater and lesser trochanteric attachments when stability is a priority over range of motion.
-Deep vein thrombosis is a major complication that may occur later during the course of recuperating after a major lower limb surgery and can prove life threatening. Hence treatment for same must be started with a low threshold and close monitoring is required.
-Patient consenting and updating next of kin is crucial in major surgical procedures with possibility of life-threatening complications.

Case 8
This was 91-year-old lady at the time of presentation with a periprosthetic Vancouver B2 fracture with loose Ogee acetabular cup component who underwent a complex revision surgery for the right hip with proximal femur replacement (PFR) with constrained acetabular liner (Figures 18 and 19). She had an Abbreviated mental test score (AMTS) of 9/10 and used one stick and occasionally crutches to mobilise in routine. She was being evaluated for signs of dementia whilst in patient, but no diagnosis arrived at for same.

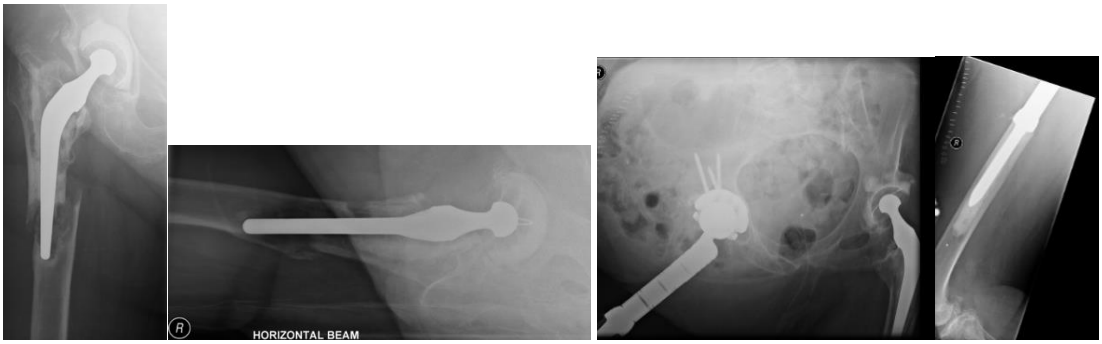

Figure 18. Pre-operative radiograph in 2017 and Immediate post-operative radiograph

Figure 19. Follow-up radiographs from April 2018

Post –operatively she recuperated gradually to her routine baseline activity status. She did develop cellulitis at the distal end of scar around eight days post-operatively, which was managed with antibiotics and no further infection was observed in follow up visits. She had developed AKI (Acute Kidney Injury) with raised eGFR (46) in immediate post –operative period (acute on chronic) that was managed with medical team's input and eGFR (estimated glomerular filtration rate) returned to satisfactory range. She continued to use a Zimmer mobility frame for mobility purpose. She had a 2 year follow up with us and passed away at the age of 93 years.

Comorbidities
-Cerebrovascular accident in the past, hearing impairment, chronic kidney disease, osteoarthritis, essential hypertension, asthma, bilateral cataracts, left ventricular hypertrophy

Learning Points

-Mobility may not return to the pre-operative state as in this case it was shifted from a single walking stick pre-operatively to a walking frame.
-Close observation for post-operative wound infection is an important part of post-operative care. A timely intervention in this case prevented an angry looking distal end wound cellulitis from developing into a worse wound infection.
-AKI (Acute Kidney Injury) is a complication observed with antibiotics post major surgical procedures in elderly population and needs medical management with careful balance of intra-venous fluid administration alongside comorbidities.
-Detailed consenting is important as this patient did not have a DNA-CPR (do not attempt cardio-pulmonary resuscitation)

Ethics
Ethical approval from the Trust audit team duly received. All patients have duly consented for their surgical procedures and have been followed up as per routine protocol and no extra calls or visits were requested for this case series. Complete data confidentiality was maintained during result analyses and dissemination. The primary auditor alone had going to have access to the data after permission from the local audit and research team. The access and analysis were done from one hospital of the Trust.

There were no potential risks of any physical harm as per the case series design since it was a retrospective analysis of existing hospital data without direct patient intervention.

Discussion
Proximal femur replacement has been chosen in salvage situations where there is no bone stock viable to be preserved or amenable to hold the standard (regular) femur prosthesis. As we can see in the results and individual case examples from our eight cases, it's not just a surgical challenge in general but a complex overall rehabilitation challenge even before the start of PFR surgery planning. Most of the patients have high ASA grades (III and above). Pain management, anaesthesia, intra-operative blood loss mitigation and post-operative rehabilitation involves prior planning, detailed written and informed consent, and likely involvement of next of kin (patients in this average age group of 75 and above, may have in early or established dementia). All patients received per operative intravenous Tranexamic acid to control intra-operative bleeding.
The surgical steps in our series were followed as per the Depuy™ technical guide and surgeon's experience. When we use a posterior approach in general and extend it distally as prequired , one of the challenges faced in the dissection whilst preserving blood supply to the already atrophying musculature and weak bony architecture. Branches of profunda tethered and adhered to scarred tissue (from previous dissections, Quadriceps release distally with collateral bleeders in particular and the possibility of nicking a medium-large branch of superficial femoral artery in proximal thigh are also certain possibilities that need to be remembered and we kept vascular clips ready on shelf along with our vascular surgeon colleagues updated and in the hospital during the PFR surgical process. The use of thin Mooreland's osteotomes was always found phenomenal in meticulous cement retrieval and eased the delivery of femur prosthesis. Some surgeons have suggested use of abduction brace as well in case some abductors were available to be attached to prosthesis. However, in our experience abduction braces are not tolerated well in elderly and cause more restriction than stability. Hence, we did not encourage any braces in post-operative period even when abductors were available with remnant greater and lesser trochanteric attachment fragments tagged to the endoprosthesis. We do not contribute the two dislocations in post-operative period to lack of brace usage as they were associated with trauma/falls from standing height and twisting of the ipsilateral leg. This may also be an area requiring further research and larger

sample size to create reliable evidence amenable to extended internal and external validation.
Using the implant instrumentation set was not associated with any difficulty in general as the two main surgeons have been well acquainted with the sets and the procedure in past training.

The cement used in all the PFR surgeries was vancomycin and gentamicin impregnated to prevent infection. We recommend the same in view of a major surgical procedure involving extended dissection, longer time frame of exposed intra-operative wounds and larger surface area of prosthesis utilised.

The use of constrained acetabular liner in these salvage situation makes it almost a routine step for the surgical team involved in this case series. Constrained acetabular liners (CAL) are implants (acetabular shell inner liners) used to increase stability of the articulating PFR prosthesis. The low-functional demand age-group does particularly satisfactorily in terms of mobility as the limited restriction of extremes in range of movement at the hip is not a concern in these elderly patients.[17,18,19]

Rehabilitation ins a big challenge to physiotherapy and occupational therapy teams as these patients usually need more than one person to help with the gait training unlike a typical primary total hip replacement in otherwise independent patient. The average time span they spent in our post-operative wards was about seven to 14 days.

In spite of timely prophylaxis against deep vein thrombosis for all patients, based on Trust protocols, we did observe one of the patients with acute myeloid leukaemia who needed treatment dose of deep vein thrombosis at a relatively young age of 67-years. There was a prior history of Iliac vein thrombosis in this patient making her a high-risk patient. This is particularly another challenging scenario in elderly patients undergoing major lower limb surgeries like proximal femur replacement.[20, 21,22]

Ortho-geriatricians play a major role in pre-operative patient preparation and post-operative rehabilitation phase.

Dislocation was the reason for re-revision one patient (Case 7). Although it was re-revised with constrained liner, there is no long term follow up available since the patient passed away relatively young with Acute myeloid leukaemia (AML). Dislocation one of the complications of PFR which needs more research and higher evidence to be able to form a cause-and-effect relationship. However, within the limitations of available data and complex revision hip arthroplasties, it is premature to draw any reliable inference. The dislocation after complex hip arthroplasty in particular is still being evaluated at our hospital, especially focussing on constrained acetabular liners used in hip arthroplasties with instability and PFR.

Limitations

This is a study level IV evidence retrospective study. It is amenable to a selection bias. The PFR surgeries included in this case series are limited at present but ongoing surgeries and further addition to the sample size may increase the chances of a significant statistical analysis. Nevertheless, our main aim of highlighting complexities with holistic patient-based management approach and preparedness was fulfilled through this publication. A formal objective scoring for outcomes was not available for all patients for a similar time frame. Few patients did not have a reasonable time in the post-operative phase and suffered medical complications serving as a limitation to availability of follow up analysis.

Conclusion from various learning points

-One of the most important learning points is prevention of dislocation that is reportedly a common complication with PFR. One of the ways to achieve that in a safe way is enhanced acetabular liners or constrained liner. The patients where a constrained liner was applied for the proximal femur replacement had a stable hip without any dislocations.

-Morbidity and mortality details and consent is a major requirement during pre-operative planning.

-In spite of the complications and morbidities associated, PFR provides a salvage option and does contribute to the improvement in quality of life.

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