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Clinical Considerations for the Implant-Seeking Post-Bariatric Surgery Patient: A Mini-Review

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ABSTRACT

Bariatric surgery is a treatment option for patients in whom lifestyle changes and pharmacotherapy does not result in desired weight loss. The physiology of these surgeries may result in nutritional derangements, which may influence wound healing. As more Americans undergo weight-loss surgeries, they have the potential to make up a consequential proportion of patients who seek dental implant therapy. This mini-review aims to review the pathophysiology of commonly performed bariatric surgery and discuss the nutritional consequences as they relate to implant surgery, as well as provide recommendations for the management of post-bariatric surgery patients in the outpatient dental setting.

Keywords

Bariatric team, Diet and nutrition, Patient access to care, Pre-surgical workup.

Introduction

Obesity is a worldwide epidemic, affecting nearly 650 million adults worldwide or approximately 13% of the world's adult population [1]. In the United States, approximately 39.8% of the adult population is obese, resulting in an estimated annual cost of $147 billion in medical expenditures [2]. Being obese is associated with a number of comorbidities, such as Type II diabetes mellitus, hypertension, dyslipidemia, cardiovascular disease, sleep apnea, and stroke [3]. The oral cavity is not immune to the adverse effects of obesity. There is evidence suggesting dental caries, periodontal disease, and tooth loss are also associated with obesity. Obese individuals have 1.49 times higher odds to be missing at least one tooth when compared to non-obese patients [4-6]. Given the increased likelihood of missing teeth, obese individuals make up a significant proportion of patients seeking end osseous dental implants for oral rehabilitation.

For patients for whom comprehensive lifestyle interventions and pharmacotherapy do not result in desired weight loss, bariatric surgery may be an option [7]. Commonly, bariatric surgery patients are adults with body mass indices (BMI) greater than 40 or those with BMIs greater than 35 with an obesity-related comorbidity. Bariatric surgery is an encompassing term that includes surgeries such as Roux-en-Y gastric bypass (RYGB), laparoscopic sleeve gastrectomy (SG), adjustable gastric banding (LAGB), and biliopancreatic diversion with duodenal switch (PBD-DS) [8]. The number of these procedures being performed annually has been increasing since 2011. Approximately 228,000 of these procedures were performed in 2017, with sleeve gastrectomy being the most common (59.39%) followed by Roux-en-Y (17.80%) and revision surgeries (14.14%) [8]. In addition to treating obesity, there is increasing support to use bariatric surgery as a surgical means to treat metabolic conditions such as diabetes; thus increasing the number of people who may qualify for such surgeries [9].

While bariatric surgeries are effective in achieving weight loss, as well as improvement in obesity-related comorbidities, after surgery, patients are known to experience macronutrient and micronutrient

deficiencies that arise from reduced dietary intake, malabsorption, or inadequate supplementation. Nutritional deficiencies can manifest as a wide range of symptoms, depending on what specific nutrient is deficient, the severity of the deficiency, and the duration of the deficient state [10]. The link between nutritional status and longevity of the dental implant has been previously reviewed [11,12]. Adequate nutrition is important for oral wound healing, whereas lack of essential nutrients depresses the body's potential for repair. Additionally, alterations in absorption of key minerals and the subsequent hormonal alterations have the potential to affect predictable placement of dental implants.

As the number of bariatric surgeries being performed increases, given the known nutritional deficits bariatric surgeries can cause, implantologists should proceed with caution when treatment planning and managing this subset of patients. The aim of this review is to provide a primer on the physiology of the more common bariatric surgery, discuss the effects of malnutrition on the placement of dental implants, and provide recommendations for management of post-bariatric patients who wish to receive dental implants.

Bariatric Surgery in Brief

Bariatric surgeries affect weight loss by malabsorption, restriction, or both. In addition to the anatomic alteration, there are hormonal effects on energy consumption and hunger [13-16]. Restrictive procedures decrease the stomach's capacity (either by dividing or removing a portion of the stomach) but leaves the small intestine functionally intact. Malabsorptive procedures decrease nutrition absorption by shortening the functional length of the small intestine (either by bypass or by diversion). Some procedures employ both mechanisms [17]. Figure 1 summarizes the more commonly performed surgeries.

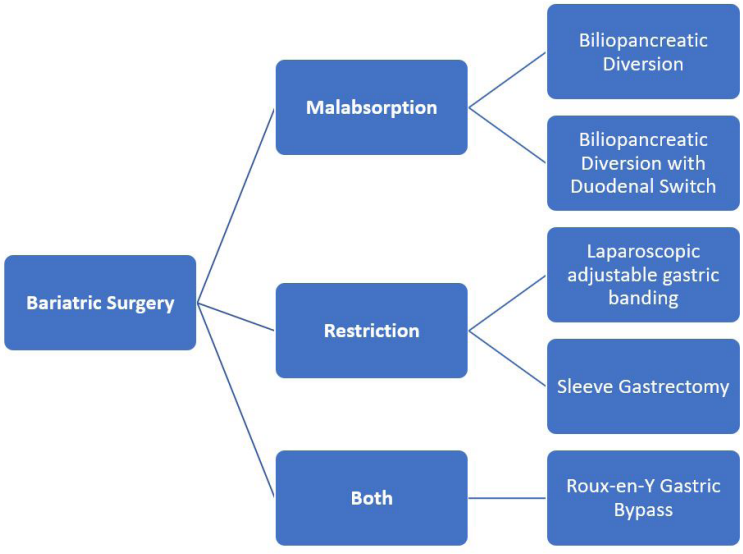
Macronutrient Deficiencies

Protein

Protein malnutrition is the most severe malabsorptive complication following bariatric surgery, affecting between 7-21%, depending on the procedure [10]. After certain bariatric procedures, particularly RYGB and SG, the most significant nutritional changes come from the reduction of the gastric capacity and rearrangement of the small intestines, resulting in decreased intake and absorption of nutrients [18]. Additionally, post-operative patients develop aversions to protein-rich foods like meat, milk, and eggs [19]. Clinically, protein malnutrition may manifest as edema, hair loss, decreased strength, fatigue, and muscle loss as well as altered healing and immunity [10].

Protein deficiency and osseointegration has been examined most extensively through rat-models. Rat-models from 1950s demonstrate protein deprivation's deleterious effects on the periodontal ligaments, gingival tissues, and alveolar bone [20,21]. More recent models demonstrate poor osseointegration in isocaloric-protein deficient rats, with those rats demonstrating lower pull-out strength and poor bone microarchitecture when fed a lower protein diet compared to the control group [22]. Conversely, the supplementation of casein and whey protein was demonstrated to be inversely associated with periodontitis [23].

The recommended intake to avoid protein malnutrition is approximately 1.1g/kg of ideal body weight, with certain bariatric procedures requiring additional supplementation [24]. Protein malabsorption has been monitored by trending the patient's serum albumin; however, current literature dissuades the use of this biomarker for evaluation the body's protein status [25-28]. Alternatively, measurement of lean body mass through dual X-ray absorptiometry or body bio impedance can evaluate protein-status but their use in post-bariatric patients has not been well validated [10].



Biliopancreatic Diversion and Biliopancreatic Diversion with Duodenal Switch (PBD-DS)

- Surgical reduction of the stomach and bypassing a portion of the duodenum

Laparoscopic Adjustable Gastric Banding (LAGB)

- A removable inflatable band is placed around a portion of the stomach to restrict caloric intake

Sleeve Gastrectomy (SG)

- Surgical reduction of the size of the stomach, resulting in decreased stomach volume and faster feeling of satiety

Roux-en-Y Gastric Bypass (RYGB)

- Surgical creation of a small gastric pouch that is connected to the jejunum, bypassing a large segment of the small intestines (duodenum)

Figure 1: Summary of the most commonly performed bariatric surgeries and mechanism of the theoretical nutritional derangement.

Carbohydrates

Carbohydrates are not considered an essential macronutrient, but are important for providing a significant portion of energy required by cells in the fed state and the exclusive source of energy for red blood cells and brain. Post-bariatric patients are encouraged to forgo simple carbohydrates in favor of fiber-rich foods to both avoid dumping syndrome and to promote adequate weight loss and enhance healthy eating [29]. With regards to implant ology, considerations of the patient's comorbidities are important while treatment planning. Many patients who undergo bariatric surgery have metabolic diseases such as diabetes, which is well-known to complicate bone metabolism, periodontal health, and dental implants [9,30-34].

Micronutrient Deficiencies

Fat-Soluble Vitamin: Vitamin D

Vitamin D is absorbed in the jejunum and ileum and plays a role in the absorption of calcium, magnesium, and phosphate; it plays a central role in bone homeostasis [35]. It is recommended that the average adult intake 600 IU/day. Vitamin D deficiency is associated with increased risk of osteoporosis, diabetes, cancer, ischemic heart disease, autoimmune, and infectious diseases [36]. The degree of deficiency is contingent on the surgery performed; LAGB and SG are associated with stable post-operative vitamin D levels, whereas RYGB and PBD-DS resulted in as high as 50% of patients experiencing vitamin D deficiency [37]. Few studies have looked at the effects of vitamin D and dental implants [38]. One group published a case series in which 2 patients experienced implant loss within 15 days of placement; both patients were noted to have severe pain and osteocytes bone upon explantation (each patient lost 2 implants). Serum analysis demonstrated vitamin D deficiency (<20 µg/L), resulting in the investigators supplementing the patients with vitamin D; however, the supplementation protocol was not published. Following supplementation, successful implant placement was achieved (Patient A received 1 implant; Patient B received 2 implants) [39]. Notably, however, larger studies have not been able to replicate this finding. In a retrospective study, Mangrano et al examined 1,740 implants placed in 885 patients, with respect to vitamin D levels. In this study, 35/885 patients (3.9%) experienced failed implants, defined as either lack of osseointegration and resultant implant mobility or peri-implantitis. The patients' vitamin D deficiencies were stratified into severe (vitamin D levels <10 ng/mL), low (vitamin D levels between 10-30 ng/mL), and normal (vitamin D levels >30 ng/mL). While a there was an inverse relationship noted, there was no statistical relationship to conclude that low serum levels of vitamin D increases the risk of dental implant failure [40,41].

Fat-Soluble Vitamin: Vitamin K

Vitamin K is absorbed in the jejunum and ileum and is a coenzyme for vitamin K-dependent carboxylase, an enzyme required for the synthesis of proteins central to hemostasis [42]. Vitamin K deficiency is reported in about 50-60% of patients who underwent PBD-DS and 50% of patients who underwent RYGB, but clinical symptoms such as bruising, bleeding, or clotting alterations were not reported [10,43,44]. Vitamin K also plays a role in bone metabolism as it promotes bone formation by stimulating osteoblast differentiation and decreases osteoclast differentiation [45]. There is increasing interest in investigating the osteoprotective effects of vitamin K to improve osteogenesis in bone graft surgeries; however, no human studies have been completed to date [46].

Water-Soluble Vitamins: Vitamin B Complex

The vitamin B complex are a group of vitamins that play an important role in cell metabolism. Vitamin B12 (cobalamin) functions as a coenzyme for several biochemical processes important for red blood cell formation, neurologic function, and DNA synthesis [47]. Vitamin B12 deficiency is a major cause of anemia in patients who undergo PBD-DS and RYGB, affecting nearly 19-35% of patients and may manifest as numbness and tingling, disrupted coordination, and paralysis in the most severe cases [10,29,48]. Vitamin B9 (folate) is critical for forming DNA and RNA and is involved in protein metabolism; it is also important for red blood cell formation [49]. Vitamin B9 deficiency can cause macrocytic anemia, thrombocytopenia, leukopenia, and glossitis [10,43].

Water-Soluble Vitamin: Vitamin C

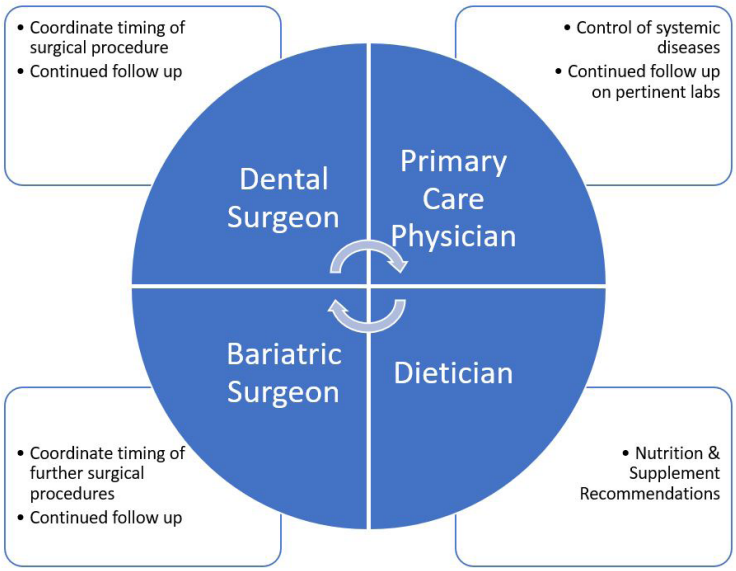
Vitamin C (ascorbic acid) is absorbed along the entire tract of the small intestine and is an important cofactor for many enzymatic reactions, including those involved in wound healing and collagen synthesis [50]. It is recommended that the average adult intake 75-90 mg of ascorbic acid daily [51]. Vitamin C deficiency has been associated with periodontal disease, though the exact mechanism is unknown [52,53]. Following RYGB, vitamin C deficiency is reported to affect 34.5% of patients [54]. One study examines the role of vitamin C in wound healing following implant surgery, and found that vitamin C supplementation (300 mg/day for 7 days) significantly improved postoperative healing following implant placement in patients with chronic periodontitis and those treated with guided bone regeneration or Bio-Oss collagen grafts. The study does not report serum levels of vitamin C, making it difficult to draw definitive conclusions; however, its conclusions that vitamin C is important with wound healing in the post-surgical phase are consistent with theoretical and rat models [55].

Minerals

Calcium

Calcium is absorbed in the duodenum and proximal jejunum and critical to bone homeostasis [56]. Patients who undergo RYGB, SG, and BPD-DS are at an increased risk of developing hypocalcemia, due to either bypass (as is the case with RYGB or BPD-DS) or suboptimal absorption environment (as is the case with RYGB, PBD-DS, and SG) [57]. Additionally, calcium absorption is dependent on vitamin D, thus decreased vitamin D absorption results in decreased calcium absorption [35]. Calcium deficiency is associated with secondary hypoparathyroidism.

Calcium deficiency has been previously studied in animal models [58,59]. While osseointegration is possible in calcium deficient



Follow Up Period	Laboratory Tests
Every 3 months for the first year	Complete blood count Glucose Creatinine
Every 6 months for the first year	Liver function tests Protein and albumin Iron, total iron-binding capacity, ferritin Vitamin B9 and B12 Calcium Parathyroid hormone
Every year after the first year	All the above

Figure 2: Recommended roles and surgical work up of the multi-disciplinary dental implant team when treating post-bariatric surgery patients.

states for rats and rabbits, time to new bone formation was noted to be delayed. Post-implant surgery calcium supplementation was noted to increase bone formation, but bone formation was noted, albeit to a lesser degree, in the persistent calcium state, suggesting that calcium deficiency may not be as strong of a factor to predict implant success [59].

Hormonal Derangement

Secondary Hyperparathyroidism

There are several reports of depleted vitamin D and calcium resulting in hyperparathyroidism in post-bariatric surgery patients [60-62]. The secondary hyperparathyroidism results from decreased calcium absorption as a result of bypassing the duodenum and a portion of the jejunum, as is the case in RYGB and PBD-DS [63,64]. Low serum calcium results in increased parathyroid hormone (PTH) secretion, which in turn results in increased conversion of vitamin D 25-OH to activated calcitriol resulting in increased calcium absorption in the GI tract as well as increased osteoclast activity resulting in cortical bone breakdown [63].

There is one case report of the placement of dental implants in a patient with secondary hyperparathyroidism; however, the etiology of this endocrine derangement is renal failure rather than post-bariatric surgery [65]. In this case, the patient underwent full mouth extraction secondary to extensive dental caries and immediate placement of dental implants with calcium sulfate bone grafting. Over 2 appointments, a total of 10 implants were placed in the maxilla and 8 were placed in the mandible. After 7 months of healing, the implants were re-evaluated; one implant was found to demonstrate dehiscence and was subsequently removed. The patient was rehabilitated with bimaxillary complete fixed dentures.

Potentially critical to the success of this case was that the patient was edentulated due to dental caries and not periodontal bone loss, thus having adequate osseous support for the implants. The preservation of the cortical bone, in the absence of periodontal bone loss, may have largely contributed to implant stability. Secondary hyperparathyroidism results in under-calcified trabecular bone, which may lead to an increased rate of failed osseo integration [66]. If cortical bone was lost due to osteodystrophy resulting from secondary hyperparathyroidism and trabecular bone is being preferentially formed, then implant survival may be compromised; however, this would be most evident as a late failure in the prosthetic phase. In the presented case, the patient was undergoing active cincacalcet pharmacotherapy to decrease his circulating PTH levels and ultimately underwent a kidney transplantation, which may have potentially reversed his secondary hyperparathyroidism and resolved any osseous dystrophy.

Recommendations

Currently, there are no accepted treatment protocols for providing dental implants in patient's post-bariatric surgery. Given the nutritional derangement and the physiologic impacts of bariatric surgery, we propose a multi-disciplinary approach when considering placement of dental implants in this patient population. A thorough knowledge of medical co-morbidities permits the surgeon to appropriately consider risk stratification (for tolerance to procedure and anesthetic), provide patient counseling of pre-/peri-/post-operative course, and consult the appropriate specialists for holistic patient care and medicolegal documentation. Figure 2 defines potential roles of the surgical team and a proposed timeline for evaluation of laboratory data [67].

Conclusion

Bariatric surgery results in anatomic and hormonal changes that may affect the placement and survival of dental implants. As the number of people who undergo these procedures increase annually, and as their dental needs evolve to need tooth replacement via dental implant, it is prudent for the implantologist to consider the nutritional deficiencies and metabolic alterations that occur

following bariatric surgery. A multidisciplinary approach, involving communication with the patient's bariatric surgeon, primary care provider, and dietician is advised to ensure not only implant survival but also maintenance of the patient's quality of life.

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