6-5-2023

Osteoporosis in the Setting of Shoulder Arthroplasty: A Narrative Review

Mohammad Daher

Mohamad Fares
Thomas Jefferson University

Peter Boufadel
Thomas Jefferson University

Akshay Khanna
Thomas Jefferson University

Ziad Zalaquett

See next page for additional authors

Review

Osteoporosis in the Setting of Shoulder Arthroplasty: A Narrative Review

Geriatric Orthopaedic Surgery & Rehabilitation
Volume 14: 1–5

DOI: 10.1177/21514593231182527
journals.sagepub.com/home/gos
Sage

Mohammad Daher, BSc[1], Mohamad Y. Fares, MD[2], Peter Boufadel, BSc[2], Akshay Khanna, BSc[3], Ziad Zalaquett, BSc[1], and Joseph A. Abboud, MD[2]

Abstract

Patients who undergo shoulder surgery are frequently affected by osteoporosis and osteopenia, and the prevalence of this association is expected to increase due to the growing number of elderly individuals undergoing these procedures. It may be advisable to conduct a preoperative DXA scan for orthopedic surgical candidates at high risk, to detect those who could benefit from early intervention and avoid any related adverse events. Some of these complications include periprosthetic fractures, infection, subsequent fragility fractures, and have an all-cause revision arthroplasty at 2 years post-op. Some studies analyzed the beneficence of antiresorptive medications pre-operatively but the latter did not show favorable outcomes. Surgical management may include cementing components of the prosthesis as well as modifying the diameter of the shoulder stem. Nevertheless, more studies are needed to evaluate the efficacy of any intervention, whether medical or surgical, to avoid any shoulder arthroplasty related-complication that may be precipitated by the reduced bone mineral density.

Keywords

osteoporosis, osteoarthritis, shoulder arthroplasty, management, bone mineral density

Introduction

A report by the US Surgeon General revealed that 10 million Americans over the age of 50 have osteoporosis, and an additional 34 million are at risk of developing the disease.[1] Osteoporosis is a prevalent degenerative bone disorder that stems from a progressive decrease in bone mineral density (BMD), while osteopenia represents a significant decrease in bone mineral density that is not sufficient to qualify for a diagnosis of osteoporosis.[2] The pathophysiology of progressive osteopenia and osteoporosis lies in discordant osteoclast and osteoblast activity, which results in an imbalance in bone resorption and formation.[2,3]

An important complication of this bone loss is the increased risk of fragility fractures. Osteoporosis results in more than 8.9 million fractures annually, and areas of the body at particular risk are the hip, vertebral bodies, and distal forearm.[3] Modifiable risk factors for osteoporosis include smoking, alcohol usage, stress, and long periods of physical inactivity.[3] Furthermore, a deficiency in vitamin D, calcium, and dietary protein particularly increases the risk of developing osteoporosis.[3–5] Non-modifiable risk factors include older age, Caucasian ethnicity, and a family history of osteoporosis, suggesting a genetic component.[3,6]

[1]Orthopedic department, Hôtel Dieu de France, Beirut, Lebanon
[2]Rothman Institute/Thomas Jefferson Medical Center, Philadelphia, PA, USA
[3]Sidney Kimmel Medical College, Thomas Jefferson University, Philadelphia, PA, USA

Corresponding Author:
Mohammad Daher, BSc, Hotel-Dieu De France, Independence street Zarif, Yasseen, Yasseen, Achrafieh 0000, Lebanon.
Email: mohdaher1@hotmail.com

Moreover, postmenopausal women and individuals with a history of previous fractures are also at disproportionate risk for developing osteopenia and osteoporosis.[3,4,6]

The impact and prevalence of osteoporosis have significant implications for orthopedic surgery patients. In shoulder surgery patients, the presence of a reduced bone mineral density has the potential to impact both the technique of surgery and the implant chosen.[4] A case-control study discovered that diminished bone density was relevant enough to cause 87.5% of surgeons to alter their technique or strategy intra-operatively.[7] Another study found the rates of preoperative osteoporosis to be 14.3% for anatomic total shoulder arthroplasty (TSA) patients and 26.2% for reverse shoulder arthroplasty (RSA) patients.[8]

That being said, the purpose of this study is to explore the prevalence of osteoporosis and osteopenia in patients undergoing shoulder surgery, describe any differences in outcomes, and highlight potential relevant medical as well as surgical considerations and interventions based on the reported clinical outcomes in order to reduce any potential associated risks.

Incidence and Screening

The incidence of shoulder arthroplasty has been growing exponentially,[9] and as the population continues to age, an increasing number of patients with osteoporosis are undergoing the procedure. Osteopenia and osteoporosis are highly prevalent among patients undergoing shoulder arthroplasty, as reported by several studies. Pervaiz et al.[10] conducted a prospective study of patients undergoing a TSA, wherein DXA scans were obtained prior to surgery. The authors found that the rates of osteopenia and osteoporosis were 43.6% and 12.2%, respectively. Similarly, Casp et al.[8] reported that the prevalence of an osteoporosis diagnosis at the time of surgery was 14.3% for anatomic TSA patients and 26.2% for reverse TSA patients. In a study by Bernatz et al, nearly one third (80/251) of the patients were diagnosed with osteoporosis,[4] while Cronin et al.[7] reported that 20% of patients had a preoperative diagnosis of osteopenia or osteoporosis. The incidence of osteoporosis prior to shoulder arthroplasty is expected to be even higher. Bernatz et al.[4] demonstrated that although 68% of the patients met the criteria for DXA testing, only 12% had in fact undergone testing within two years of the surgery, indicating insufficient screening.

Numerous validated screening protocols are available to identify orthopedic surgical candidates at high risk of osteoporosis who may benefit from a preoperative DXA scan (National Osteoporosis Foundation (NOF), U.S Preventive Service Task Force, the International Society for Clinical Densitometry…). While the majority recommend BMD evaluation in all women aged 65 years or older, irrespective of clinical risk factors,[11–15] recommendations with regards to testing in older men and in patients under the age of 65 years vary. The NOF recommends BMD measurements for women aged ≥65 years and men aged ≥70 years, regardless of clinical risk factors; younger postmenopausal women, women in the menopausal transition, and men aged 50 to 69 years with clinical risk factors for fracture; adults who have a fracture after age ≥50 years; and adults with a condition or taking a medication associated with low bone mass or bone loss.[11] However, the UPSTF found screening older men without clinical risk factors to be of limited benefit.[12,13]

The gold standard for diagnosing osteoporosis is DXA scanning, which measures the BMD at the femoral head and lumbar spine. A reference group of young adults and age-, sex-, and race-matched controls is used to compare the patient's BMD. T and Z scores are used to compare the patient's BMD to that of an average 30-year-old woman and an age-, sex-, and race-matched control, respectively. The WHO BMD classification is based on the T score: osteoporosis is defined as a T score ≤ -2.5, and osteopenia is defined as a T score < -1 and > -2.5.[16] However, some authors recommend using the Fracture Risk Assessment Tool (FRAX) to diagnose osteoporosis. [11,12,16] FRAX is a widely used tool that estimates the 10-year probability of a hip fracture and a major osteoporotic fracture (defined as a clinical vertebral, hip, forearm, or proximal humerus fracture) for untreated patients aged 40 to 90However, some authors recommend using the Fracture Risk Assessment Toolyears. [17,18] Although the FRAX calculation includes femoral neck BMD and various clinical risk factors, it can be calculated without BMD, making it practical and beneficial when DEXA scans are unavailable. Chang et al.[16] found that a high FRAX with or without BMD is sufficient for diagnosing osteoporosis using a novel screening protocol. Moreover, Pervaiz et al.[10] explored the utilization of CT scans of the shoulder as a method of assessing the metabolic bone condition. The authors found a significant correlation between proximal humerus Hounsfield units (HU) values and femoral neck BMD and T scores measured using DXA. This suggests that CT-derived HU values may be used to predict osteoporosis and the need for further evaluation and treatment. The mean HU values for normal, osteopenic, and osteoporotic patients were 121.3, 103.4, and 92.1, respectively. As preoperative CT scans of the shoulder are a standard procedure prior to arthroplasty, CT-derived HU values may be an appropriate alternative to assess the BMD of the proximal humerus and glenoid.[7]

A preoperative osteoporosis diagnosis may influence the surgeon's decision making. Therefore, screening patients prior to surgery can identify patients at high risk of osteoporosis and assess the need for further diagnostic evaluation and treatment. Screening protocols are simple,

use basic patient information, and can be performed in any orthopedic practice without additional imaging or cost.[16] Given the increasing prevalence and significance of osteoporosis in shoulder arthroplasty, screening is a necessary and effective strategy.

Associated Complications

The presence of osteoporosis in the prospective shoulder arthroplasty patient has well been documented to cause potential comorbidities following the procedure.[8,19–21] Having compromised bone integrity and bone loss threatens the stability and robustness of the prostheses and can predispose to numerous complications, which include periprosthetic joint fractures and infection.[8,19–21]

One propensity score-matched retrospective cohort study by Testa et al.[19] explored the complication rates after shoulder arthroplasty in patients with and without a prior history of fragility fractures. Fragility fractures are fractures that occur due to low trauma events and can often be attributed to osteoporosis. The study showed that patients with prior fragility fractures were more likely to sustain periprosthetic fractures, infection, subsequent fragility fractures, and have an all-cause revision arthroplasty at 2 years post-operatively when compared to patients with no history of fragility fractures. Another study by Casp et al.[8] explored the association between osteoporosis and postoperative prosthetic-related complications in patients undergoing shoulder arthroplasty and reported similar findings. The authors concluded that osteoporosis represented a significant risk factor for periprosthetic fractures and revision shoulder arthroplasty within 2 years of surgery. The effects of osteoporosis have also been linked to complications in RSA, as one systematic review explored possible causes behind acromial stress fractures post-RSA and showed that old age and female gender can constitute risk factors for patients.[20] The authors noted that both of these factors can be associated with osteoporosis and advised appropriate counseling for osteoporotic patients undergoing RSA.[20] Similarly, one large multicenter study involving 15 institutions explored the incidence of acromial stress fractures and scapular spine fractures following RSA, and aimed at identifying associated risk factors.[21] The authors reported that osteoporosis constituted an independently predictive risk factor for acromial stress fractures and scapular spine fractures following RSA.[21] As such, the deleterious effects of osteoporosis in the setting of arthroplasty have been adequately documented by several studies in the literature.

Given the findings of the aforementioned studies, it would be reasonable to believe that treating osteoporosis in prospective shoulder arthroplasty patients can play an important role in preventing post-operative complications.

Management

Medical

The management of osteoporosis in patients undergoing shoulder arthroplasty is not very common, and the literature is thus very scarce. Bernatz et al. [4] assessed patients undergoing shoulder replacement; if they met certain criteria (according to the national osteoporosis foundation), they were given osteoporosis medication 6 months pre- and/or post-operatively. Such criteria included the presence of a previous low energy fracture after age 50, a T score < -2.5 and a T score between −2.5 and −1 with a fracture risk assessment of the hip >3% or a major osteoporotic fracture >20%.[4] However, one must always consider the side effects of every treatment. Although the side effects of bisphosphonates are rare, they are important and include gastrointestinal inflammation, atypical femur fractures, and jaw osteonecrosis.[11] In this retrospective study, there was no data about the outcomes of these treated patients.[4] However, a study by Mai et al.[22] showed that according to a multivariate analysis controlling for both osteoporosis and osteopenia, patients who received bisphosphonates prior to surgery had a significantly increased risk of intraoperative fractures as well as a statistically significant 8-fold increase in complications at one year, which may or may not require revision surgery, including stress fractures, periprosthetic fractures, aseptic loosening, scapular notching, and periprosthetic fractures. This may be explained by the fact that long-term usage of bisphosphonates may result in an excessive suppression of bone turnover, which affects physiological stress responses, thus increasing the risk of fracture and other complications. Nevertheless, this association was not seen at two years post-operatively or with revision surgery, which may be due to the loss of follow-up. Therefore, obtaining a patient's history of this medication may affect management as a whole.

Examples of such a change of management is stopping bisphosphonates for a while prior to TSA in patients with glenohumeral osteoarthritis.[22] Other options include anabolic agents such as teriparatide, selective estrogen receptor modulators, and RANK-L inhibitors such as denosumab, whose effect does not last for a long time after stopping.[4,22] Nonetheless, more studies are needed to assess the utility of osteoporosis treatment and the adequate treatment in this specific clinical scenario.

Surgical

As for surgical management, the knowledge of a preoperative BMD can help the surgeon choose the implant as well as the surgical technique, whether it is about the usage of cement or the diameter of the humeral stem. In fact, the use of a stemless anatomic total shoulder arthroplasty is contraindicated when osteoporosis is present.[23] Furthermore, cementing the stemmed humeral component is an option in patients with a low BMD in order to avoid the risk of intra-operative fracture, which may occur by press-fitting a non-cemented humeral component.[4] However, Pervaiz et al. [24] reported with their logistic regression model that age (and not BMD) was a significant predictor for the use of cement in TSA which makes the latter's usage controversial and surgeon-dependent. Yet, this model indicated that patients with a lower BMD had a higher statistically significant chance of getting a larger-diameter humeral stem (10-14 mm instead of 6-8 mm) (P = .016).[24] Nevertheless, more studies are needed to see whether cement, or a larger humeral stem diameter can benefit osteoporotic patients.

Conclusion

In conclusion, osteoporosis and osteopenia are prevalent among patients undergoing shoulder surgery, and the rates of these conditions are expected to rise due to the increasing number of older adults undergoing these procedures. Preoperative DXA scanning could be recommended for high-risk orthopedic surgical candidates to identify those who may benefit from intervention. Medical and surgical considerations and interventions should also be explored to reduce the potential risks associated with reduced bone mineral density in shoulder surgery patients. Improved screening protocols and education for both patients and healthcare providers can help reduce the morbidity associated with this prevalent degenerative bone disorder.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Mohammad Daher https://orcid.org/0000-0002-9256-9952

References

1. Office of the Surgeon General (US). Bone Health and Osteoporosis: A Report of the Surgeon General. *Rockv Off Surg Gen* 2004;20945569.
2. Varacallo M, Seaman TJ, Jandu JS. *Osteopenia*. Treasure Island (FL): StatPearls Publishing. http://www.ncbi.nlm.nih.gov/pubmed/24994054 (2023).
3. Pouresmaeili F, Kamalidehghan B, Kamarehei M, A comprehensive overview on osteoporosis and its risk factors. *Ther Clin Risk Manag*. 2018;14:2029-2049.
4. Bernatz JT, Brooks AE, Nguyen BP, Prevalence and treatment of osteoporosis prior to elective shoulder arthroplasty. *J Am Acad Orthop Surg Glob Res Rev* 2020;4;e20.00204. Epub ahead of print 2020. doi:10.5435/JAAOSGlobal-D-20-00204
5. Entezari V, Lazarus M. Surgical considerations in managing osteoporosis, osteopenia, and vitamin D deficiency during arthroscopic rotator cuff repair. *Orthop Clin North Am*. 2019;50:233-243.
6. Clynes MA, Harvey NC, Curtis EM, The epidemiology of osteoporosis. *Br Med Bull*. 2020;133:105-117.
7. Cronin KJ, Vaughan A, Tzeuton S, Prospective assessment of osteoporosis in total shoulder arthroplasty. *Semin Arthroplast JSES*. 2023;33:15-21.
8. Casp AJ, Montgomery SR, Cancienne JM, Osteoporosis and implant-related complications after anatomic and reverse total shoulder arthroplasty. *J Am Acad Orthop Surg*. 2020;28:121-127.
9. Wagner ER, Farley KX, Higgins I, The incidence of shoulder arthroplasty: rise and future projections compared with hip and knee arthroplasty. *J shoulder Elb Surg*. 2020;29:2601-2609.
10. Pervaiz K, Cabezas A, Downes K, Osteoporosis and shoulder osteoarthritis: incidence, risk factors, and surgical implications. *J shoulder Elb Surg*. 2013;22:e1-e8.
11. Cosman F, de Beur SJ, LeBoff MS, Clinician's guide to prevention and treatment of osteoporosis. *Osteoporos Int*. 2014;25:2359-2381.
12. US Preventive Services Task ForceCurry SJ, Krist AH, Screening for osteoporosis to prevent fractures: US preventive services task force recommendation statement. *JAMA*. 2018;319:2521-2531.
13. Viswanathan M, Reddy S, Berkman N, Screening to prevent osteoporotic fractures: updated evidence report and systematic review for the US preventive services task force. *JAMA*. 2018;319:2532-2551.
14. LeBoff MS, Greenspan SL, Insogna KL, The clinician's guide to prevention and treatment of osteoporosis. *Osteoporos Int*. 2022;33:2049-2102.
15. Lim LS, Hoeksema LJ, Sherin K, Screening for osteoporosis in the adult U.S. population: ACPM position statement on preventive practice. *Am J Prev Med*. 2009;36:366-375.

16. Chang E, Nickel B, Binkley N, A novel osteoporosis screening protocol to identify orthopedic surgery patients for preoperative bone health optimization. *Geriatr Orthop Surg Rehabil*. 2022;13:21514593221116412.
17. Chavda S, Chavda B, Dube R. Osteoporosis Screening and fracture risk assessment tool: its scope and role in general clinical practice. *Cureus*. 2022;14:e26518.
18. Marques A, Ferreira RJO, Santos E, The accuracy of osteoporotic fracture risk prediction tools: a systematic review and meta-analysis. *Ann Rheum Dis*. 2015;74: 1958-1967.
19. Testa EJ, Albright JA, Lemme NJ, Increased risk of periprosthetic fractures and revision arthroplasty in patients undergoing shoulder arthroplasty with a history of prior fragility fractures: a matched cohort analysis. *J Am Acad Orthop Surg*. 2023;31:e473-e480.
20. Lucasti CJ, Namdari S. Acromial stress fractures: a systematic review. *Arch bone Jt Surg*. 2019;7:397-401.
21. ASES Complications of RSA Research GroupMahendraraj KA, Abboud J, Predictors of acromial and scapular stress fracture after reverse shoulder arthroplasty: a study by the ASES Complications of RSA multicenter research group. *J shoulder Elb Surg*. 2021;30:2296-2305.
22. Mai DH, Oh C, Doany ME, Preoperative bisphosphonate treatment may adversely affect the outcome after shoulder arthroplasty. *Bone Joint Lett J*. 2019;101-B:147-153.
23. Hawi N, Tauber M, Messina MJ, Anatomic stemless shoulder arthroplasty and related outcomes: a systematic review. *BMC Musculoskelet Disord*. 2016;17:376.
24. Pervaiz K, Cabezas A, Downes K, Osteoporosis and shoulder osteoarthritis: Incidence, risk factors, and surgical implications. *J Shoulder Elb Surg*. 2013;22:e1.