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Periprosthetic fracture as a late mode of failure of the Anatomique Benoist Girard II femoral prosthesis

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Abstract

Aim: The Anatomique Benoist Girard (ABG) II femoral implant was a commonly used stem for primary total hip replacement (THR) at our institution (Launceston, Tasmania Australia). We identified peri-prosthetic fracture as the main cause of late failure.

Methods: The late periprosthetic fracture rate for ABG II implants was reviewed with national statistics, using Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) data. National revision rates for periprosthetic fracture were used to compare ABG II with all other cementless femoral stems.

Result: ABG II stems accounted for 1% (2719 implants) of all femoral stem implants in Australia during the 12-year review period, compared to 23% (587 implants) in Launceston Hospitals. Although the Launceston cumulative percent revision rate for the ABG II stem was lower than the National rate at all time points, the reasons for revision were similar. The most common reason for revision of ABG II was fracture (56.8%), followed by loosening (15.3%). This differs from the reasons for revision in other cementless prostheses (loosening 23.9%, fracture 20.8%, dislocation 18.7%). Cumulative percent revision rates from late periprosthetic fracture, were higher for the ABG II stem than other cementless femoral prostheses.

Conclusion: This review of the AOANJRR has confirmed a local and national higher revision rate of the ABG II stem due to late periprosthetic fracture compared with other cementless stems. Stem design must be considered to reduce the risk of late periprosthetic fracture.

Introduction

The Anatomic Benoist Girard (ABG) II (Stryker Orthopaedics, Mahwah, NJ, USA) is an anatomical cementless femoral prosthesis introduced in 1996. The TMZF alloy implant (comprised of Titanium, Molybdenum, Zirconium and Iron) was designed to provide primary stability and load transfer through the hydroxyapatite coated metaphyseal fit. The anatomical stem has built in 12° of anteversion. The ABG II model was developed to improve proximal stress transfer to reduce stress shielding in the area and favour enhanced bone remodelling.[1,2]

Previous studies have reported good long-term results with the ABG stem.[3,4] In Launceston, Tasmania; the ABG II stem was a popular choice of implant from late 1990s until 2015. We observed the main cause of failure was late peri-prosthetic fracture (PPF) (Fig. 1). PPF is of concern due to the significant impact on the patient and cost to the health care system.[5] Several studies have shown poor long term functional outcome and slower return to pre-fracture mobility after periprosthetic femoral fractures,[6] in addition to an increased mortality risk.[7,8]

The Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) provides a tool to assist in interpretation of local arthroplasty revision rates. AOANJRR data was used to compare local with national ABG II results. The national rates of late PPF were also reviewed for ABG II and other cementless femoral stems.

The aim of this study was to compare our local rates of revision for PPF for the ABG II stem to the national revision rates using

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Fig. 1. X-ray of an ABG II periprosthetic fracture.

data from the AOANJRR. A secondary aim was to compare the rate of revision for PPF in the ABG II to all other cementless stems.

Methodology

The Australian Orthopaedic Association National Joint Replacement Registry began data collection on 1 September 1999. Complete nationwide data collection commenced in 2002 capturing close to 100% of the arthroplasty procedures performed in Australia.[8] Registry data are validated against data provided by state and territory health departments in Australia via sequential multilevel matching processes. A matching program is run monthly to search for all primary and revision arthroplasty procedures recorded in the registry that involve the same side and joint of the same patient, thus enabling each revision to be linked to the primary procedure. Data are also matched biannually with the Australian Government Department of Health and Ageing National Death Index, to obtain information on the date of death. After cross-checking data, the Registry is able to include over 98% of joint procedures performed in Australia.[8] The registry defines revisions as reoperations of previous hip arthroplasties in which one or more of the prosthetic components is replaced or removed, or one or more components is added. The Registry does not record reoperations where a component was not added or removed. The study population comprised all primary total conventional hip replacements implanted for osteoarthritis between 1 January 2006 and 31 December 2018. Procedures using prostheses with an exchangeable neck or metal on metal bearing surface with head size >32 mm were excluded, as we have previously reported a higher rate of revision for these types of stems and bearing surfaces.[9,10]

Statistical analysis

Cumulative percent revision, defined as the complement of the Kaplan–Meier estimate of survivorship, was used to describe the rate of revision. An accompanying 95% confidence interval was calculated using unadjusted pointwise Greenwood estimates. Patients were censored at the time of death, or closure of the database at the end of the study period. The registry defines revisions as reoperations of previous hip arthroplasties in which one or more of the prosthetic components is replaced or removed, or one or more components is added. Because the overall proportion of patients who died during the study period was sufficiently low, we used Kaplan–Meier estimates rather than competing risk estimates.[11] We used hazard ratios from Cox proportional hazards models, adjusting for age and sex, to compare the revision rates. The proportional hazards assumption was tested by including an interaction between each predictor and the log of time in the Cox model. If the p-value for this interaction term was <0.05, then time-varying hazard ratios are presented. The analysis was performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

The registry recorded 2719 procedures with an ABG II femoral stem over the 12-year period, of which 587 were implanted

Table 1 Summary of primary total conventional hip replacement by model (primary diagnosis OA)

Variable		ABGII	Other Cementless Femoral Stems	TOTAL
Age				
	Median (IQR)	66 (60, 72)	66 (59, 73)	66 (59, 73)
Gender				
	Male	1267 (46.6%)	96 696 (50%)	97 963
	Female	1452 (53.4%)	96 621 (50%)	98 073
Hospital location				
	Launceston Hospitals	587 (21.6%)	1967 (1%)	2554
	Other Tasmanian Hospitals	43 (1.6%)	6547 (3.4%)	6590
	Other States	2089 (76.8%)	184 803 (95.6%)	186 892
Total		2719	193 317	196 036

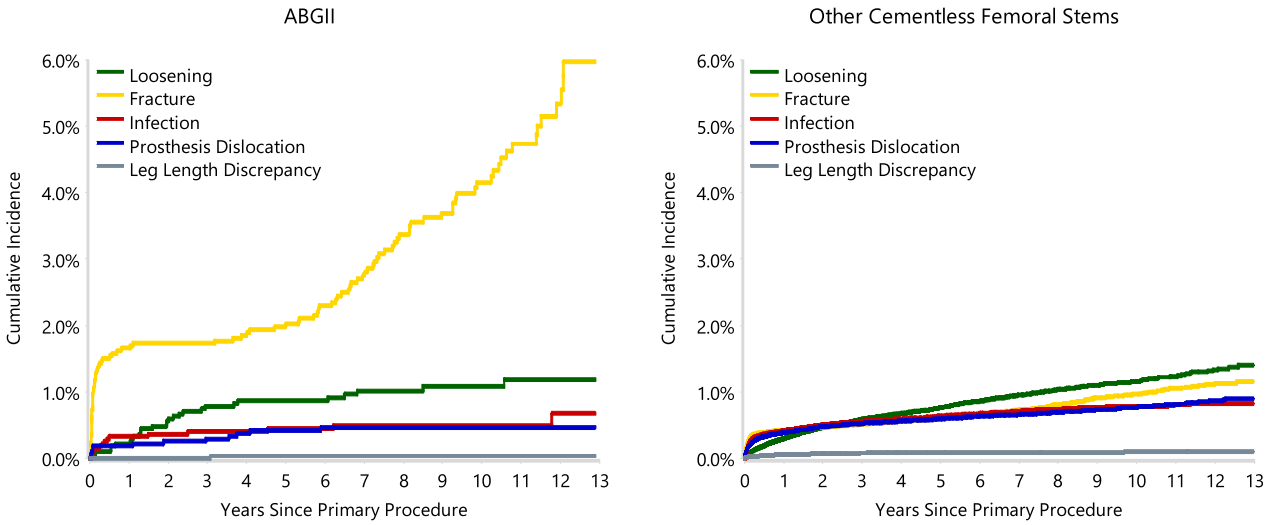
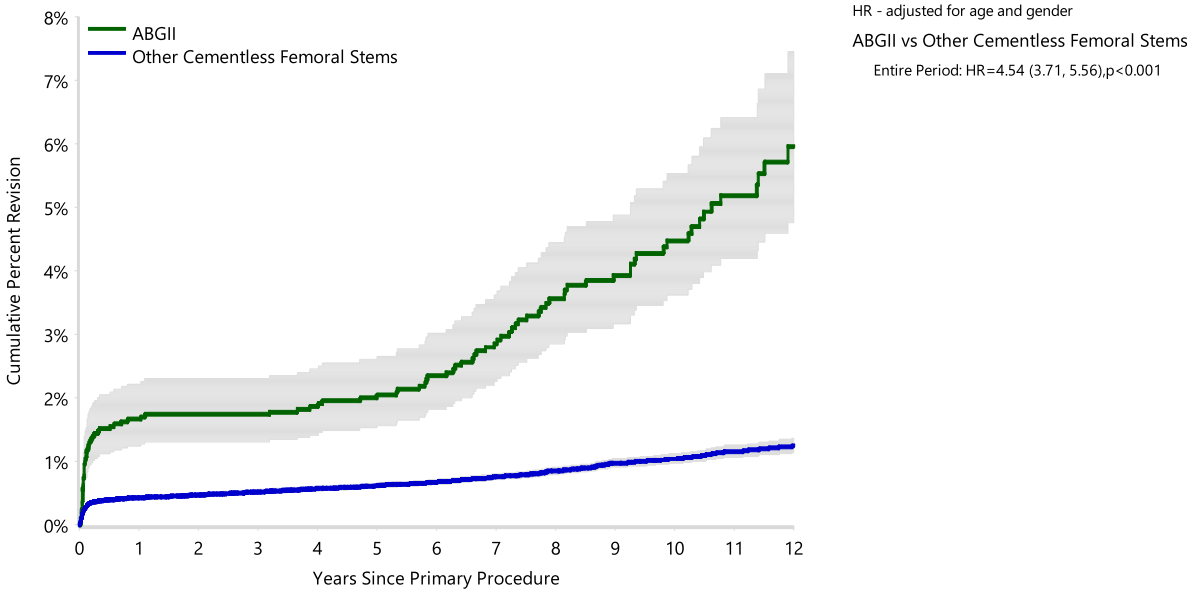


Fig. 2. Cumulative incidence revision diagnosis of primary total conventional hip replacement by model (primary diagnosis OA).

locally in Launceston. This equates to 1% of all femoral cementless stems implanted nationally and 23% of all cementless stems in Launceston. The age and gender of patients who received an ABG II was comparable to all other cementless implants (Table 1).

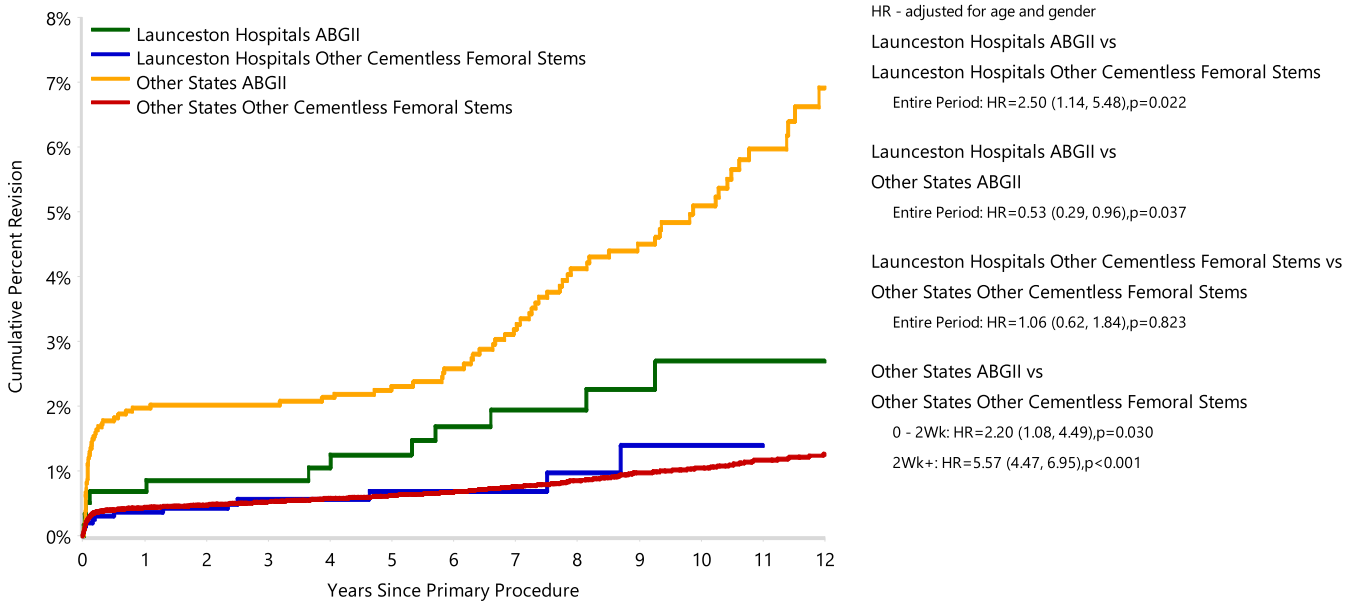
The ABG II had a higher rate of all cause revision compared to other cementless stems (HR = 1.60 (95% CI 1.38, 1.85), $p < 0.001$). The cumulative percent revision for all cause revision of the ABG II was 9.8% (95% CI 8.3, 11.6) at 12 years compared to 5.6% (95% CI 5.3, 5.8) for all other cementless stems.



Number at Risk	0 Yr	1 Yr	2 Yrs	3 Yrs	4 Yrs	5 Yrs
ABGII	2719	2607	2535	2434	2289	2083
Other Cementless Femoral Stems	193317	167288	144421	122475	102321	83731

Number at Risk	6 Yrs	7 Yrs	8 Yrs	9 Yrs	10 Yrs	11 Yrs	12 Yrs
ABGII	1831	1619	1398	1182	937	675	354
Other Cementless Femoral Stems	67157	52180	39107	27711	18321	10952	5113

Fig. 3. Cumulative percent revision of primary Total conventional hip replacement by model (primary diagnosis OA, revision for fracture).



Number at Risk		0 Yr	1 Yr	2 Yrs	3 Yrs	4 Yrs	5 Yrs
Launceston Hospitals	ABGII	587	565	551	530	496	468
	Other Cementless Femoral Stems	1967	1720	1469	1211	984	759
Other States	ABGII	2089	1999	1941	1861	1750	1574
	Other Cementless Femoral Stems	184803	159907	138074	117112	97913	80194

Number at Risk		6 Yrs	7 Yrs	8 Yrs	9 Yrs	10 Yrs	11 Yrs	12 Yrs
Launceston Hospitals	ABGII	423	378	310	243	176	116	61
	Other Cementless Femoral Stems	555	429	299	218	141	80	36
Other States	ABGII	1374	1210	1064	921	744	547	283
	Other Cementless Femoral Stems	64458	50039	37530	26666	17702	10607	4959

Fig. 4. Cumulative percent revision of primary total conventional hip replacement by hospital location and model (primary diagnosis OA, revision for fracture).

The most common reason for revision of the ABG II stem was periprosthetic fracture and this was the major reason for the difference in revision rates between the two groups (Fig. 2). The cumulative percent revision for PPF for the ABG II was 6.0% (95% CI 4.8, 7.4) at 12 years compared to 1.2% (95% CI 1.1, 1.4) for other cementless stems (HR = 4.54 (95% CI 3.71, 5.56), $p < 0.001$) (Fig. 3). The increased rate of revision for PPF was present in both males and females, and for all head sizes (<32, 32 and >32 mm).

We also examined the local rate of revision for PPF for the ABG II stem compared to all other cementless stems. The ABG II stem had a higher rate of revision for PPF than all other cementless stems performed locally (HR = 2.50 (95% CI 1.14, 5.48), $p = 0.022$). However, there was a lower rate of local revision for PPF for the ABG II stem compared to ABG II stems performed throughout the rest of the country (HR = 0.53 (95% CI 0.29, 0.96), $p = 0.037$) (Fig. 4).

Discussion

This study has used the AOANJRR data to confirm that despite favourable local results for ABG II stems compared with national data, there is a higher rate of PPF requiring revision than for other cementless femoral implants. After 6 years, the cumulative percentage revision for PPF rises profoundly for the ABG II stem compared to all other cementless stems.

In Australia, the use of cementless fixation has increased from 51.3% in 2003 to 60.8% in 2019[8] of all THA. Higher rates of early revision for PPF with cementless implants are well known. Risks for early PPF include female gender,[12–15] increased age,[16,17] osteoporosis,[18,19] implant design,[20] uncemented femoral prosthesis[17–25] and surgical technique,[22,23,11] Strict adherence to the surgical technique[26] and design features[27] of the ABG II stem were thought to minimize the early failure due to PPF. Despite this,

the ABG II stem has previously been shown to have an early risk of PPF followed by good medium-term results.[3,4,25,28]

Increasing numbers of PPF have been reported and are predicted to rise.[29] Late PPF have been previously attributed to falls, osteoporosis and stem loosening but implant design may have a bigger part to play than previously thought. A previous review has shown single-wedge or blade-type and 'fit-and-fill' stems had significantly more PFFs compared with anatomic type stems.[20] However, they point out that previous literature has poorly described the type of stem used and more long-term reporting of stem type and PPF is required. The anatomic shape of this stem is likely to be important in influencing risk for late periprosthetic fracture. It has been postulated that the ABG II stem results in remodelling causing osteoporosis, around the lateral midstem.[19] The remodelling predisposes to a clamshell type fracture pattern associated with the anatomic stem.[30] The ABG II stem is now no longer available, though its withdrawal was largely market driven rather than due to late fracture risk. Further studies examining stem designs with higher rates of PPF will be important[20,31] to minimize late PPF risk in the future.

There are both strengths and limitations to this study. We were able to use the national registry to confirm our local audit experience that suggested a higher rate of revisions for PPF compared to all other cementless stems. However, we had a lower rate of revision for the ABG II than nationally. Other hospitals that may note higher than expected revision rates can confirm this with national registry data.[32]

There are limitations to this study. The common clam-type fracture pattern seen with the ABG II stem, requires most ABG II fractures to have revision surgery. Other cementless stems may allow internal fixation with retention of the original implant and these cases may not be registered by the AOANJRR. Constantin *et al.* reported twice the operation rate for PPF than the revision rate in a select group of hospitals.[33] This may have led to a comparatively higher reported rate of revision for PPF for the ABG II than other cementless stems. The Registry does not collect imaging data so we cannot comment if stem position or stem size relative to the bone may have been a contributing factor to the rate of PPF.

Conclusion

There is a higher rate of revision for the ABG II stems due to periprosthetic fracture compared with other cementless stems. This difference was present in both local and national level data. Stem design is a consideration that must be considered in order to reduce the risk of periprosthetic fracture.

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Author contributions

Jonathan S. Mulford: Data curation; formal analysis; investigation; methodology; writing – original draft; writing – review and editing. **Ronnie Mathew:** Data curation; writing – review and editing. **David Penn:** Conceptualization; investigation; project administration; supervision; writing – review and editing. **Alana Cuthbert:** Formal analysis; methodology; writing – review and editing. **Richard de Steiger:** Formal analysis; methodology; project administration; supervision; writing – review and editing.

Conflict of interest

None declared.

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