A Review Paper

The Effects of Obesity Surgery on Bone Metabolism: What Orthopedic Surgeons Need to Know

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Abstract

Morbid obesity affects approximately 9 million Americans. Obesity is associated with a reduced risk of osteoporosis, whereas weight loss decreases bone density. Obesity surgery has profound effects on bone, which are well described in the gastrointestinal literature; yet, there are virtually no reports in the orthopedic literature.

The Roux-en-Y procedure is the leading bariatric operation performed in the United States. In this surgery, the primary sites for calcium absorption are bypassed. Patients become calcium- and Vitamin D-deficient, and the body then up-regulates parathyroid hormone, causing increased production of Vitamin D and increased calcium resorption from bone. Gastric banding utilizes a restrictive band and has not been shown to produce the same bone loss as the Roux-en-Y procedure, nor has there been evidence of secondary hyperparathyroidism.

It is important for orthopedists to be aware of the types of obesity surgery and their sequelae on bone, as this may impact bone density, fracture risk, and fracture healing.

Morbid obesity, defined as body mass index of 40 kg/m^2 or more, affects approximately 9 million Americans.[1] The effects of obesity in general are well known. Obese patients are at increased risk for type 2 diabetes, hypertension, hypercholesterolemia, coronary artery disease, stroke, gallbladder disease, sleep apnea, certain cancers (colon, breast, endometrial, prostate), and osteoarthritis. Obesity itself is associated with reduced risk for osteoporosis, whereas productive weight loss decreases bone mineral density and thus increases fracture risk.[2]

Sixty-three thousand obesity surgeries were performed in the United States in 2002, almost 100,000 in 2003,[3] and the number is expected to top 200,000 by 2010. The aim of bariatric surgery is to produce weight loss either by creating a malabsorptive state or by physically limiting food intake. Malabsorption surgeries, such as the Roux-en-Y procedure, are thought to produce more weight loss than banding techniques do, but they can have profound effects on metabolism. The bony effects of obesity surgery are well known to general and gastrointestinal surgeons but have not been described in the orthopedic literature.

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Physiologic Impact of the Roux-en-Y Bypass Procedure

The Roux-en-Y procedure is the leading weight reduction operation offered in the United States. In this surgery, a small stomach pouch is created, which is then anastomosed to the proximal jejunum (the bypassed portion of the stomach and duodenum are anastomosed to the side of the distal jejunum). Weight loss occurs because of food intake restriction and the malabsorptive state. Patients who undergo this surgery are known to develop osteoporosis as a sequela; the duodenum and the proximal jejunum, which are the primary sites for calcium absorption in the body, are bypassed. The remaining small intestine can poorly absorb about 20% of dietary calcium; this absorption is also dependent on vitamin D intake. To further complicate the issue, the Roux-en-Y anastomosis may cause malabsorption of vitamin D because of poor mixing of bile salts with fat at the anastomosis site[4,5] and may impair fat absorption (vitamin D is a fat-soluble vitamin) because of uncoordinated mixing of food with bile and pancreatic secretions. In addition, increased intestinal fat causes steatorrhea, which further reduces calcium absorption. Thus, patients undergoing Roux-en-Y bypass surgery become deficient in calcium and vitamin D.[6] Without oral supplementation, most postsurgical patients ingest less than half of the recommended daily dose of vitamin D and about 50% of the recommended daily dose of calcium.[7] Poor tolerance for milk and dairy products (a result of the surgery) can compound the problem.

The body reacts to this decreased calcium absorption by up-regulating parathyroid hormone (PTH), leading to secondary hyperparathyroidism, which in turn increases production of vitamin D and increases calcium resorption from bone.[8] Hypocalcemia also stimulates conversion of inactive vitamin D (25-hydroxyvitamin D) to the active form (1,25-dihydroxyvitamin D), which, along with PTH, stimulates bone resorption. Coates and colleagues[9] found increased bone resorption and decreased bone mass by dual-energy x-ray absorptiometry (DXA) scans beginning 3 to 6 months

after Roux-en-Y surgery. Laboratory results have shown that vitamin D deficiency and hyperparathyroidism were worse in the first year after surgery[10] but were also progressive over time[11] and possibly lead to osteopenia, osteoporosis, and osteomalacia if left untreated.[4]

Physiologic Impact of Gastric Banding Surgery

In gastric banding (another popular weight loss surgery) and its variants, food intake is physically limited. In contrast to the Roux-en-Y procedure, gastric banding does not produce the metabolic complications that lead to bone loss.[12,13] In addition, there is no evidence of secondary hyperparathyroidism up to 2 years after surgery,[14] probably because there is no creation of an abnormal malabsorptive state.

"Bypass Bone Disease"

Bypass bone disease, a complication of bariatric bypass surgery, has been described in the gastrointestinal literature[4,7] as being characterized by musculoskeletal aches and pains and height loss; it is thought to be caused by osteoporosis from inadequate calcium intake and absorption and, in some cases, by osteomalacia from vitamin D deficiency. De Prisco and Levine[15] also indicated that patients who undergo bariatric surgery are affected by "metabolic bone disease" symptoms similar to those noted in the older gastrointestinal literature, in patients who underwent partial gastrectomy, a procedure known to cause secondary bone loss, so they recommended that all bariatric surgery patients receive long-term follow-up, from a primary care physician, for the metabolic aftereffects. With regard to orthopedic surgery, there is only one case report of delayed fracture healing after bariatric surgery[16] (we have noted the same finding anecdotally). The authors of the report described nonunion of a distal radius fracture sustained with minimal trauma by a patient who had undergone jejunoileal bypass surgery (no longer commonly performed) 5 years earlier. As the patient also had developed generalized muscle and bone pain, the intestine was reanastomosed, and there was evidence of fracture healing 6 weeks afterward, and resolution of musculoskeletal symptoms.

Education and Screening Implications for Orthopedic Surgeons

We believe that, given the increasing rate of obesity surgery in the United States, orthopedic surgeons should be aware of the effects of bariatric surgery on bone, as calcium and vitamin D malabsorption and osteoporosis can all affect bone and bone healing. The effects of gastric surgery on bone are particularly important, as many women who undergo this surgery are approaching their menopausal years, when osteoporosis becomes naturally more of an issue.

Patients considering gastric bypass should be counseled before the surgery regarding its risk for bone loss caused by calcium and vitamin D malabsorption. Patients at high risk for osteoporosis (eg, previous fracture, family history of osteoporosis) should have preoperative DXA screening to establish a baseline. Patients with severe osteoporosis (T scores below –3.0) should consider maximizing bone health before surgery. Alternatively, these patients may be counseled regarding gastric banding as opposed to Roux-en-Y.

When working with gastric bypass patients, orthopedists need to be cognizant of bone issues in the setting of malabsorption. For those patients who present without fracture but are considering orthopedic surgery, surgeons need to be prepared for the possibility of poor bone quality. In our practice, we have noted anecdotally that patients may experience delayed fracture healing or even nonunion of an arthrodesis. For those patients who present with fracture, orthopedists must consider osteoporosis screening. The National Osteoporosis Foundation recommends screening for all postmenopausal women who present with fractures. No recommendations exist for screening male patients. Our opinion is that men with fragility fractures should be screened.

Osteoporosis screening should include a thorough history (including specific questions about risk factors), physical examination, DXA evaluation, and, in many cases, laboratory studies. This screening may be done by an interested orthopedist, but referral to the patient's primary care provider or metabolic bone specialist is also reasonable. Risk factors for osteoporosis include female sex, advanced age, family history of osteoporosis, low body weight, previous fracture, maternal hip fracture, early menopause, smoking, alcohol abuse, glucocorticoid use, anticonvulsant use, and disordered eating (anorexia nervosa).[17] Laboratory studies vary according to clinical scenario, provider preference, and practice patterns but typically include complete blood cell count, metabolic panel with phosphorus, 25-hydroxyvitamin D level, PTH level, and 24-hour urine calcium collection. For elderly patients at higher risk for multiple myeloma, serum protein electrophoresis is often included in a screening panel. Studies have shown that patients after gastric bypass have elevated bone resorption markers, but use of bone turnover markers in clinical practice is not routine.

Metabolic Management After Roux-en-Y Bypass Surgery

Controversy surrounds recommendations for calcium and vitamin D intake after gastric bypass. The duodenum and proximal jejunum, sites of 80% of calcium absorption, are bypassed. The remaining 20% of calcium absorption depends on vitamin D and occurs in the remaining small intestine. Some authors have suggested that calcium and vitamin D in higher than average doses may be necessary to overcome malabsorption.[18] Improvement in bone turnover markers has been reported with supranormal calcium intake; bone resorption tends to decrease. More research is needed to clarify the appropriate calcium and vitamin D doses after bypass surgery, specifically the potential negative effects (ie, nephrolithiasis, renal toxicity). However, it is encouraging that bone resorption markers decrease when calcium and vitamin D are ingested in adequate amounts. It is recommended that post-

menopausal women consume 1200 to 1500 mg of calcium daily. It is possible that postmenopausal women who have had gastric bypass will need more than this recommended amount. Goode and colleagues[18] found that modest calcium (1.2 g/d) and vitamin D (8 µg/d) supplementation over 6 months did not suppress PTH or bone resorption. Expert opinion and current evidence suggest that optimal serum 25-hydroxyvitamin D levels are higher than 50 nmol/L (20 ng/mL), requiring vitamin D intake higher than 20 µg/d.[19] Although the recommended daily allowance for vitamin D is 400 to 800 IU, there is little risk for toxicity at higher supplementation levels. Our recommendation for bariatric surgery patients is to measure serum 25-hydroxyvitamin D levels and replenish them to the serum levels just recommended. Even in the absence of vitamin D deficiency, we would recommend vitamin D supplementation of 800 IU daily in the obesity surgery population.

The underlying pathophysiology of bone loss in the setting of gastric bypass is increased bone resorption caused by calcium and vitamin D malabsorption. In the setting of acute fracture, delayed union, or nonunion, it is tempting to consider an anabolic agent (teriparatide) as the initial osteoporosis treatment, but reduction in bone resorption is the primary goal. After a patient has adequately replenished calcium and vitamin D, the treatment of choice is an antiresorptive agent, such as alendronate, ibandronate, or risedronate. Suzuki and colleagues[20] reported improvement in bone mineral density and bone turnover markers with alendronate and vitamin D_3 in a population of gastrectomy/gastric bypass patients followed over the long term. Newer options, such as annual intravenous zoledronic acid infusion, may be considered for patients who do not tolerate oral bisphosphonates.

Conclusions

Obesity surgery, particularly Roux-en-Y gastric bypass, has metabolic bone complications. With obesity becoming more prevalent, bariatric surgery is becoming more popular. When managing a patient for gastric bypass, orthopedists should be aware that they may encounter suboptimal bone. The patient should be counseled regarding the potential for osteopenia related to obesity surgery. More research is needed to clarify the risk for gastric bypass on fracture union and arthrodesis/fusion complications.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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