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REVIEW ARTICLE

CALCIUM AND ITS ROLE IN PROSTHODONTICS: A SHORT REVIEW

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ABSTRACT

Osteoporosis is a disease of bone which is usually seen in middle aged post-menopausal women. The osteoporotic bones are weak and prone to fractures. Osteoporosis in simple terms means "porous bone". It is a silent disease.

Oral health maintenance for adults with osteoporosis is important. Bone weakness and loss usually affects the ridges that hold dentures resulting in ill-fitting dentures. These patients require new dentures more often than those who have strong, healthy bones. Regular dental visits and a healthy lifestyle is necessary in strengthening and maintenance of good bone health. A well balanced diet with high amounts of vitamin-D & calcium along with regular physical activity is recommended in such patients.

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INTRODUCTION

The relationship of osteoporosis to alveolar and residual ridge resorption is of justifiable concern to the dental profession. Although generalized bone loss is characteristic of osteoporosis, the first sign may be alveolar bone loss, followed by loss in the vertebrae and long bones. (Blank *et al*., 1987)Many patients exhibit continuing bone resorption under well-made dental prostheses. This situation is frustrating to the dentist who has exercised utmost care as to tissue support, occlusion, and other mechanical factors in making the prostheses. These patients return with complaints of discomfort and inability to tolerate their prostheses, showing rapid, inexplicable bone loss (Baxter, 1981).

Definition

Osteoporosis has been defined by WHO in 1994 as "a disease characterized by low bone mass and microarchitectural deterioration of bone tissue leading to enlarged bone fragility and a consequent increase in fracture risk".(Bandela *et al*., 2015)

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Recommended Daily Allowance: Daily requirements of calcium for adult males and females is 500-1000mg.

Functions of calcium

- Activation of enzymes
- Muscles-Calcium mediates excitation & contraction of muscle fibers
- Nerves: Calcium is necessary for transmission of nerve impulses from pre-synaptic to post-synaptic region
- Secretion of hormones: Calcium mediates secretion of insulin, parathyroid hormones etc from the cells
- Myocardium: Calcium prolongs systole
- Coagulation: Calcium is known as Factor IV in blood coagulation cascade
- Bone & Teeth: The bulk quantity is used for bone & teeth formation

Absorption of calcium(Rodwell, 2015)

Absorption of calcium occurs mainly from upper jejunum and duodenum. The absorption is by a carrier mediated mechanism: The carrier molecule (calbindin) resides in the "brush border" of the jejunal mucosa. A derivative of Vitamin D- 1, 25 DHCC (Calcitriol) facilitates this carrier mediated transport. A small amount of calcium is also absorbed via passive diffusion. (Rodwell, 2015)(Figure 1)

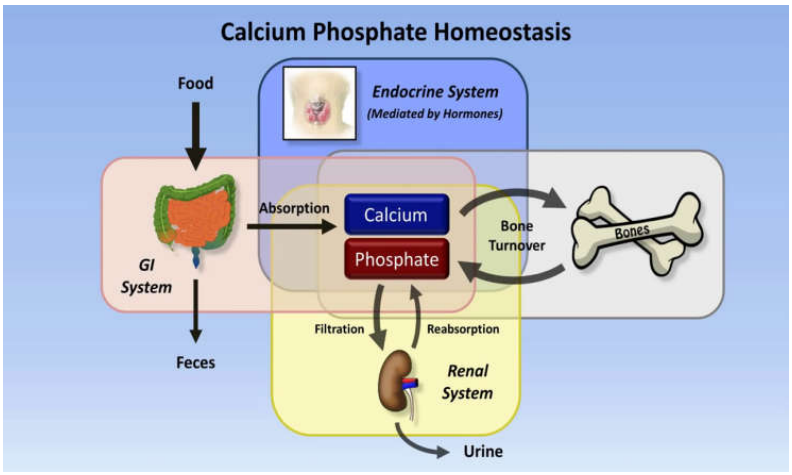

Figure 1. Calcium phosphate homeostasis

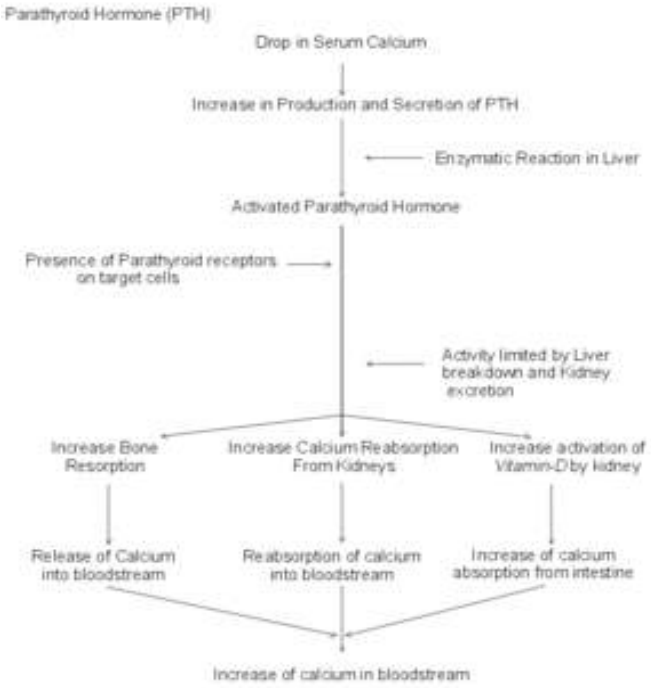

Figure 2. Factors regulating serum calcium level

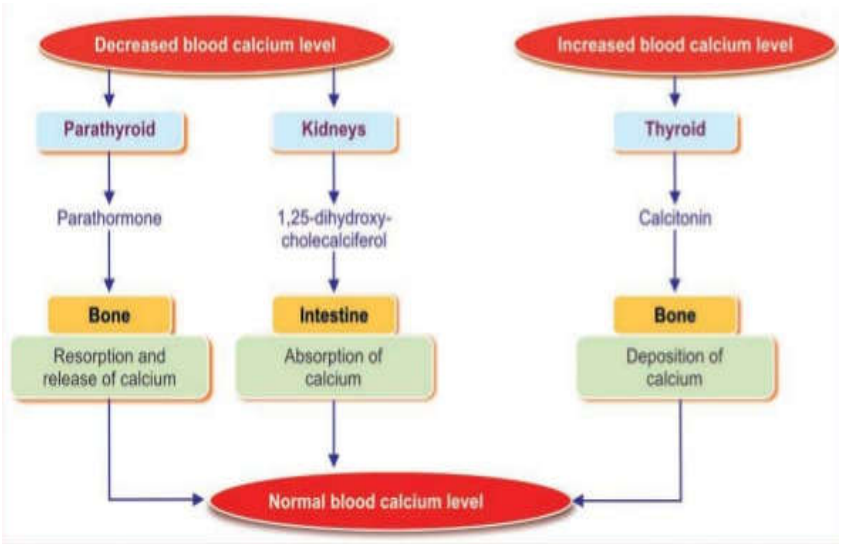

Figure 3. Factors regulating serum calcium level

Factors affecting absorption of calcium (Satyanarayana, 2017)

- Vitamin D: Calcitriol induces the synthesis of the carrier protein (Calbindin) in the intestinal epithelial cells
- Parathyroid hormone: It increases calcium transport from the intestinal cells
- Acidity: It favours calcium absorption
- Phytic acid: It is present in cereals. It reduces uptake of calcium
- Oxalates: Forms insoluble calcium oxalates; so absorption is reduced
- Phosphate: High phosphate content will cause precipitation as calcium phosphate

Calcium balance (Satyanarayana, 2017)

- Dietary absorption is the only means of obtaining calcium
- There are several mechanisms whereby calcium is lost from the body, including renal clearance, excretion of unabsorbed calcium in the faeces & dermal losses
- If the amount of calcium absorbed is greater than the amount lost, excess calcium is deposited in the skeleton. This is referred to as positive calcium balance
- If losses exceed absorption, calcium is mobilized from the skeleton to optimally maintain the narrow limits of extracellular fluid calcium, & is referred to as negative calcium balance
- A negative calcium balance sustained over a period of time will lead to osteoporosis

Factors regulating serum calcium level (Figure 2 & 3)

Vitamin D

- The active form of Vit D is dihydroxycholecalciferol or calcitriol
- The calcitriol includes a carrier protein in the intestinal mucosa which increases the absorption of calcium. Hence blood calcium level tends to be elevated
- It is involved in minimizing the excretion of calcium through kidney by decreasing their excretion and enhancing reabsorption.

Parathyroid hormone

- This hormone is secreted by the four parathyroid glands embedded in the thyroid tissue.
- The chief cells of the gland secrete the PTH.
- Control of release of the hormone is by negative feedback by the ionized calcium in serumPTH & Bones.
- In the bone, PTH causes demineralization or decalcification.
- PTH causes decreased renal excretion of calcium and increased excretion of phosphates

Calcitonin

- It is secreted by the thyroid parafollicular or clear cells. Calcitonin secretion is stimulated by serum calcium.
- Calcitonin decreases serum calcium level. It inhibits resorption of bone.
- It decreases the activity of osteoclasts and increases that of osteoblasts.
- Calcitonin and PTH are directly antagonistic. The PTH and calcitonin together promote the bone growth and remodelling.

Conditions arising from irregularities in calcium metabolism

Hypercalcemia: The term denotes that the blood calcium level is more than 12mg/dl. The major cause is hyperparathyroidism. There is osteoporosis and bone resorption. Pathological fracture of bones may result.

Hypocalcemia & Tetany: When serum calcium level is less than 8.8 mg/dl, it is hypocalcemia. If serum calcium level is less than 8.5 mg/dl, there will be mild tremors. If it is lower than 7.5mg/dl, tetany, a life-threatening condition will result. Tetany may be due to accidental removal of parathyroid glands.

The Oral manifestations are enamel hypoplasia, delayed eruption, and there may be multiple unerupted teeth. The Dental management is prevention of caries with periodic check-up, as pulp chambers are large, caries easily involve the pulp causing pulpitis, requiring endodontic treatment. Delayed eruption and hypodontia cause malposition and has to be treated by orthodontics.

Rickets

Occurs in children between 6 months to 2 years of age. Affects long bones. Lack of calcium causes failure of mineralization resulting into formation of cartilagenous form of bone.The oral manifestations are hypoplasia and hypocalcification. Dental management is by full mouth pulpectomies, placement of posterior stainless steel crowns, and anterior composite resin restorations.

Osteomalacia: is softening of the bones, caused by not having enough vitamin D or by problems with the metabolism of this vitamin. These softer bones have a normal amount of collagen that gives the bones its structure, but they are lacking in calcium. The common oral manifestation is in the form of severe periodontitis.

Hyperparathyroidism

They are of two types, primary and secondary

- Oral manifestations: loss of bone density, mobile teeth, drifting of teeth, complaint of vague jaw bone pain, sensitive teeth, soft tissue calcifications and dental abnormalities such as development defects, alterations in dental eruption.
- Dental management: The clinical management of these patients does not require any special consideration. There is a higher risk of bone fracture, so we must take precaution in surgical treatments.

Osteoporosis

After the age of 40-45, calcium absorption is reduced and calcium excretion is increased, so, there is a net negative balance for calcium. This is reflected in demineralization.

After the age of 60, osteoporosis is seen.Osteoporosis is the most prevalent metabolic bone disease that is associated with an increased risk for fractures. Women above 50 years of age have a 40% risk for these fractures. The basic abnormality is decrease in bone mass, which attains a peak by the age of 30 and starts declining by 35 to 45 years of age in both men and women. After the age of 40-45, calcium absorption is reduced and calcium excretion is increased; so, there is a net negative balance for calcium. This is reflected in demineralization. Decreased absorption of vitamin D and reduced levels of androgens/ estrogens in old age are the causative factors. Interleukin-1 and 6 also play important roles in the genesis of the condition. Osteoporosis is more severe and starts early in Indians, compared to Westerners (Vasudevan 2014).

Osteoporosis and Residual Ridge Resorption (RRR): RRR after tooth loss is a well described biological reaction. A decrease in biomechanical loading on bone reduces the stresses within the bone and results in resorption within the bone and its periosteal surface. The single case control study seems to indicate that the bone mineral content status in the jaws is lower in patients with symptomatic osteoporosis than in healthy age and menopausal age-matched females and that osteoporosis may produce a risk factor for severe resorption of the maxillary residual ridge, while this relationship is not clear cut in the mandible. (Habets LLMH *et al*., 1998)

Treatment

- Estrogen therapy remains controversial because of uncertainty about long-term benefits
- Vit D is another widely used therapeutic adjunct because of its important role in bone metabolism
- The most controversial experimental therapy is the use of fluoride
- Increasing calcium intake by means of dairy foods & supplementation is the most practiced method in the prevention & management of osteoporosis to optimize calcium balance

Recommendations relevant to the prevention &management of osteoporosis are

- Avoid a high protein diet & maintain daily protein intake levels of 50-60 grams to promote a positive calcium balance
- Maintain the RDA of 800mg of calcium for men & non-pregnant women
- Participate in regular exercise programs appropriate to age & health status
- Avoid risk factors related to osteoporosis such as smoking, excessive alcohol, & the generous use of caffeine- containing beverages

Prosthodontic management of the osteoporotic patient (Bandela *et al*., 2015) While fabricating removable dentures, the main area of focus should be on reduction of the forces on residual ridge. Mucostatic or open mouth impression techniques, selective pressure impression technique, should be employed to reduce mechanical forces while impression making. Semi anatomic or non-anatomic teeth with narrow buccolingual width should be selected. Optimal use of soft liners, extended tissue intervals by keeping the dentures out of mouth for 10 hours a day can be advised. While fabricating fixed partial denture in periodontally compromised abutments it may accelerate the bone loss in osteoporotic patients. So, the fabrication of FPD should follow treatment of osteoporosis rather than preceding it.(Bandela *et al*., 2015)

Conclusion

Disturbances in calcium intake and excretion result in deranged metabolism accounting for abnormal serum levels. As a result of the essential role played by these minerals in intra and extracellular metabolism is disturbed, the clinical manifestations of related disease states are extensive. Thus, an understanding of the basic mechanism of calcium metabolism and pathophysiology of various related disorders is helpful in guiding therapeutic decisions.

Conflict of Interest statement

The authors declare that there is no conflict of interest and no financial interest in the subject discussed in this paper.

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