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Nationwide trends in management of proximal humeral fractures: an analysis of 77,966 cases from 2008 to 2017

Andrew S. McLean, BPhty(Hons), MBBS(Hons)[a,*], Nathan Price, MD[a], Stephen Graves, MBBS, FRACS, FAOrthA, DPhil[b], Alesha Hatton, BMedMath(Hons)[c], Fraser J. Taylor, BSc, MBChB, FRACS, FAOrthA[a]

[a]*Department of Orthopaedics, Gold Coast University Hospital, Gold Coast, QLD, Australia*
[b]*Australian Orthopaedic Association National Joint Replacement Registry, Adelaide, SA, Australia*
[c]*South Australian Health and Medical Research Institute, Adelaide, SA, Australia*

Background: There is no consensus as to the treatment of proximal humeral fractures (PHFs), particularly in elderly patients. There is increasing evidence that nonoperative management may have similar functional outcomes to operative management, which is potentially conflicting with increasingly improved surgical techniques and implants. The aim of this study was to investigate the changes in the incidence and management of PHFs across Australia over a 10-year period.

Materials and methods: We retrospectively reviewed all hospitalizations of patients with PHFs from 2 Australian national health care databases from 2008 to 2017. We recorded the incidence of PHFs and annual utilization rates of commonly used treatment options including nonoperative management, hemiarthroplasty (HA), reverse total shoulder arthroplasty (RTSA), and open reduction–internal fixation (ORIF).

Results: The incidence of PHFs increased from 26.8 per 100,000 person-years in 2008 to 45.7 per 100,000 person-years in 2017. There was a decrease in operative management from 2008 to 2017, with 32.5% and 22.8% of all PHFs treated operatively in 2008 and 2017, respectively ($P = .001$). ORIF use decreased significantly from 76.6% to 72.6% ($P = .004$). RTSA use increased significantly from 4.1% to 24.5% ($P < .001$). HA use decreased significantly from 19.3% to 3% ($P < .001$).

Conclusions: Whereas the incidence of PHFs increased, the operative management of PHFs decreased significantly from 2008 to 2017, particularly in patients aged 65 years or older. This decrease in operative management was in part due to a significant decrease in ORIF and HA use in patients aged 65 years or older. There was a significant increase in RTSA use.

Level of evidence: Epidemiology Study; Large Database Analysis

Keywords: Proximal humeral fractures; reverse shoulder arthroplasty; open reduction–internal fixation; hemiarthroplasty; shoulder arthroplasty; epidemiology

No IRB approval was required for this database analysis.

*Reprint requests: Andrew S. McLean, BPhty(Hons), MBBS(Hons), Department of Orthopaedics, Gold Coast University Hospital, 1 Hospital Blvd, Southport, QLD 4215, Australia.

E-mail address: Andrew.McLean2@health.qld.gov.au (A.S. McLean).

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Proximal humeral fractures (PHFs) are common, representing 4% to 5% of all fractures.[10] With an aging population and the associated increase in osteoporosis and falls, the incidence of PHFs in elderly persons is increasing.[5,21,22] The majority of PHFs are minimally displaced and can be treated nonoperatively.[23]

Several treatment options exist for the management of displaced and/or complex PHFs, including nonoperative management, closed reduction, closed reduction–internal fixation, open reduction–internal fixation (ORIF), hemiarthroplasty (HA), and reverse total shoulder arthroplasty (RTSA). The decision-making process for treatment options is guided by surgeon preference, a multitude of patient factors, and the available evidence base.[24] Currently, there is mounting high-quality evidence for nonoperative management of PHFs having similar functional results to operative management (ORIF, HA, and RTSA), particularly in patients aged 65 years or older.[4,28] In the comparison of surgical options, there is a growing body of evidence to support RTSA in the management of complex PHFs in elderly patients.[9,11,12,32-34] This is reflected in the increasing use of RTSA for the management of PHFs worldwide.[3,27] The decision-making process for the treatment of PHFs remains complex, even with increasing high-quality studies available to the treating surgeon.

In this setting, the primary aim of our study was to investigate the changes in the incidence and management of PHFs across Australia over a 10-year period. We hypothesized that nonoperative management would have increased significantly over the study period, in particular in elderly patients.

Materials and methods

We undertook a retrospective descriptive analysis of principal diagnoses and procedures related to PHFs in Australian public and private hospitals over a 10-year period, from January 2008 to December 2017. We extracted data from the National Hospital Morbidity Database (NHMD) of the Australian Institute of Health and Welfare and the Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR).

NHMD data extraction

Procedural and principal diagnosis data were extracted from the NHMD as previously described in the literature.[36] The NHMD is compiled from data supplied by Australian state and territory health authorities and contains deidentified electronic summary records of inpatient episodes of care in Australian public and private hospitals, with a negligible proportion of missing data (0.004% of cases per year).[35] The data do not include outpatient episodes of care. The database lists the year of encounter, patient age and sex, diagnosis, and procedure performed. Procedures are coded by the second edition of the *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision*, Australian modification (ICD-10-AM) and the third to ninth editions of the *Australian Classification of Health Interventions*. The principal diagnoses are coded by the second to ninth editions of the ICD-10-AM.

Patients aged 15 years or older who received diagnoses of PHFs were identified by ICD-10-AM code S42.2 (fracture of upper end of humerus). Open reduction of a fracture of the proximal humerus with internal fixation and open reduction of an intra-articular fracture of the proximal humerus with internal fixation were identified by ICD-10-AM procedure codes 47429-01 and 47432-01, respectively. We were unable to extract data for shoulder arthroplasty and external fixation from the NHMD. We excluded closed reduction and closed reduction–internal fixation as they are not commonly used as definitive treatments in the adult Australian population.

AOANJRR data collection

The AOANJRR began data collection on September 1, 1999, and was expanded to include shoulder arthroplasty procedures in April 2004; this registry has documented almost all shoulder arthroplasty procedures Australia-wide since November 2007. All stemmed HA and RTSA procedures reported with the primary diagnosis of fracture to the AOANJRR between January 1, 2008, and December 31, 2017, were included. Procedures were grouped according to HA and RTSA by age and sex.

Statistical analysis

Age-adjusted and sex-specific incidence rates for PHFs were expressed as number per 100,000 persons based on yearly population figures provided by the Australian Bureau of Statistics.[2] Management options were expressed as a percentage of all PHFs and operatively managed PHFs. A 2-sample test of proportions was used to compare the change in management from 2008 to 2017. Statistical analysis was performed with SPSS software (version 19; IBM, Armonk, NY, USA).

Results

A total of 77,966 hospitalizations of patients with a diagnosis of PHF were registered during the 10-year study period. The incidence of PHF increased significantly from 28.5 per 100,000 person-years in 2008 to 45.7 per 100,000 person-years in 2017 (Fig. 1). The incidence of PHF was greatest in women older than 85 years, with 711.8 per 100,000 person-years in 2017. The greatest increase in incidence was in women aged 65 to 69 years, increasing over 2-fold in the study period. Both male and female patients and all patients (aged $\geq$65 and <65 years) showed significant increases in the incidence of PHFs across the study period ($P < .001$).

Overall, nonoperative management was the most common treatment choice from 2008 to 2017. The use of nonoperative management increased significantly from 67.6% to 77.2% ($P = .001$) over the 10-year study period (Fig. 2), with an associated decrease in the use of operative management of 29.9% from 2008 to 2017, with

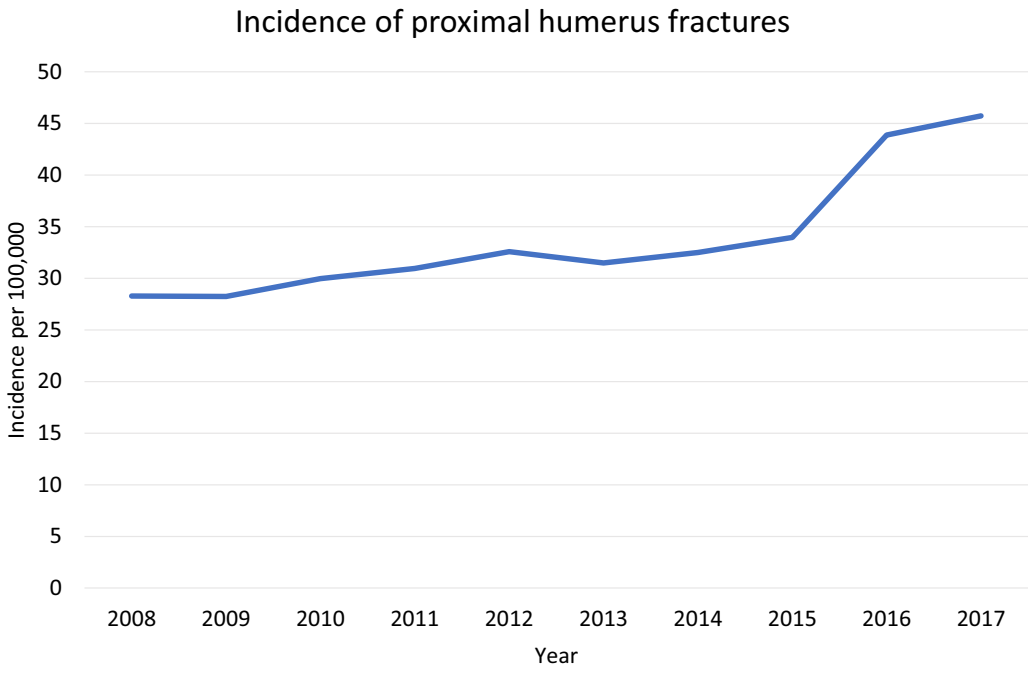

Figure 1 Incidence of proximal humeral fractures from 2008 to 2017.

32.5% and 22.8% of all PHFs treated operatively in 2008 and 2017, respectively ($P = .001$) (Fig. 2, Table I). The use of nonoperative treatment increased significantly whereas the use of operative treatment decreased significantly in both the younger group (<65 years) and older group (≥65 years) ($P < .001$) but more so in the former group.

ORIF remained the most common operative procedure for the management of PHFs throughout the study period. ORIF use decreased significantly from 76.6% of all operative procedures in 2008 to 72.6% in 2017 ($P = .004$) (Fig. 3). Conversely, RTSA use increased significantly from 4.1% to 24.5% ($P < .001$). HA use decreased significantly from 19.3% to 3% ($P < .001$) over the study duration.

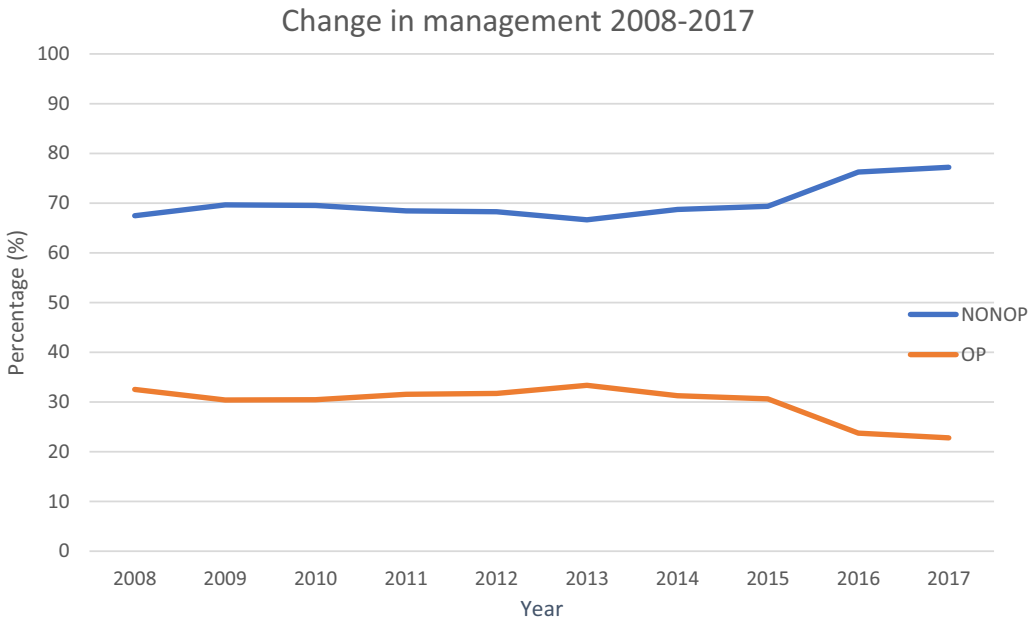

Figure 2 Trends in management of proximal humeral fractures. *NONOP*, nonoperative management; *OP*, operative management.

Table I Number of PHFs and operative procedures each year

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
PHF, n	6008	6125	6605	6916	7411	7290	7637	8096	10,621	11,257
ORIF, n	1496	1407	1544	1648	1733	1831	1801	1881	1839	1862
HA, n	378	368	354	359	361	305	219	163	115	76
RTSA, n	80	86	115	174	256	296	369	438	570	628
OP procedure, %	32.52	30.38	30.48	31.54	31.71	33.36	31.28	30.66	23.76	22.79

PHF, proximal humeral fracture; *ORIF*, open reduction–internal fixation; *HA*, hemiarthroplasty; *RTSA*, reverse total shoulder arthroplasty; *OP*, operative.

ORIF use in the younger group (<65 years) remained steady, comprising 88.8% and 90% of all operative procedures in 2008 and 2017, respectively ($P < .001$) (Fig. 4). Conversely, RTSA use increased significantly from 1.5% to 7.2% ($P < .001$). HA use decreased significantly from 9.7% to 2.8% ($P < .001$) over the study duration.

ORIF use in the older group (≥65 years) decreased significantly from 63.3% to 56.8% of all operative procedures over the study period ($P < .001$) (Fig. 5). Conversely, RTSA use increased from 6.9% to 40% ($P < .001$). HA use decreased significantly from 29.8% to 3.1% ($P < .001$) over the study duration.

The use of humeral head replacement with either HA or RTSA increased by 17.1% overall ($P = .002$) and increased by 17.8% in patients aged 65 years or older ($P = .002$), whereas in the group younger than 65 years, the use of humeral head replacement remained similar, with a decrease of 10.8% ($P = .36$). Patients with PHFs who were aged 65 years or older were more likely to be treated nonoperatively ($P = .001$), and those treated operatively were less likely to receive ORIF ($P = .001$) and more likely to receive humeral head replacement ($P = .001$).

Discussion

The incidence of PHFs increased significantly, which is consistent with previous reports over the last several decades.[21,22] The incidence of PHFs increased in both men and women but more so in those patients aged 65 years or older. This finding is similar to findings of previous reports and is likely to continue because of increased falls and osteoporosis in this population.[21,22]

Nonoperative management remained the mainstay of treatment. Our results found an increase in the use of nonoperative management from 67.6% to 77.2% over the 10-year period, with an increase of 14.4%. The majority of this increase was seen between 2015 and 2016 (Fig. 2), which may partly relate to the publication of the PROFHER (Proximal Fracture of the Humerus Evaluation by Randomisation) randomized clinical trial,[28] which showed no significant difference between operative and nonoperative treatment in patient-reported clinical outcomes over a 2-year period after fracture occurrence. The PROFHER authors concluded that their results did not support the trend of increased surgery in patients with displaced fractures of the proximal humerus and may have influenced this

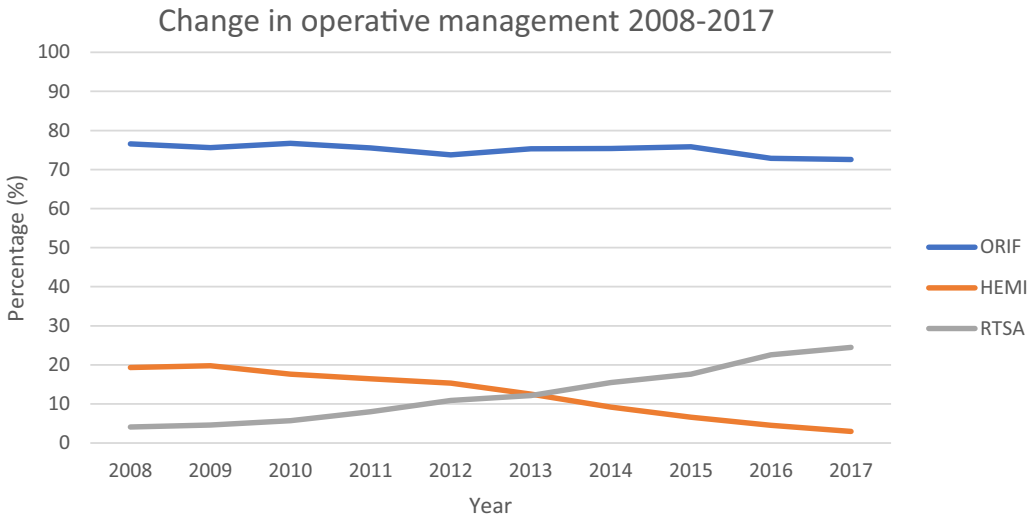

Figure 3 Trends in management of operatively treated proximal humeral fractures in all patients. *ORIF*, open reduction–internal fixation; *HEMI*, hemiarthroplasty; *RTSA*, reverse total shoulder arthroplasty.

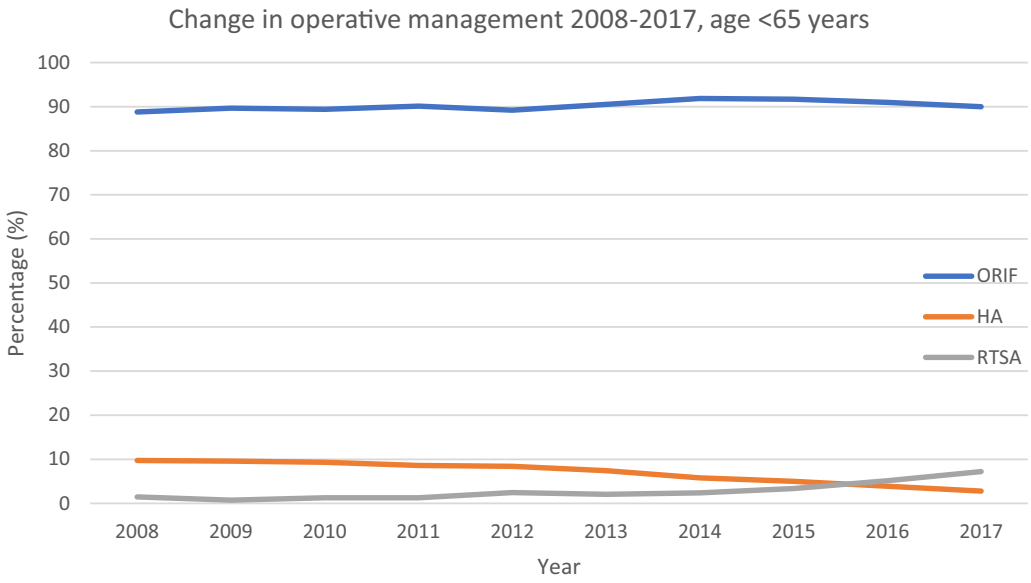

Figure 4 Trends in management of operatively treated proximal humeral fractures in patients younger than 65 years. *ORIF*, open reduction–internal fixation; *HA*, hemiarthroplasty; *RTSA*, reverse total shoulder arthroplasty.

increase in nonoperative management.[20] However, there has been criticism of the PROFHER trial's weaknesses and applicability to certain fracture patterns.[14,30]

Nonoperative management was significantly more likely in patients aged 65 years or older than in patients younger than 65 years, which likely reflects lower patient demand, suitability for operative management, and surgeon preference. Our study found that the rate of nonoperative management was lower than the historically quoted 80% to 85% rate.[23] This may be because our study was only able to analyze NHMD data from inpatient episodes of care, and outpatient episodes of care will likely increase the rate of nonoperative management, which may then approach reported rates of operative management in other series.[23]

Operative management decreased across both age groups over the study period. This decrease was mainly due to a decrease in ORIF and HA use in both age cohorts. This decrease in operative management is consistent with the increasing body of literature showing that nonoperative management may have functionally similar results to operative management in all age groups and particularly patients aged 65 years or older.[4,16,28]

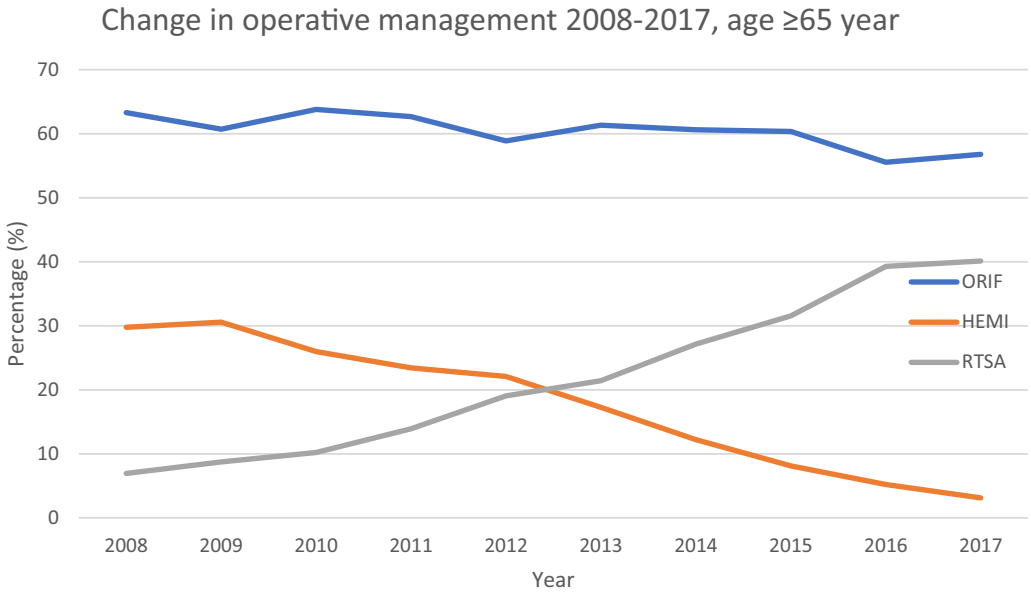

Figure 5 Trends in management of operatively treated proximal humeral fractures in patients aged 65 years or older. *ORIF*, open reduction–internal fixation; *HEMI*, hemiarthroplasty; *RTSA*, reverse total shoulder arthroplasty.

ORIF use decreased significantly during the study period, but ORIF remained the most common operative intervention. ORIF comprised 89% to 91% of all operative intervention in patients younger than 65 years. This is likely because of the preference to preserve the humeral head and questions regarding the longevity of humeral head replacement in younger active patients.[16,19] In patients aged 65 years or older, the use of ORIF decreased by 10.3%. The decreased use of ORIF is likely a result of the high complication rate and similar functional outcomes to nonoperative management in elderly patients.[13,25,37] However, this significant decrease in ORIF use was minor compared with that in HA use.

A significant decrease in the use of HA occurred over the study period. Initially, HA was popular in both the younger group (<65 years) and older group (≥65 years), making up almost 10% and 30% of all operations, respectively, at its peak use in 2009. However, HA is technically demanding, relying on anatomic tuberosity fixation and healing for optimal results, which has resulted in unreliable outcomes.[1,6] There is also increasing evidence that HA has similar functional outcomes to nonoperative management[7,26] and poorer functional outcomes than RTSA.[8,32,34]

The addition of RTSA to the operative treatment algorithm in the past decade has shown a significant increase in RTSA use, particularly in elderly patients. In patients aged 65 years or older, RTSA is currently the treatment choice in approximately 7% of all PHFs or 40% of operatively managed PHFs and is now more popular than HA. This significant uptake of RTSA has been well documented[3,15,27,29,31] and may result from a number of factors: First, there is increasing evidence from comparative studies that RTSA outperforms HA in range of motion and patient-reported outcome measures.[8,32] Second, surgeons are having increased exposure to RTSA for other indications and are likely to be more comfortable with glenoid exposure and implant position. RTSA is now so commonly used that it is our recommendation that orthopedic trauma and shoulder surgeons treating PHFs in elderly patients should be comfortable with the use of RTSA.

Large database studies have well-documented inherent weaknesses,[5,17,18,22] which our study shares. First, the NHMD only records inpatient episodes of care. PHFs do not always require an inpatient episode of care, and many are treated on an outpatient basis. Thus, many patients with PHFs who were likely treated nonoperatively were not captured in our study. This would underestimate the rate of nonoperative management and is a major weakness of this study. Second, the accuracy of the data is dependent on complete and proper coding. Third, it was not possible to identify whether PHFs that were treated nonoperatively or by ORIF during our study period were subsequently treated by humeral head replacement as we were unable to link the 2 databases. This also led to an additional procedure count for the same fracture. Finally, we would have preferred to analyze variations in management by state or region of Australia, as variation in management is often a marker of lack of consensus[5]; however, this was not possible because of limitations in the NHMD. Conversely, the strength of this study is the completeness of data as the NHMD and AOANJRR capture nearly all PHFs across the nation, which is ideal for analyzing trends in management.

Conclusion

Over a 10-year period, from 2008 to 2017, the incidence of PHFs increased, particularly in elderly patients. Nonoperative treatment was the most common treatment choice, regardless of age. The proportion of operatively treated PHFs decreased significantly. ORIF remained the most common treatment choice for operatively managed PHFs. ORIF and HA use decreased significantly. A significant increase occurred in the use of RTSA, most notably in patients aged 65 years or older.

Disclaimer

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