Does Intestinal Resection Affect the Absorption of Essential Vitamins, Minerals, and Bile Salts? An Overview of the Literature

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As the number of persons living long lives following ostomy and bowel resection surgery increases, so do their questions about the effect of surgery on chronic conditions commonly associated with aging. The literature was reviewed to evaluate current evidence about the effect of bowel resection on the absorption of vitamins and minerals and related health concerns such as osteoporosis, gallstones, and renal calculi. Present knowledge about the process of vitamin and mineral absorption in the intestine and clinical study results suggest that chronic inflammation and corticosteroid use may adversely affect absorption. In general, a history of bowel resection does not appear to increase the risk of developing osteoporosis, gallstones, or renal calculi and the body can adjust to losing significant sections of intestine. Strategies to help prevent the majority of long-term complications should be encouraged, including monitoring hydration and transit time, consuming low-digestible carbohydrates, and avoiding processed foods as well as agents with chelating properties.

KEYWORDS: ostomy, nutrient absorption, osteoporosis, gallstones

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A survey of the Fort Worth ostomy association found the majority of the members are >65 years of age. Many have had their ostomies for more than two decades. Thus, people who have had significant bowel resections such as ileostomies, ileoanal pull-throughs, continent diversions, and colectomies are living long enough to have to deal with some of the same degenerative diseases and conditions commonly encountered by all older adults. Of particular concern: Does living with an incomplete intestine increase risk for age-related disabilities such as osteoporosis?

The intestine seems to adapt to surgery and resections. Generally, the physiology of vitamin and minerals (absorption from the resected intestine and subsequent use by the body) requires adequate nutritional intake, including enzymes and specific hormones in amounts sufficient to process the nutrients. Even with as little as one third of the small intestine present, the body continues to maintain adequate vitamin and

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mineral stores as long as the patient maintains a healthy diet. However, loss of the distal ileum and colon can affect bile salt production. Changes in nutritional absorption have been found to cause higher numbers of gallstones among patients who have short bowel syndrome than among the normal population. Calcium-related renal stones also are more common among persons with significant reductions in bowel length secondary to increased transit time of effluent, which results in dehydration and concentrated urine output.

Clinicians, caregivers, and patients need to know whether significant changes resulting from bowel resection increase the risk of osteoporosis, gallstones, and renal stones in persons with a stoma. Because mineral absorption in people with ostomies was a concern of the members of the Fort Worth Chapter of the United Ostomy Association (UOA), a literature search was conducted to determine if intestinal resection with loss of significant portions of the intestine can affect absorption of vital nutritional elements. The most productive searches resulted from using the word calcium in combination with Crohn’s or inflammatory bowel and yielded English-language articles published between 1989 and 2007; most involved retrospective research. The literature search focused on the anatomy of the intestine, the physiology that affects mineral and bile salt absorption, and whether intestinal resection can result in latent deficiencies of essential vitamins and minerals. The results of the literature search, first presented to the UOA Fort Worth chapter members, are summarized to help clinicians optimize care of all persons with a stoma.

**Anatomy and Function**

The intestinal tract comprises the stomach, the small intestine, and the large intestine or colon. Alcohol, some medications, and simple carbohydrates are absorbed directly from the stomach. Each section of the intestine is responsible for the absorption of a particular nutritional element.

**Small intestine.** The small intestine in the adult is approximately 22 feet long and consists of the duodenum, the jejunum, and the ileum. The small intestine wall is arranged in folds of absorptive cells and villi. Most nutrient absorption occurs in the small intestine, including minerals, vitamins, proteins, and fats. Iron, calcium, magnesium, and zinc are absorbed almost immediately after leaving the stomach — ie, in the 8 feet of the duodenum and the jejunum. Sugars and vitamin C, as well as thiamin, riboflavin, pyridoxine, and folic acid, are absorbed in the upper third of the small intestine. Protein is absorbed approximately midway through the ileum. Vitamins A, D, E, and K, fats, and cholesterol are absorbed in the lower third of the ileum. Vitamin B₁₂ is absorbed just before the small intestine joins the large intestine. Bile salts are reabsorbed in the distal ileum and the ascending colon.

**Large intestine.** The large intestine (colon) is responsible for reabsorption of water, sodium, potassium, and vitamin K. However, retrospective studies have shown that the large intestine also is responsible for absorption of small amounts of calcium and magnesium. Ohta et al injected magnesium and calcium directly into the large intestine of rats through a cecostomy tube. Calcium, magnesium, and phosphorus levels in the feces, urine, and femur were measured by spectrophotometer; it was found that a small amount of calcium and magnesium was absorbed by the large intestine and absorption amounts increased slightly when oral ingestion of the minerals was withheld.

**Absorption.** Immediately following removal of portions of the small and large intestines, the body...
experiences problems with absorption. Disrupted release of enzymatic secretions and an unusually rapid increase in the gastric emptying account for the multiple loose stools that occur with new resections. Depending on the portion of intestine removed, the patient may need at least 1 year for the bowel to return to normal function. The bowel stabilizes because the proximal portion of the ileum has a greater capacity for absorption than the distal portion.

A person can lose up to one half of the distal ileum and still maintain a normal diet; digestion and absorption of nutrients occurs basically within the first 100 cm of jejunum. A review of the literature has shown that once the patient with an ostomy is consuming regular food, the small intestine expands and lengthens slightly to increase absorption. After approximately 1 year, most people with ostomies are able to control the consistency of the effluent and absorption of most of the needed nutrients returns to normal. Total parenteral feedings do not produce the increase in ileum circumference and do not promote increased reabsorption.

Minerals. Three major factors affect mineral absorption: the solvency of the mineral, transit time, and the intestine’s ability to absorb the nutrient. Other factors that can affect the absorption of nutrients include emotional stress, chronic diarrhea, oral antibiotics, and corticosteroids.

The cilia that line the small intestine are responsible for nutrient absorption. The bacterial flora found in the intestine breaks down nutrients. Emotional stress is known to have a destructive effect on the cilia and antibiotics can destroy the normal flora. Destruction of the cilia and the flora results in copious amounts of diarrhea. Diarrhea increases transit time and reduces the absorption of nutrients. Diarrhea also can be the result of loss of intestinal tissue, medications (eg, sorbitol-containing products), diet, and chronic malabsorption of nutrients. Antidiarrheal medications should be taken only on physician recommendation and are contraindicated in persons with colitis and other infectious diarrheas. Klein and Jeejeebhoym recommend loperamide to reduce transit time related to mechanical diarrhea because it is metabolized quickly by the liver, making it available faster than codeine and diphenoxylate.

Physical impairments to absorption. The cecal valve prevents backflow of stool into the small intestine, slows transit time into the large intestine, and prevents bacteria in the large intestine from contaminating the effluent in the ileum. Loss of the cecal valve complicates the absorption process. Overgrowth of bacteria from the large intestine increases the destruction of vitamin B₁₂ and iron and hampers carbohydrate and protein metabolism. The lack of nutrient absorption secondary to an incompetent cecal valve results in abdominal pain and loose stools.

Diarrhea secondary to increased transit time is common immediately after surgery and, for ileostomy patients, can be an on-going problem. Persons with ileostomies are known to suffer from chronic poor absorption of nutrients, putting them at increased risk for dehydration. Depending on the amount of small intestine surgically removed, loose watery stools and increased transit time can reduce the absorption of fats, proteins, and vitamins. Because vitamin B₁₂ is absorbed at the lowest portion of the small intestine, persons with an ileostomy and urostomy also are at greater risk for the development of pernicious anemia. Ileostomy and urostomy patients should talk to their physicians about periodic testing for vitamin B₁₂ deficiency. Starting oral food intake and maintaining a well-balanced diet are extremely important in preventing loss of minerals and other nutrients.

Medications. Corticosteroids have multiple effects on the body’s metabolism. Long-term steroid use is known to cause thinning of the bone and the skin. Moreover, steroids decrease absorption of vitamin A through the gut, which can be especially detrimental to wound healing. There is some evidence in the literature, as well as clinician experience, to suggest that patients with chronic non-healing wounds who are on steroid therapy may benefit from a vitamin A compound placed directly into the wound.

Other medications that affect absorption (especially of vitamins A, D, E, K, and B₁₂) include cholestyramine and other bile acid-binding resins. Selected diuretics increase calcium, magnesium, potassium, and zinc excretion in urine. Prednisone decreases calcium absorption. Sulfasalazine decreases folic acid absorption. Deficiencies in folic acid can result in mucosal changes in the intestinal lining.
Calcium Absorption

The chemical absorption of calcium through the gut and the use of calcium to produce bone minerals are complicated processes. Calcium absorption is dependent on magnesium levels, vitamin D levels, proteins, and parathyroid levels. The parathyroid hormone regulates the amount of calcium absorbed from the intestine and the amount of calcium lost from the bones. This hormone also affects vitamin D levels, which actively stimulate the absorption of calcium. Calcium absorbed through the intestine binds with the protein calbindin. All of these elements have to be present in adequate amounts to maintain bone strength.

Certain medications — particularly aluminum-containing antacids — affect calcium absorption, binding to the calcium; if used for prolonged periods, they contribute to bone thinning. In terms of solvency, calcium citrate is more easily absorbed than calcium carbonate.

Abnormal acid-base balances also affect blood levels of calcium and magnesium. Cloutier and Barr proposed a theory regarding acid-base balance — ie, high protein diets increase the amount of calcium lost through the kidneys. The researchers reviewed multiple studies and suggested that changes in protein ingestion (either increasing or decreasing the intake) affected acid-base balance of the body, subsequently affecting calcium absorption. A (Japanese) retrospective study involved fructooligosaccharides (simple carbohydrates and sugars) that appear to enhance fermentation in the intestine, lowering the pH in the intestinal tract and stimulating increased passive and active mineral transport of magnesium and calcium.

Influence of magnesium and parathyroid function. Several studies indicate that 20% to 50% of children with insulin-dependent diabetes (IDDM) have significant bone loss. The defining factor appears to be low magnesium levels. In a study by Saggese et al., children with IDDM were told to eat various concentrations of magnesium and calcium. Serum levels of parathyroid hormone, magnesium, calcium, and vitamin D were compared over a 60-day period. Fructosamine levels also were measured and remained stable. Magnesium was shown to be the catalyst that controlled absorption levels, playing an essential role in enzyme activity related to cellular metabolism. No correlation was made between children and adults with diabetes because the amount of calcium needed varies by age.

Determining the calcium balance. Calcium balance is the difference between the ingestion of dietary calcium and dermal, fecal, and urinary losses of calcium. The simplest way to assess mineral levels involves blood samples. However, normal lab values in the plasma are not conclusive, given the body’s capacity to maintain a normal equilibrium. The body will maintain normal plasma levels by pulling the minerals it needs from any available source, including bone. Therefore, plasma levels may be normal while bone density is decreased. Adding the measurement of fecal calcium increases the accuracy by determining the loss of minerals secondary to malabsorption.

Body mass indices, bone scans, bone density indices, and dual-energy x-ray absorptiometry (DEXA; two-view, low-dose radiation exposure x-rays of the lower spine and hips) provide increasingly accurate bone health information.

Conditions Related to Malabsorption

Osteoporosis. Osteoporosis is a disease characterized by thinning of the bones. Fractures frequently occur in the spine, pelvis, and long bones. Osteoporosis has long been associated with menopause because low estrogen levels result in increased bone reabsorption. However, the current theory is that bone strength is established during young adulthood. If bone strength is not maximized during these critical years, a higher likelihood exists for fractures as a part of the natural aging process.

Age-related osteoporosis is the result of both excessive bone reabsorption and defective bone formation. Magnesium and calcium, as well as zinc and copper, absorption changes with age. Magnesium and calcium intake by the elderly has been reported to be far below recommended dietary levels. Low zinc levels can affect protein absorption, which has an indirect effect on calcium levels. Low copper levels also affect bone strength through collagen depletion.

Crohn’s Disease (an inflammatory bowel disease) and bowel resection with or without stoma formation, have long been associated with osteoporosis.
and increased potential for fractures. However, the research on the relationship and causes of osteoporosis in persons with these conditions has been inconclusive. The prevalence of osteoporosis depends on the population studied; in patients with inflammatory bowel disease, it has been reported to range between 12% and 44%; according to 2007 US statistics from the National Osteoporosis Association, 55% of persons 50 years of age and older are at risk. Van Hogezand reviewed a number of studies relating to intestinal disease and osteoporosis. Results indicated that fewer than 50% of subjects had decreased bone density, either in the form of osteoporosis or osteopenia.

Although steroids are known to cause thinning of bone, patients with inflammatory bowel disease have been known to show signs of bone thinning even before beginning steroid treatment. In a study of 32 men, 22 to 32 years of age, newly diagnosed with inflammatory bowel disease and evaluated before receiving corticosteroid therapy, nine (28%) were found to have decreased bone mass. The study concluded that patients with low body mass and inflammatory bowel problems for more than 6 months are at greater risk for bone mass loss. Van Hogezand et al have conducted extensive research related to Crohn’s disease. One retrospective study involved 146 patients (61 men, 85 women; mean age of 43 years) with Crohn’s disease (mean duration 20 years) who were receiving a variety of therapies including corticosteroids. Among participants, 66% had undergone ileum resection. According to the authors, “ileum resection was the most predictive factor for osteoporosis: RR3.84 (CI 1.24–9.77, P = 0.018), followed by age: RR1.05 (CI 1.02-1.08, P <0.001).” However, following a review of seven studies, a definite relationship between bowel disease, bowel resection, chemical treatment, and loss of bone mass could not be established. Nevertheless, frequent bone mass assessments in patients with inflammatory bowel disease, Crohn’s disease, and intestinal resection, as well as those undergoing steroid therapy, are recommended. A healthy diet during the young adult years may help prevent late life bone health complications.

In a review of the literature, Lee et al conclude that bone loss is related to a combination of factors that include the disease itself and associated inflammation, high-dose corticosteroid use, weight loss and malabsorption, a lack of exercise and physical activity, and an underlying genetic predisposition to bone loss.

Kung et al discuss the concept that osteoporosis is genetically related. According to the authors, women in Hong Kong generally have a low average calcium intake of <500 mg/d. A study evaluated 25 women with low bone density who had experienced vertebral fractures, 25 age-matched post-menopausal women without fractures, and 15 healthy pre-menopausal women. Over a 6-month
period, four distinct phases of increased (600-mg and 1,200-mg supplements) and decreased (300-mg and 500-mg supplements) calcium ingestion were monitored. Calcium levels were assessed through blood and urine samples during each phase of the study. Bone mineral density (BMD) was measured by dual-energy X-ray. The study concluded that intestinal calcium absorption was not significantly different between pre- and post-menopausal women. Although the researchers found lower plasma vitamin D levels and higher urinary calcium levels among the older female population, the final conclusion of the research team was that osteoporosis is genetically determined — that female members of osteoporotic families have a significantly (P <0.05) altered bone turnover response to acute changes in calcium intake. Subsequently, the net balance in bone turnover was significantly (P <0.005) lower than that of the healthy control subjects (P <0.05). An important part of the study concluded that calcium absorption through the small intestine is not affected by increasing the calcium dosage or absorptive ability of calcium by the gut.

**Gallstones.** Production of bile acids for the breakdown of nutrients is another complicated chemical process, involving at least 12 enzymatic steps to convert cholesterol to bile acids. The process is controlled by multiple factors, including nutritional status and the condition of the digestive system. Bile production starts with the presence of food in the stomach. As soon as the stomach empties, the gall bladder releases bile into the small intestine. Bile salts combine with amino acids, cholesterol, fat-soluble vitamins, lipids, and metal ions (eg, iron and calcium) as they travel through the small intestine and the ascending large intestine. At various times in the digestive process, bile salts are conjugated (soluble) and unconjugated (insoluble). The majority of bile salts are reabsorbed in the distal end of the small intestine. A small amount of the bile salts are absorbed in the ascending large intestine. In normal intestinal tracts, only a minimum of bile salts is lost through feces and the process is so efficient that very little bile is lost from the blood supply. The same bile salts are reprocessed by the liver and excreted back into the gall bladder, on average, between three and 12 times a day. Although considered very rare, short bowel syndrome and hemicolectomy involving the ascending colon can affect the re-absorption of bile salts. One study documented a high prevalence of gallstones following colectomy in a sample of dogs. Ten dogs were subjected to proctocolectomy and over a 12-week postsurgical period, bile and serum were collected. Seven dogs developed gallstones. The study concluded gall stone formation was the result of increased unconjugated (water insoluble) bilirubin in the gall bladder bile. When the distal ileum and colon were removed and the bilirubin could not be reabsorbed, the liver increased the production of insoluble bilirubin from five- to 20-fold, providing the basis for increased gallstone production. The researchers also found increased acid levels and increased ionized calcium in the bile of the colectomized dogs.

Bile salts also affect the absorption of water and the production of mucus to lubricate feces. Bile acid diarrhea results from malabsorption of bile salts, increased fluid loss, increased bacterial activity in the large intestine, and increased lipid and cholesterol loss through the intestine. Conversely, chronic constipation can result from excessive absorption of bile salts, fluid, and loss of mucus. Finally, reduced bile salt production affects the absorption of fats and fat soluble vitamins, leading to chronic malnutrition. Calcium salts also may precipitate out and not be absorbed into the system. In mild cases, bile acid secretion may be normal in the morning because of replenished reserves during the night but decreases as the day progresses.

**Renal stones.** A 20-year retrospective study involving 1,941 patients with renal stones included patients who had Crohn’s disease, ulcerative colitis, ileal bypass, ileal resection, and total colectomy. Study results indicated that patients with bowel issues have less urine output secondary to increased intestinal transit time. The increased concentration of urine was a factor that contributed to stone formation. Increased transit time also led to a mildly acidic state that increased the excretion of magnesium and calcium into the urine. A review of four cases involving three colectomies and one ileal...
resection describes the complex nature of chronic inflammatory processes, low urine volume, and increased acid balance as the source of increased occurrence of renal stones. Thus, calcium supplements should be taken with food to enhance proper absorption and reduce the potential for calcium to enter the kidneys and form kidney stones.7

**Lifestyle Strategies**

**Transit time.** Slowing transit time gives the intestine more time to absorb fluids. Diet is a major educational focus for persons with increased transit time of fecal effluent. Healthy eating usually becomes a way of life for people with Crohn’s Disease, inflammatory bowel disease, diverticulitis, or stomas. The need to prevent blockages and diarrhea is a major concern.23

**Probiotics.** Probiotics34 are live micro-organisms that are beneficial for improving intestinal flora. Six major types are found in the intestine; of the six, acidophilus (Lacto-bacillus) is probably the best known although not the most effective. Lacto-bacillus appears to help prevent colitis. The authors suggest that Lacto-bacillus might be beneficial in Crohn’s Disease, active pouchitis, and some other inflammatory bowel diseases. Yogurt, milk, and active yeast products also provide live anaerobic bacteria to the gut. Saccharomyces boulardii has been shown to reduce antibiotic-induced diarrhea. 29 Persons with severely compromised immune systems should consume probiotics with care because an overgrowth of intestinal bacteria can occur.30

**Low-digestible carbohydrates.** Low-digestible carbohydrates (example: Nutriose FB™, Roquette, Lestrem Cedex, France) have many beneficial effects, especially on energy intake, digestive physiology, and mineral absorption as well as an ability to reduce intestinal transit time.37 The drawback of these low-digestible carbohydrates is increased flatulence. Vermorel et al27 studied 10 healthy men for 31 days to determine the effects of adding low-digestible carbohydrates to their diets. The researchers found that adding 50 g DM/day of low-digestible carbohydrates to the subjects’ diets reduced transit times without causing gastric distress.

Sports drinks, on the other hand, contain high concentrations of sugars that can increase transit time. Chemically balanced liquids specifically developed to replace electrolytes (eg, Pedialyte™, Abbott Labs, Abbott Park, Ill) are the better choice for rehydration.32 Other healthy foods include wheat flour, rice bran, olive oil, anti-oxidants, and raw fruits and vegetables. Green leafy vegetables are a good source of magnesium. Sunshine is a good source of vitamin D.12

**Discussion**

Current research suggests that living with an incomplete intestine does not in and of itself increase the likelihood of developing osteoporosis. Calcium, magnesium, and vitamin D are absorbed immediately after leaving the stomach. The amount of calcium absorbed is determined by the parathyroid hormone and varies as people age. Bone growth is at its peak in young adulthood. Exercise and good nutrition are vital to enhancing bone strength.1 However, because the parathyroid utilizes only the amount of calcium it needs, taking megadoses of calcium and other minerals results in excretion of excess calcium through the stool, not absorption.22 The small intestine has a remarkable ability to stretch and lengthen to provide greater surface area for absorption. However, this only occurs on an oral diet. Tube feedings and total parenteral nutrition do not accomplish the same goal.1 Acid balance, hormone levels, and proper diet all work together to maintain normal mineral absorption. Avoiding processed foods and therapeutic agents with chelating properties can prevent most trace element deficiencies.12

Bone thinning appears to be more related to lifestyle, chronic inflammatory processes, and heredity than to intestinal issues. Intestinal resection in people with normal eating habits and normal effluent output should not be at any higher risk for vitamin and mineral deficiencies than individuals with normal bowel function.31

Similarly, gall stone formation related to intestinal dysfunction is rare and generally only occurs as a complication of short bowel syndrome.17 A survey done by the Fort Worth chapter of the UOA1 found that out of 125 members only three had both an ileostomy and a history of gall bladder surgery.
Renal stones related to intestinal malfunction are a result of dehydration, usually secondary to increased transit time of effluent. Adequate fluid intake and slowing transit time reduces the risk of developing renal stones.\(^4\)

**Conclusion**

Having an ostomy does not necessarily increase risk for osteoporosis. Osteoporosis appears to be related to heredity. People with a family history of osteoporosis should be tested periodically for bone mass. Nutrition, lifestyle, and exercise appear to be the important factors relating to vitamin and mineral absorption and bone health for people with stomas. Good nutrition during young adulthood when bone growth is rapid provides bone mass in later life. Persons with decreased intestinal capacity should be able to maintain healthy body functions by eating properly, exercising, and taking medications as prescribed. - OWI

**References**