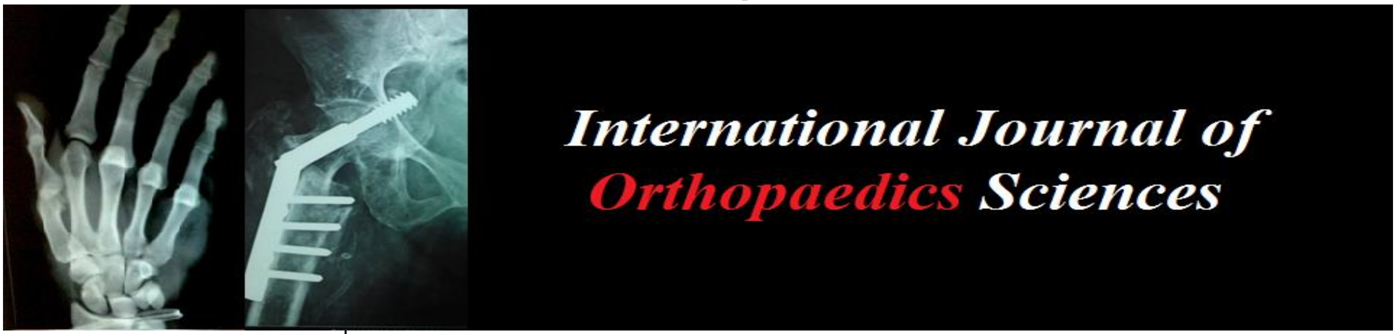

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Maximising stability after revision hip arthroplasty for vancouver B periprosthetic fractures

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Abstract
Objectives: The risk of hip dislocation after revision total hip arthroplasty can be as high as 27% following surgery for periprosthetic fractures. A novel technique described by the senior authors in 2015, involving a trans trochanteric osteotomy and minimal superior capsulotomy, minimises this risk.
Design: Prospective cohort study
Setting: Sir Charles Gairdner Hospital, Hollywood Private Hospital
Patients: Forty-two patients with Vancouver B type periprosthetic hip fractures, fixed using our superior capsulotomy technique.
Intervention: The approach involves extending the fracture proximally to the tip of the greater trochanter, splitting the gluteal tendons and superior capsule in the same plane, in a titrated manner such that the head dislocates from the socket with a 'pop'. The femoral component is revised and the cup and liner retained.
Main Outcome Measurements: The primary outcome of interest was dislocation rate.
Results: Patients averaged 80 years of age. Mean follow up was 31 months (range 12 months to 5 years). The primary finding was zero cases of hip joint dislocation. The average Oxford hip score was 31/48, the physical component and mental component Short Form 12 mean scores were 31.7 and 53.6 respectively at 1 year following revision. Functional scores did not significantly thereafter at 2 and 5 years. Mean subsidence at 1-year post operatively was 8.73mm. Two stems were revised.
Conclusion: The outcomes of this operative technique in revision arthroplasty of Vancouver B periprosthetic hip fractures is promising, with no cases of hip dislocation, along with satisfactory patient clinical outcomes.
Level of Evidence: Prospective Cohort Study, Level II.

Keywords: Revision hip arthroplasty; patient outcomes; dislocation rate; minimising dislocation; Vancouver periprosthetic femoral fractures

Introduction
Total hip arthroplasty (THA) has proven to be an effective treatment in managing pain and dysfunction caused by degenerative osteoarthritis. THAs are increasing in volume, and with this increase, inevitably we see an increase in periprosthetic fractures. These pose an ever-growing challenge to reconstructive hip arthroplasty surgeons, and an added burden on hospital and government budgets. Of the 11,907 revision arthroplasty cases reported to the Australian registry in 2016 [1], periprosthetic fractures were listed as the third highest cause, accounting for 18.7% of all THA revisions. Vancouver B type fractures represent a significant proportion of femoral periprosthetic fractures, with some studies quoting the incidence as high as 80% of all proximal femoral periprosthetic fractures [2].
Periprosthetic femoral fractures can present the surgeon with complex challenges. Reconstructive surgery is often laborious, and patient satisfaction is low [2]. The choice of management is dependent upon type and location of the fracture, patient factors such as medical comorbidities, mobility level and quality of bone stock.
The goal of revision arthroplasty in these situations is to achieve fracture union, implant stability and return the patient to pre-injury function, whilst also minimising the risk of complications. Hip dislocations are the most frequent complication [3] following total hip arthroplasty, and can occur in up to 27% of patients [4].

The extent of soft tissue dissection has been postulated to be the most important variable impacting dislocation after revision hip arthroplasty, and needs to be minimised [4].
The technique, first described by the senior authors in 2015, takes into consideration the potentially destructive nature of revision hip arthroplasty surgery, by utilising a minimal superior capsulotomy without disrupting the acetabular component [5]. The aim of this study is to report the mid-term findings of this surgical technique.

Methods

Patients were prospectively recruited from two hospitals between December 2005 and July 2016. Patients were consented preoperatively to enrol into our study. The inclusion criterion was the presence of a Vancouver B periprosthetic femoral fracture, fixed using our superior capsulotomy technique.

Fig 1: Pre-operative x-ray

The technique, described in detail by Khan *et al*. [5], incorporates an incision along the mid-lateral femoral plane, splitting Gluteus Maximus (GM) proximally and fascia lata distally. Vastus Lateralis (VL) is retracted anteriorly, taking care to ligate the perforating vessels, providing excellent exposure to the femoral shaft and fracture. The extent of the fracture is explored and exposed, and the femoral component assessed. If the fracture does not extend proximally, it is extended as a controlled osteotomy, with an oscillating saw, starting from the fracture to the tip of the greater trochanter (GT), just posterior to the anteriorly retracted border of VL. The medial femoral cortex, including calcar, is osteotomised, for clear exposure, and to ease stem explant. As our osteotomy reaches the tip of the GT, the tendon of gluteus medius (GM) is split in the mid-lateral plane, in line with the osteotomy to expose the superior capsule. Our osteotomy aims to incorporate the fracture and create an ‘open book’ configuration to the proximal femur. This provides a panoramic view of the fracture and in situ implant, enabling visualisation and extraction of any cement (if present).

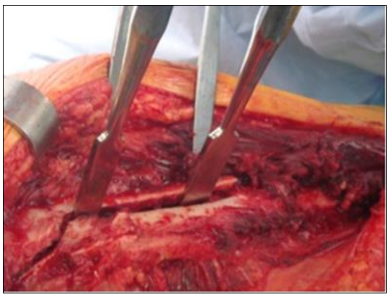

Fig 2: Opening of the fracture

The femoral stem is now disengaged from the distal femur, with the head remaining enlocated within the socket; a titrated capsulotomy in line with the GM split is performed, just sufficient to allow dislocation of the femoral head from the socket. Thus the anterior and posterior capsule remains untouched. Sutures are placed into the corners of the capsule to assist the soft tissue repair.
The acetabular components are assessed both radiographically and intra-operatively, and retained if there is no concern regarding stability of fixationor liner wear. In our consecutive series of 42 patients, all acetabular shells were retained. The liner dictates femoral head size.

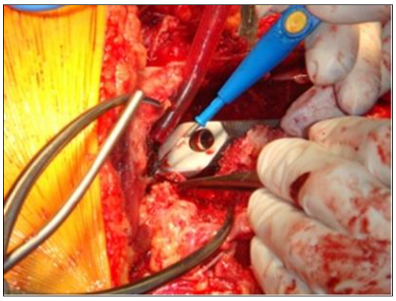

Fig 3: Titrated superior Capsulotomy

Prior to reaming of the canal, a femoral cable is applied prophylactically distal to the tip of the fracture. Reaming is undertaken with care to achieve the correct size and length, especially in cases involving significant proximal femur comminution, where leg length is not easy to evaluate. Trialling is performed to ensure correct leg length, rotation and offset, prior to insertion of the definitive implants.
Once the joint has been reduced, the proximal femur is reconstructed around the prosthesis. Circumferential cables secure the osteotomy fragments, which may be reamed or fashioned to fit around the prosthesis proximally. Allograft struts were utilised in cases of significant comminution or thin cortices. Soft tissue repair commences with capsular closure, utilising the preplaced sutures in the capsulotomy corners, followed by GM tendon repair. Layered closure of the remaining soft tissues is then followed by skin closure with staples.
The use of cement for the femoral component was left up to the individual surgeon’s preference. In our series 16 patients received long stemmed cemented components. This was the preference of one surgeon in cases where there was minimal comminution and anatomical reduction was achieved, allaying concerns of cement interdigitation at the fracture. The remainder received long stemmed modular uncemented stems.
In our cohort of patients, 24 out of 42 periprosthetic fractures had intact proximal segments, which included the calcar, greater and lesser trochanters. The remainder of the cohort had fractures that extended into and involved the proximal aspect of the femur.

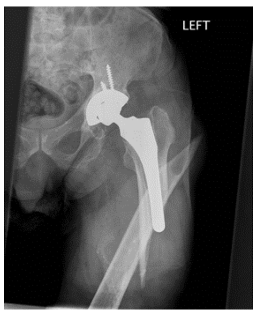

Fig 4: Fracture with intact proximal segment

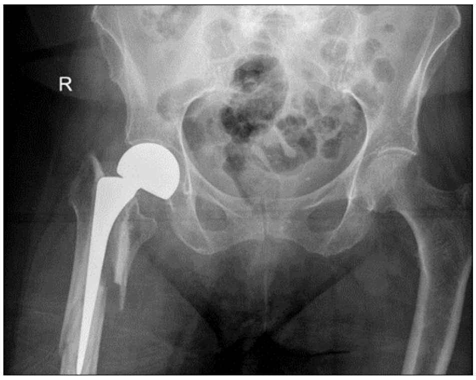

Fig 5: Fracture with comminuted proximal segment

Indications for this surgical technique include periprosthetic femoral fractures that are inherently unsuitable for internal fixation (Vancouver B2 and 3. This technique may also be used in selected cases of isolated femoral component revision in the absence of a fracture.

All revision surgeries were performed by one of 3 experienced arthroplasty surgeons. Following surgery, patients followed a standardised care pathway and were encouraged to weight-bear (as tolerated) from the first post-operative day.

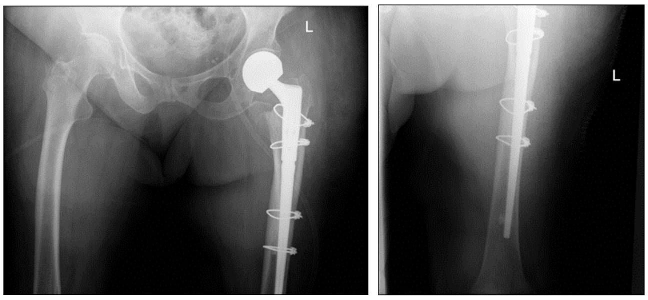

Fig 6: Post-operative x-ray

Our primary outcome measure was the incidence joint dislocation. This complication was asked of patients at each assessment time-point, and noted in correspondence from the General Practitioner.

Hip function was measured using the Oxford Hip Score [6, 7], a succinct self-reported scoring system used to assess function and pain in patients undergoing hip replacement surgery. The Short Form 12 (SF12) measured health and wellbeing from the patient's perspective [8]. These patient-reported outcomes provide reliable, valid and responsive data regarding patient perceptions of hip problems [7, 9, 10].

Stem subsidence was evaluated by comparing an AP radiograph taken immediately post-operatively with repeat AP films taken at minimum 1-year post operation. Correction for magnification differences was made by comparing the diameters of the femoral heads, and adjusting accordingly. The most distal cerclage cable was used as a reference point. The femoral stem's reference point was the distal tip. The distance (in milimeters) was calculated between these two reference points, and any differences between the temporal points represented stem subsidence.

Our assessment schedule included the intra-operative period, inpatient stay, and outpatient clinic follow-up to 1 year. Interview by phone was undertaken at the later time-points to clarify any reported complications.

Results

Patient selection

This prospective series includes forty-two patients averaging an age of 80 years (range 57 to 95). There was a higher ratio of females to males (3:2). Follow up averaged 31 months (range 12 months – 5 years). 9 patients died during the course of this study. Their data up until death was included in the study. Two stems were revised, and 2 were unable to complete functional scores due to cognitive decline. Complete data was available on 25 patients at last review.

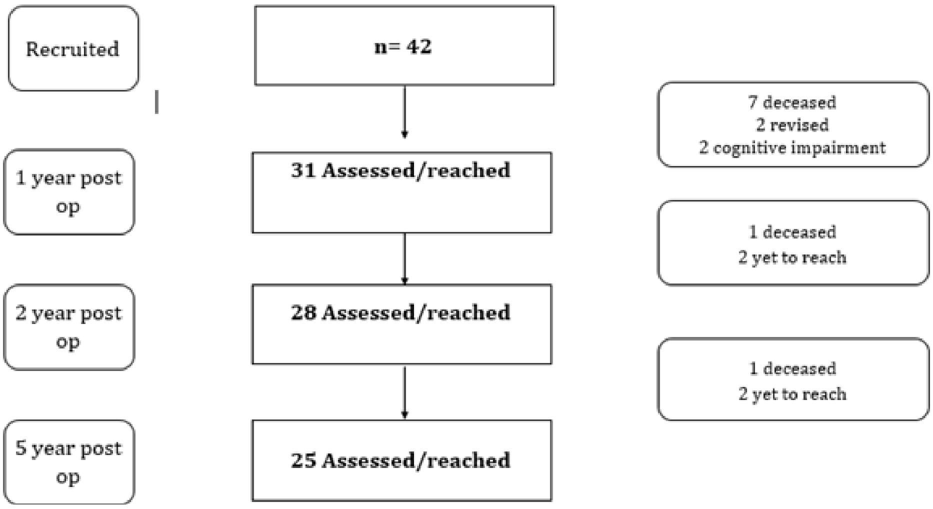

Fig 7: Patient flow

Surgical Management

The femoral head sizes retained from the primary THA ranged between 22-56mm (Table 1). 16 patients underwent revision to a cemented stem, 26 receiving uncemented press-fit stems. All patients required cables in their fracture fixation; 2 patients requiring adjunct plate fixation; 6 required cortical strut grafts (Table 2).

Table 1: Frequency of Different Head Sizes on the Original Prosthesis

Vancouver Grade	Number
B1	6
B2	35
B3	1

Table 2: Methods of fracture fixation

Fixation methods	N
Cemented	16/42
Uncemented	26/42
Allograft	6/42
Cables	42/42
Plate fixation	2/42

Patient Outcomes

There were no cases of hip joint dislocation following revision arthroplasty with our technique. This outcome was assessed in all patients at each assessment window, with relatives verifying complication incidence of the 2 participants with early cognitive decline.

The Oxford hip score averaged 32/48 at 1-year, 33/48 at 2-years and 35/48 at 5 years. The physical and mental components of the SF12 general health survey are tabled below, and did not significantly vary through the course of our follow-up. (Table 3).

Table 3: Oxford Hip and SF 12 scores

Clinical Scores	1 year n=22	2 year n=26	5 year n=10
Oxford Hip Score Average (SD)	32 (6.0)	33 (8.3)	35 (11.2)
SF12 physical component Average (SD)	31.7 (10.1)	34.0 (9.0)	30.7 (10.2)
SF12 mental component Average (SD)	53.6 (10.8)	52.0 (10.1)	55.1 (10.6)

Stem Subsidence

Femoral tip subsidence after 1-year post revision averaged 8.73mm (range 0-32mm) in 30 patients available for follow-up. Subsequent x-rays in 20 patients confirmed minimal further subsidence (mean <1mm).

Two patients underwent further stem revision; one had hip pain upon sitting and straight-leg raising. The second patient experienced groin pain following the index revision and was revised at 4 months. Intra-operatively the fracture was observed to be united, however both femoral and acetabular components were loose.

Two patients returned to theatre for reasons unrelated to the femur. The first patient underwent subsequent cup revision due to hypertrophic bone formation. The stem was stable and could not be explanted. The second patient fell, sustaining a new Vancouver C periprosthetic fracture that was managed with plate fixation. There was one case of pulmonary embolism, one patient acquired a chest infection, and two cases of post-operative ileus occurred in this cohort.

Discussion

Hip dislocation is a frequent cause of failure in revision hip arthroplasty, often requiring reduction under anaesthetic to re-enlocate the joint, or a revision arthroplasty. In this often frail and elderly cohort, this complication poses risks including morbidity, as well as a significant cost to the health care system.

In our series of 42 patients, the novel technique described appeared to be safe, with zero cases of hip joint dislocation. This outcome compares favourably to the hip dislocation rate reported by Young *et al.* [11] In their evaluation of femoral periprosthetic fractures, fixed using a long stem prosthesis, their cohort of 50 patients included 15 requiring revision arthroplasty. 27% of the revision dislocated during their mean follow-up of 3.3 years. Neuman *et al.* [12] evaluated 55 patients, with a mean follow-up of 67 months, after revision hip arthroplasty for Vancouver B2/B3 periprosthetic fractures revised with a distally fixed, modular stem, inserted using a lateral transgluteal approach. There was a 4% dislocation rate. Limitations of both studies include small sample sizes.

In a larger cohort of 1,548 patients undergoing revision hip arthroplasty for either aseptic loosening or periprosthetic fracture, Alberton and his colleagues [4] studied the association of surgical approach and hip dislocation. 115 hip dislocations occurred; 7.5% with anterolateral, 7.8% with lateral and 6.1% with posterior approach. The authors emphasized that minimising tissue dissection was an important variable to reduce dislocation risk [3]. Our study reaffirms this model of minimal soft tissue dissection. Chivas [13] *et al.* also showed that dislocation rates can be lowered with careful soft tissue balancing and meticulous closure of the capsule, and report a 2.5% dislocation rate in 79 revision THAs. Similar results were reported by Fink *et al.* [14] utilising a less invasive, modified transfemoral approach to the femoral shaft in 68 patients with a minimum of 24 month follow-up after revision hip arthroplasty. 22 cases were cementless stem revisions, of which only 1 case of dislocation (5%) was recorded.

It is well recognised that increasing head size confers extra stability [13, 15, 16]. Of note in our own cohort was that the existing head was retained, and stability preserved, even with small head sizes of 22mm.

Hummel and colleagues [17] used larger femoral head sizes and a posterior capsular repair with the aim of reducing the dislocation. A significant decrease in hip dislocations, from 10.6% to 2.7%, was reported. However, they were unable to quantify the significance of each factor on the subsequent reduction in hip dislocations.

Our physical and mental component scores of the SF12 PROM were 32 and 54 respectively. These results, when compared to a sample of the general population of over 75 years old [8], of 39 and 54 respectively are promising. The Oxford Hip Score of 31/48 places our patients' outcomes within the category of 'fair' hip function [10, 18]. These findings, whilst not directly comparable, are in keeping with Lubbeke *et al.* [19] series that averaged a "fair" Harris Hip Score of 76.7, and compare favourably against Mulay *et al.* [20] cohort that averaged a "poor" 69.

A potential disadvantage of this approach would be hip abductor weakness, due to superior gluteal nerve injury. Frequently reported complications [21] of femoral and greater trochanteric osteotomy include non-union of the osteotomy, migration or fracture of the osteotomy fragment, wire breakage and trochanteric bursitis. However, there were no incidents of this nature recorded in our cohort.

Adbel *et al.* [22] assessed femoral subsidence in their series looking at aseptic revision total hip arthroplasty with modular stems. At 1-year post revision, their results showed a mean stem subsidence of 16mm, ranging from 2-19mm. They utilised similar post-operative radiographic intervals to our study (1, 2 and 5 years). In keep with our own results, femoral stem subsidence was shown to stabilise after 1-year post operatively. On average we had a slightly older populace, (80 vs. 69 years) but comparable subsidence rates. Similar rates of subsidence can be seen in other studies [23, 24, 25].

Laurer and colleagues [26] retrospectively analysed complications arising in femoral periprosthetic fracture management with revision arthroplasty versus plate osteosynthesis. They found a higher rate of implant failure and surgical complications in B1 type fractures treated with open reduction and internal fixation compared to revision arthroplasty. The higher rate of treatment failure associated with plate osteosynthesis in comparison to revision arthroplasty was also demonstrated by Lindagl *et al*. [27] who assessed risk factors for failure after treatment of the different Vancouver grade periprosthetic factors.

In addition to the findings of our study, this unique technique promises significant financial benefits through reducing dislocation incidence and the costs associated THA dislocation. Sanchez-Sotelo [28] cite the average hospital cost for a closed reduction of a primary THA, to be 19% of the hospital cost of a total hip arthroplasty. If a revision arthroplasty was required, the hospital cost rose to 148% of the initial THA, amounting to tens of thousands of dollars (USD) per case. Similarly De Palma *et al*. [29] reported on the financial burden of 87 dislocations within 6 weeks of surgery. A 352% increase in cost of an uncomplicated revision THA was reported.

The main limitation of this study is its small sample size and statistical power. As such, whilst our results to date are promising, this limitation should be noted. The advanced age of this population was a further and unavoidable limitation to achieving longer-term follow-up. 16% of the cohort was deceased within a year of surgery. Whilst ideal, a large randomised controlled trial with minimal dropouts, presents a significant challenge to researchers investigating this orthopaedic population.

Conclusion

Vancouver type B fractures represent a high proportion of femoral periprosthetic fractures[2] and present reconstructive hip surgeons with a considerable challenges, including prevention of post-revision dislocation [3]. Our novel technique provides surgeons with a reassuring platform to revise the femoral component, whilst still respecting the integrity of the anterior and posterior capsule. We have found the technique to be safe and easy to use, resulting in excellent hip stability.

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