

Original Article

Osteoporosis Screening Is Often Indicated but Overlooked Prior to Rotator Cuff Repair

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Purpose: To (1) report the percentage of patients undergoing rotator cuff repair (RCR) who were appropriately screened with dual-energy X-ray absorptiometry testing prior to surgery, if indicated, and (2) determine the percentage of patients properly prescribed osteoporosis medications within 6 months of surgery. **Methods:** Consecutive patients aged 50 years or older who underwent elective RCR at a single tertiary-care center over a 1-year period were reviewed. Fracture risk was estimated using the Fracture Risk Assessment Tool (FRAX) with and without bone mineral density. The U.S. National Osteoporosis Foundation (NOF) criteria for screening and treatment were applied. Patients with acute fractures or revision surgery were excluded. **Results:** Of the 218 patients included, 129 were women (58.1%). The mean age was 61.5 ± 7.2 years. One hundred thirty-one RCRs (60.1%) occurred within 3 months of injury. A total of 69 patients (31.7%) met the NOF criteria for bone mineral density screening. Of these patients, 23 (33.3%) were appropriately screened with a dual-energy X-ray absorptiometry scan. Primary care providers initiated bone health assessment in 18 of the 23 appropriately screened patients, with orthopaedic providers initiating the workup in 3 patients (13.0%). Thirty-two patients (14.7%) met the NOF criteria for pharmacologic management of osteoporosis. Of these patients, 5 (15.6%) were treated. Patients meeting the medication criteria were older (69.1 ± 7.7 years vs 60.2 ± 6.3 years, $P < .001$), had a lower body mass index (28.8 ± 6.1 vs 31.5 ± 6.5 , $P = .028$), and had chronic rotator cuff tears ($P = .015$). **Conclusions:** Patients aged 50 years or older undergoing RCR are often not appropriately screened for osteoporosis. Even when appropriately screened, only 15.6% of patients meeting the indications for pharmacologic intervention for bone health optimization were prescribed appropriate medications. Although bone health optimization may or may not affect surgical timing, patient encounters related to rotator cuff tears can be used as an opportunity for providers to initiate osteoporosis screening and treatment protocols. **Level of Evidence:** Level IV, therapeutic case series.

Osteoporosis is a common condition in the United States. Wright et al.¹ reported that of the 99 million U.S. citizens aged 50 years or older, 10.2 million had osteoporosis. Osteoporosis is diagnosed using the World Health Organization criteria based on dual-energy X-ray absorptiometry (DXA) screening. A bone

mineral density (BMD) T-score of -2.5 or less defines osteoporosis, whereas T-scores between -2.5 and -1 define osteopenia.² Rotator cuff (RC) tears are a common source of pain and dysfunction that predominantly affect the aging population.³ The structural integrity and healing of a repaired RC is important and has been associated with better outcomes.⁴ Several patient-specific factors have been reported to influence tendon healing after rotator cuff repair (RCR), including patient age, tear size, fatty infiltration, muscle atrophy, muscle retraction, smoking, diabetes, vitamin D deficiency, and osteoporosis.⁵⁻⁹ Furthermore, the greater tuberosity is known to become osteopenic after RC tears, which is correlated to the severity of retraction and chronicity of the tear.¹⁰⁻¹⁴ BMD has been shown to have significant effects on RCR healing, given that patients with osteopenia have a more than 4-fold increased risk of repair failure and patients with osteoporosis have a 7-fold increased risk of retear.² Surgeons have recognized bone quality as an important prognostic factor for RCR¹⁵⁻¹⁷ and adjusted their

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technique by limiting decortication to rely on cortical and superficial trabecular bone for fixation, placing anchors 90° to the cortex, and distributing force with an increased number of anchors, suture tape, or advancement of the medial-row anchors.^{18,19} Animal models have suggested that bisphosphonates and teriparatide injections may increase the amount of stress the RC can withstand before failure.^{20,21}

As of 2014, the U.S. National Osteoporosis Foundation (NOF) guidelines have included fragility fractures and fracture risk as estimated using the Fracture Risk Assessment Tool (FRAX)²² to define indications for pharmacologic treatment.²³ To date, a paucity of literature exists examining whether patients undergoing RCR are being appropriately screened, as well as whether they are receiving pharmacologic management when indicated for low BMD. A previous study in a similar cohort reported that osteoporosis is common and undertreated in patients aged 48 to 92 years prior to total joint arthroplasty, with nearly 25% of patients meeting the NOF criteria for pharmacologic management.²⁴

The purpose of this study was to (1) report the percentage of patients undergoing RCR who were appropriately screened with DXA testing prior to surgery, if indicated, and (2) determine the percentage of patients properly prescribed osteoporosis medications within 6 months of surgery. We hypothesized that preoperative osteoporosis would be under-screened in this population. However, in patients who were appropriately screened, we hypothesized that these patients would have received appropriate medical management.

Methods

Consecutive patients who underwent RCR at a single tertiary-care center over the year prior to study initiation (August 2018 to August 2019) were reviewed. Patients were identified by Current Procedural Terminology (CPT) codes for RCR: CPT code 29827 (arthroscopy, shoulder, surgical, with RCR), CPT code 23410 (repair of musculotendinous cuff, acute), CPT code 23412 (repair of musculotendinous cuff, chronic), and CPT code 23420 (reconstruction of complete shoulder [rotator] cuff avulsion, chronic [includes acromioplasty]). Patients were included if they were at least 50 years of age and underwent one of the aforementioned RCR procedures. The exclusion criteria included concomitant acute fractures (e.g., acute proximal humeral fracture undergoing hemiarthroplasty) or revision surgery. The indications for surgery, tendons repaired, and concomitant procedures were recorded from the surgeons' operative reports. Institutional review board exemption (under 45 CFR 46, category 4) was obtained for this study.

Electronic medical records were reviewed for demographic information, RC tear acuity (a tear was defined as acute if occurring within 3 months of surgical date), preoperative osteoporosis risk factors, previous

low-energy adult-age fractures, secondary causes of osteoporosis, prior DXA testing, current calcium and vitamin D supplementation, and osteoporosis pharmacotherapy (prescription within 6 months before or after surgery).

Fracture Risk Assessment

The FRAX calculator is a fracture risk assessment tool intended for postmenopausal women and men aged 50 years or older to estimate the percentage risk of sustaining a fracture over a 10-year time frame.²³ Separate percentages are determined for the risk of a hip fracture and the risk of all major osteoporotic fractures, defined as fractures of the hip, spine, wrist, or humerus.²⁵ The FRAX calculator, recommended by NOF, was used to estimate fracture risk without femoral neck BMD for all patients.²² FRAX calculation is used as part of the diagnostic evaluation to determine which patients are indicated pharmacologic treatment of osteoporosis.

Patient risk factors included in the FRAX assessment are detailed in [Table 1](#). A separate calculation of the FRAX percentage with femoral neck BMD was completed for patients who underwent DXA testing in the 2-year period preoperatively. The NOF criteria for BMD testing and pharmacologic osteoporosis treatment ([Table 2](#)) were applied to all patients.

DXA Screening

The lowest T-score from either the lumbar vertebrae (average of 2 lumbar vertebrae while excluding vertebrae with degenerative or surgical changes) or proximal femur (femoral neck and total femur) was recorded. An "appropriately screened" patient was defined as a patient who met the indications for BMD evaluation and underwent a DXA scan in the 2 years prior to RCR. An "appropriately treated" patient was defined as a patient who was receiving NOF-recommended and U.S. Food and Drug Administration–approved osteoporosis medications including bisphosphonates, estrogen agonist or antagonist (raloxifene), estrogen and/or hormone therapy, tissue-selective estrogen complex, parathyroid hormone 1-34 (teriparatide), and receptor activator of nuclear factor κ B ligand inhibitor (denosumab).²³ During the study period, there was no routine, standardized screening protocol used by providers and provider-extenders for identifying patients at risk of osteoporosis and in need of further testing.

Statistical analysis was completed using IBM SPSS Statistics software (version 26; IBM, Armonk, NY). Shapiro-Wilk testing was performed to determine whether continuous variables were normally distributed. For parametric continuous variables, 2-sample *t* tests were used, whereas Mann-Whitney *U* testing was used for nonparametric variables. For categorical variables, χ^2 analysis was performed. In some subsets, descriptive statistics were used because the intention

Table 1. Clinical Risk Factors Included in FRAX²²

Age
Sex
Body mass index
Previous fracture*
Hip fracture in parent
Active smoker
Glucocorticoid use [†]
Diagnosis of rheumatoid arthritis
Secondary osteoporosis [‡]
≥3 Alcoholic drinks/d
Femoral neck BMD (in grams per square centimeter), if available

BMD, bone mineral density; FRAX, Fracture Risk Assessment Tool.

*Previous fracture in adult life occurring after low-energy trauma.

[†]Equivalent to 5 mg of prednisolone daily currently or for more than 3 months in the past.

[‡]Secondary cause of osteoporosis: type 1 diabetes, osteogenesis imperfecta, untreated long-standing hyperthyroidism, hypogonadism or premature menopause, chronic malnutrition, or malabsorption and chronic liver disease.

was not to detect differences between groups but rather to profile the bone health of all patients presenting for RCR. $P < .05$ was considered statistically significant.

Results

A total of 218 patients aged at least 50 years underwent RCR during the aforementioned 1-year period. The mean age was 61.5 ± 7.2 years, and most patients were women ($n = 129$, 58.1%). The RC tears in most patients ($n = 131$, 60.1%) were acute (RCR within 3 months of injury). The vast majority of patients underwent RCR of the supraspinatus tendon (96.8%) with subacromial decompression (90.4%). A complete breakdown of patient demographic characteristics, surgical procedures performed, and osteoporosis risk factors is detailed in Table 3.

Adult-age fractures occurred in 25 patients (11.5%), with 6 vertebral fractures (2.8%), 5 ankle fractures (2.3%), 5 distal radius fractures (2.3%), 4 proximal humeral fractures (1.8%), 2 tibial shaft fractures (1%), 1 patellar fracture (0.5%), 1 lateral compression pelvic fracture (0.5%), and 1 hip fracture (0.5%). Two patients had secondary causes of osteoporosis owing to malabsorption from long-standing inflammatory bowel disease. Table 4 details osteoporosis risk factors for the entire case series.

Fracture Risk Assessment and Osteoporosis Screening

A total of 69 patients (31.7%) met the NOF criteria for BMD screening; however, only 23 of these 69 patients (33.3%) were appropriately screened with a DXA scan within 2 years of the surgical date. A total of 50 patients (22.9%) underwent a DXA scan at some point in their lifetime. The 23 patients who were appropriately screened underwent a DXA scan at a mean of 13.1 ± 6.4 months prior to the surgical date. The mean FRAX

percentage for a major fracture in the next 10 years without BMD was $6.8\% \pm 4.4\%$ for the entire case series. Patients who were indicated for BMD screening but did not undergo a DXA scan had a FRAX major fracture risk of $10.9\% \pm 5.5\%$ and FRAX hip fracture risk of $2.3\% \pm 2.2\%$. These risk percentages were significantly higher ($P \leq .001$) than those of patients not indicated for BMD screening. The latter group showed a FRAX major fracture risk of $4.9\% \pm 1.9\%$ and FRAX hip fracture risk of $0.5\% \pm 0.4\%$. Table 5 details the FRAX calculations for all subgroups.

The primary care provider (PCP) ordered the DXA scan in 18 of the 23 patients (78.2%) who were appropriately screened with a DXA scan. An orthopaedic provider initiated the evaluation in 3 cases (13.0%), an oncologist initiated the workup in 1 patient (4.3%) because of a cancer history, and an obstetrics and gynecology provider initiated the workup in 1 patient (4.3%) because this provider was serving in a PCP-type role. In 2 of the 3 cases in which an orthopaedic surgery provider ordered the DXA scan, the scan was obtained at the direction of our spine colleagues for patients with a fracture history whereas a single patient had a DXA scan ordered by a sports medicine provider after meeting the NOF screening criteria.

Osteoporosis Population and Treatment

Thirty-two patients (14.7%) met the NOF criteria for pharmacologic management of osteoporosis based on

Table 2. NOF Guidelines for Which Patients Should Undergo BMD Screening and Receive Pharmacologic Therapy for Osteoporosis²³

BMD screening criteria
Women
All women aged ≥ 65 yr
Younger postmenopausal women and women in menopausal transition with clinical risk factors for fracture*
Women aged ≥ 50 yr who have had adult-age fracture
Women with condition (e.g., rheumatoid arthritis) or taking medication (e.g., glucocorticoids, with daily dose of prednisone ≥ 5 mg or equivalent for ≥ 3 mo) associated with low bone mass or bone loss
Men
All men aged ≥ 70 yr
Men aged 50-69 yr with clinical risk factors for fracture*
Men aged ≥ 50 yr who have had adult-age fracture
Men with condition (e.g., rheumatoid arthritis) or taking medication (e.g., glucocorticoids, with daily dose of prednisone ≥ 5 mg or equivalent for ≥ 3 mo) associated with low bone mass or bone loss
Guidelines for pharmacologic intervention
T-score ≤ -2.5 at femoral neck or spine [†]
History of hip or vertebral fracture
T-score between -2.5 and -1 at femoral neck or spine and 10-yr risk of hip fracture $\geq 3\%$ or major osteoporotic fracture $\geq 20\%$

BMD, bone mineral density; NOF, U.S. National Osteoporosis Foundation.

*Clinical risk factors found in Table 1.

[†]After appropriate evaluation to exclude secondary causes.

Table 3. Patient Demographic Characteristics and Surgical Information

	n or Mean	% or SD
Sex		
Male	89	40.8
Female	129	59.2
Age, yr	61.5	7.2
Body mass index	31.1	6.5
Laterality		
Right	126	57.8
Left	92	42.2
Ethnicity		
White	202	92.7
African American	11	5.0
Hispanic or Latino	2	0.9
Asian	2	0.9
Native American	1	0.5
Vitamin D level within 2 yr of surgery	48	22.0
Vitamin D deficiency	17	7.8
Acute rotator cuff tear	131	60.1
Surgical procedures performed		
Supraspinatus repair	211	96.8
Infraspinatus repair	89	40.8
Subscapularis repair	49	22.5
Biceps tenotomy	113	51.8
Biceps tenodesis	42	19.3
Mumford procedure or distal clavicle excision	103	47.2
Subacromial decompression with or without acromioplasty	197	90.4

SD, standard deviation.

either DXA scan, FRAX calculation, or the presence of an osteoporotic fracture. This population consisted of 14 of the 23 patients (60.9%) who were indicated based on DXA scan results, 6 patients who had vertebral fractures and another patient who had a hip fracture, and 18 patients who had either a FRAX major fracture risk greater than 20% or a FRAX hip fracture risk greater than 3% in the next 10 years. In 6 of the 32 patients (18.8%), more than 1 parameter indicating pharmacologic management was met. Of the 32 patients meeting the medication criteria, only 5 (15.6%) were prescribed an appropriate medication. Three patients were prescribed teriparatide injections, and two were prescribed a bisphosphonate medication. Fig 1 details the screening and pharmacologic management of the study cohort. Patients meeting the criteria for treatment with medication were, on average, significantly older (69.1 ± 7.7 years vs 60.2 ± 6.3 years, $P < .001$) and had a significantly lower BMI (28.8 ± 6.1 vs 31.5 ± 6.5 , $P = .028$). These patients were also more frequently found to have chronic RC tears ($P = .015$).

Discussion

The findings of this study demonstrate that approximately one-third of patients aged 50 years or older undergoing RCR meet the criteria for osteoporosis

screening, although only 33.3% of these patients are appropriately screened. In addition, 14.7% of all patients meet the criteria for osteoporosis medication, but only 15.6% of these patients receive appropriate pharmacologic therapies. In most of the patients who were appropriately screened, their PCP performed screening. Patients with low BMD meeting the criteria for treatment with medication were nearly 9 years older, on average; had a lower body mass index; and had chronic RC tears.

Osteoporosis negatively affects clinical outcomes in patients undergoing RCR. Chung et al.² evaluated post-operative RCR integrity in 272 patients with a mean age of 59.5 years and identified osteoporosis as an independent risk factor for failure on multivariate analysis after controlling for patient age. Nho et al.²⁶ noted that older patients have 1.08 times greater odds of a tendon defect after repair with each 1-year increase in age. In a cohort study using the PearlDiver database (PearlDiver, Colorado Springs, CO) including 2,706 patients who underwent arthroscopic RCR, it was reported that patients with osteoporosis had a higher rate of revision RCR (6.58%) than patients without osteoporosis (4.51%, $P = .008$). Yet, patients with a diagnosis of osteoporosis who were appropriately prescribed bisphosphonates did not have significantly lower revision RCR rates as compared with age- and sex-matched patients with osteoporosis not receiving bisphosphonates.²⁷ These results suggest that bisphosphonate therapy in the patient with osteoporosis and an RC tear may not necessarily lead to improvement in clinical outcomes. Teriparatide has been shown in an animal model to increase bone density of the humeral head, and it may improve the mechanical properties of the infraspinatus tendon enthesis.²¹ Further study of this and other medications used to treat osteoporosis will be needed to determine their effect on RCR outcomes.

Despite the importance of BMD to the clinical outcomes of RCR, it may not be advisable to delay surgery to improve BMD pharmacologically in the setting of an acute RC tear. Acute RC tears have been shown to have superior clinical outcomes if repaired early.^{6,28-31} In addition, it may take several months or longer to significantly improve BMD with pharmacologic intervention.³²⁻³⁴ In patients with

Table 4. Osteoporosis Risk Factors for All Patients (N = 218)

	n	%
Previous fracture at age ≥ 50 yr	25	11.5
Fracture in lifetime	48	22.1
Previous hip fracture	1	0.5
Previous spine fracture	6	2.8
Hip fracture in parent	3	1.4
Active smoker	35	16.1
Glucocorticoid use	11	5.0
Rheumatoid arthritis	1	0.5
≥ 3 Alcoholic drinks/d	12	5.5
Secondary osteoporosis	2	0.9

Table 5. FRAX Calculations for Series and Subgroups

	FRAX Calculation, %	
	Mean	SD
Entire series without BMD (N = 218)		
Major fracture risk	6.8	4.4
Hip fracture risk	1.1	1.6
Patients not meeting screening criteria (n = 149)		
Major fracture risk	4.9	1.9
Hip fracture risk	0.5	0.4
Patients meeting screening criteria (n = 69)		
Major fracture risk	10.9	5.5
Hip fracture risk	2.3	2.2
Patients with BMD at femoral neck (n = 23)		
Major fracture risk	11	5.0
Hip fracture risk	1	0.5

NOTE. FRAX percentages are listed for the case series as a whole and for patients who were indicated for dual-energy X-ray absorptiometry (DXA) testing but did not receive testing, patients who were indicated and did receive DXA testing, and patients who underwent a DXA scan within 2 years of surgery.

BMD, bone mineral density; FRAX, Fracture Risk Assessment Tool; SD, standard deviation.

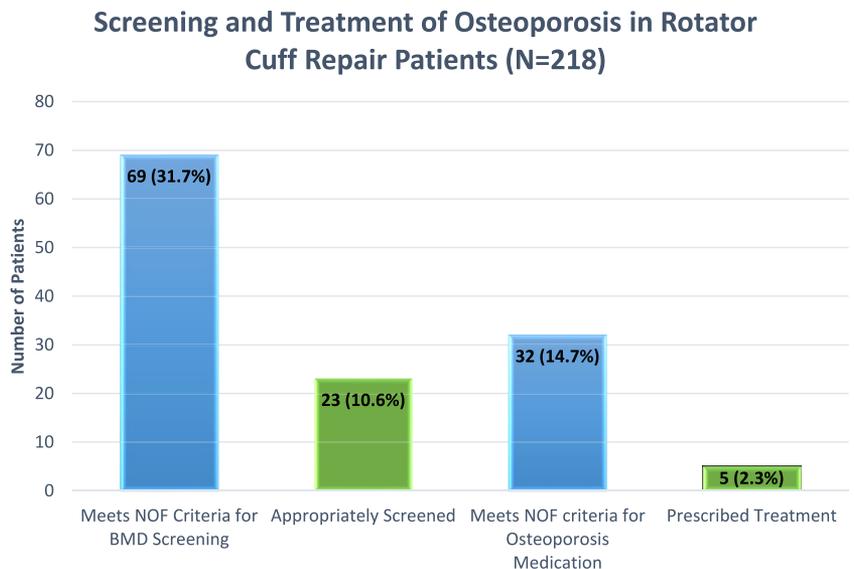
chronic tears or tears amenable to initial nonoperative management, it may be reasonable to screen for low BMD and begin treatment. Orthopaedic surgeons may be the first providers to see these patients and should be familiar with the screening criteria for osteoporosis. The importance of early detection and screening cannot be understated, especially if patients will require eventual surgical management. Our study identified that PCPs are often the providers ordering DXA scans in patients with RC tears who meet indications. At least in the study population at our institution, orthopaedic surgeons rarely were the providers initiating bone health evaluation. Furthermore, 46 patients (21.1%) were not appropriately screened

despite presenting for at least 1 orthopaedic office visit prior to surgery. Although these findings may be specific to this patient population, they highlight the need for further education of orthopaedic providers.

Diagnosis of an RC tear represents an opportunity to improve overall patient health. Despite the significant morbidity and mortality of fragility fractures, the United States continues to be inconsistent with recommended screening and treatment, leading to what some experts have labeled a bone health “crisis.”³⁵⁻³⁸ This has been recognized as a critical issue by the American Orthopaedic Association, leading to the development of the Own the Bone (OTB) initiative.³⁷ As stated by the OTB program, all patients aged 50 years or older scheduled to undergo major orthopaedic surgery should be screened for low BMD.³⁷ The OTB program, which launched in 2009, includes a Web-based registry program to empower medical systems to reduce the incidence of fractures and initiate early, appropriate medical management.³⁹ This initiative also emphasizes the critical role and responsibility orthopaedic surgeons have in recognizing the need for screening and initiating referrals. Our institution created a fracture liaison service and metabolic bone clinic staffed by physicians and physician-extenders with intimate knowledge of screening guidelines, as well as indications, duration, and dosing of pharmacologic treatment including but not limited to calcium and vitamin D supplementation, activity recommendations, and both anabolic and antiresorptive medications. Surgeons can refer patients to this clinic for prompt and comprehensive bone health optimization.

Despite these programs being in place at the study institution, a significant percentage of patients were not appropriately screened based on the NOF and OTB guidelines. The reasons are likely multifactorial. First,

Fig 1. Percentages of patients who met U.S. National Osteoporosis Foundation (NOF) criteria for bone mineral density (BMD) screening and number of patients appropriately screened, along with number of patients who met criteria for osteoporosis pharmacologic management and number of patients indicated for medication who were prescribed medication.



consultations with the fracture liaison service at our center are triggered by a sentinel event, namely a low-energy mechanism fracture. If a patient does not sustain a fracture, then this service is not typically consulted. Another potential reason is lack of understanding of the NOF screening guidelines by both PCPs and orthopaedic surgeons. Although the OTB program has done an excellent job of raising awareness through initiatives, guidelines, and publications, the screening criteria have not been integrated into a new patient checklist or other part of the clinic workflow, reminding busy surgeons and trainees in the clinic to investigate bone health. A final reason postulated for the low screening rates is that bone health may not have been seen as a significant factor affecting clinical outcomes and operative techniques within the orthopaedic–sports medicine department in comparison with subspecialties such as trauma, spine, and adult reconstruction. Given the results of this study, expansion of the institution’s fracture liaison service to capture at-risk patients undergoing any elective surgical procedure would be beneficial.^{37,40} Ongoing quality-improvement efforts are underway to address this issue, including placement of the NOF screening criteria on the walls of provider workrooms in the clinic both as a quick reference and as a reminder to diligently assess bone health when reviewing the medical history with the patient. Ideally, this will be integrated into the electronic medical record as part of a new patient intake process.

Limitations

The retrospective nature of the study design is limited by the accuracy of recorded data in the medical record. At the time of data collection, there was no formal osteoporosis screening protocol in place within the sports medicine department; thus, these data may not be reflective of other institutions with screening protocols. Multiple surgeons contributed cases to this series, and there may be variation in surgical indications and approaches to bone health screening based on individual surgeon preferences. Furthermore, this study did not directly examine any clinical outcomes of RCR and the effects of bone health on outcome. Finally, these data are reflective of the patient population seen in a single geographic region of the United States. It is not known if these data are reflective of patient populations in other regions.

Conclusions

Patients aged 50 years or older undergoing RCR are often not appropriately screened for osteoporosis. Even when appropriately screened, only 15.6% of patients meeting the indications for pharmacologic intervention for bone health optimization were prescribed appropriate medications. Although bone health optimization may or may not affect surgical timing, patient encounters related

to RC tears can be used as an opportunity for providers to initiate osteoporosis screening and treatment protocols.

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