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Dental Implants and Osteoporosis - A Clinical Update

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Abstract: ***Osteoporosis is a metabolic bone disease that makes bones more fragile and increases the risk of breaking them. Osteoporosis is assumed to be an osseointegration risk because it is linked to a reduction in bone formation, which is thought to hinder the body's natural ability to heal and prevent proper bone apposition at the implant site. Osteoporosis can affect dental implant placement as osteoporotic individuals have greater alveolar ridge resorption, altered trabecular patterns mostly in the anterior maxilla and posterior mandible. The present review gives an insight into the current concepts on implant placement and suggested treatment modifications in osteoporotic patients.***

Keywords: implant osseointegration, alveolar bone, bisphosphonates, implant failure

1. Introduction

Osteoporosis is a metabolic bone disease that makes bones more fragile and increases the risk of breaking them. This is caused by a number of things, including low bone mineral density, loss of cancellous bone microarchitecture, and changes in the properties of bone material (). Osteoporosis can be either primary or secondary. Common Osteoporosis can be either primary, which is caused by age-related bone loss, or secondary, which is caused by things like glucocorticoids or malabsorption. Primary osteoporosis is more common. Two subtypes of primary osteoporosis have been identified: Type I osteoporosis, also called postmenopausal [1] osteoporosis, occurs when trabecular bone is lost as a result of accelerated turnover due to a decrease in estrogen levels [2]. Diagnosis of osteoporosis in clinical practice typically involves the patient's medical history, a physical examination, and diagnostic testing (such as a bone mineral density scan) (BMD) [3]. Bone mineral density (BMD) accounts for 75% of bone strength, which is related to fracture risk and is determined by a number of bone properties [3]. Bone mineral density is expressed as a value in either milligrams per square millimeters or milligrams per cubic millimeter (weight of mineral per unit area or volume). Dual-energy X-ray absorptiometry (DEXA) is the gold standard formeasuring bone mineral density (BMD) [4]. T-scores are used to characterize BMD by contrasting it with the mean peak BMD of a healthy, young adult population of the same gender; in this case, white, non-race-adjusted women serve as the reference group. One of the criteria for the diagnosis of osteoporosis outlined by the World Health Organization (WHO) is a bone mineral density (BMD) T-score in the whole hip, femoral neck, or lumbar spine that is more than 2.5 standard deviations below the mean for young, healthy persons [5]. Fractures are more common in individuals with osteoporosis because of the buildup of microdamage and the inability to repair it correctly [5]. Fractures are more common in individuals with osteoporosis because of the buildup of microdamage and the inability to repair it correctly.

Diagnosis and Prevalence of Osteoporosis

Close to 200 million people worldwide experience osteoporosis each year. According to the World Health Organization, there is a deficiency in statistics regarding the incidence and prevalence of osteoporosis in poor nations. Among Indian women, osteoporosis prevalence estimates range from 8 percent to 62 percent, depending on the study. This demonstrates substantial diversity in incidence across India. The risk of developing osteoporosis is much greater in the elderly than in younger adults or men. Accordingly, a recent study from North India found that the prevalence of osteoporosis was greater in women than in men across all age groups, with a 3.0% and 36.4% prevalence in women aged <30 and >70, respectively. Women were shown to have a higher prevalence of osteopenia (40.3% vs. 29.9%) than men [6]. Menopause in women is mostly responsible for the disparities between the sexes. Numerous additional things influence skeletal wellness. Factors that increased risk of fracture included older age, being female, having a lower level of education, not working, being overweight, undergoing androgen deprivation therapy, consuming dairy products for longer, and having a recent fracture during the preceding decade. Bone health is affected by dietary choices, which have been shown to be either beneficial or detrimental. Vitamins including vitamin C, vitamin B12, and carotenoids are known to boost bone health [7].

Osteoporosis and Bone Healing

Osteoporosis is assumed to be an osseointegration risk because it is linked to a reduction in bone formation, which is thought to hinder the body's natural ability to heal and prevent proper bone apposition at the implant site. Despite the lack of data comparing the bone healing rates of control and osteoporotic populations, histomorphometry studies have shown that bone remodeling was normal in a large proportion of patients diagnosed as being osteoporotic. In osteoporotic patients, the observed clinical heterogeneity in bone remodeling may be a reflection of the phasic fluctuation of the disease, or bone metabolism may have returned to normal by the time the condition is diagnosed.

However, the fact that osteoporotic fractures tend to heal quickly provides some reassurance that the repair process is still effective in osteoporotic patients. Possibly related to this is the fact that woven bone formation, which is crucial for post-fracture bone union, is less receptive to endocrine and other regulation than lamellar bone. The imbalance between bone resorption and formation is thought to be at the root of bone loss, which can be caused by a decrease in bone formation and an increase in bone resorption, or both. Bone tissue is constantly being removed and replaced as part of the remodeling process, which helps keep the skeleton's biomechanical competence (its ability to withstand load without accumulating fatigue damage) at a high level. Time- and location-specific rates of bone loss and gain are controlled by the rate and magnitude of the replacement. In some people with osteoporosis, the process of bone remodeling is hyperkinetic, leading to accelerated bone loss.

Oral Implant Therapy in osteoporotic patients

Osseointegration is "direct functional and structural connection between living bone and the surface of a load bearing implant" in one of the early definitions in 1981 [8]. Osseointegration has also been described as a time-dependent healing process that achieves and maintains clinically asymptomatic, rigid fixation of alloplastic material in bone during functional loading [9]. Post implant healing occurs in three stages after a precisely made bone osteotomy receives an implant made of a bio-inert material such as titanium. Local plasma proteins are first adsorbed on the implant surface and a clotting cascade is initiated, causing the release of various cytokines from local cellular elements, which regulate adhesion molecule production, increase vascularization rate, enhance collagen synthesis, regulate bone metabolism, and activate osteoclasts. 3-4 days after surgery, an early inflammatory response with neutrophil migration and aggregation occurs, followed by macrophages becoming the primary phagocytic cells in the wound 5-6 days later. New vascularization, differentiation, proliferation, cell activation, and the creation of an immature connective tissue matrix characterize the second proliferative phase. Undifferentiated mesenchymal cells differentiate into fibroblasts, osteoblasts, and chondroblasts during this phase, with osteoblasts overseeing the majority of bone repair [10]. The restoration of the cortical [11] necrotic boundary by creeping substitution is the outcome of combined osteoclast-osteoblast action. Blood vessels enter the necrotic border zone, which osteoclasts resorb, and osteoblasts replace with new bone. With time, the healing wound becomes more organized, and the fibrocartilaginous callus changes into a bone callus. Finally, during the maturation phase, the immature bone matrix is remodeled, and osteoclasts and osteoblasts continue to resorb and deposit bone for many years [12]. An osseointegrated oral implant must meet certain requirements in terms of function, tissue physiology, and patient satisfaction in order to be called successful [11]. The term "implant survival" refers to an oral implant that is still functional but does not achieve all the success requirements [9], [13]. Implant failure, on the other hand, is defined as the first time the implant's performance is tested quantitatively and falls below a predefined acceptable limit [14]. Recent myocardial infarction and cerebrovascular accident, valvular prosthesis surgery, immunosuppression, bleeding issues, active treatment of malignancy, drug abuse, psychiatric illness, and intravenous bisphosphonate treatment are among the few absolute contraindications to dental implant rehabilitation [15]. Adolescence, age, osteoporosis, smoking, diabetes, positive interleukin-1 genotype, human immunodeficiency virus infection, and cardiovascular disease are some of the relative contraindications and diseases addressed in the literature that may negatively impact dental implant outcomes. [15]. Adolescence, age, osteoporosis, smoking, diabetes, positive interleukin-1 genotype, human immunodeficiency virus infection, and cardiovascular disease are some of the relative contraindications and diseases addressed in the literature that may negatively impact dental implant outcomes.

Clinical trials of dental implant in osteoporosis patients

Becker et al. [16] conducted a case-control study to investigate the relationship between osteoporosis and dental implant failure. A total of 49 cases (aged 44-82 years) who had received 184 dental implants and had lost them were compared to 49 controls (aged 43-85 years) who had received 180 implants and had not lost them. There were 5 osteoporotic patients in the cases with implant failures, compared to 7 osteoporotic patients in the controls with no implant failures. The average duration of follow-up was 3.9 years. All patients had their peripheral DEXA values measured at the proximal and distal ulna. The groups' mean DEXA scores did not differ significantly. The resulting T-scores revealed that the control group had seven patients with osteoporosis and the case group had five. They discovered no link between T-scores and implant failure. However, implant failure was 3.7 times more likely in sites with type 3 or type 4 bone quality [17].

Friberg et al. [18] reported on a retrospective study of 13 osteoporosis patients (11 women and 2 men). Five of the patients were completely edentulous, six were edentulous in the maxilla, and three were partially edentulous. Dental implants were placed using an adapted bone site preparation technique, which resulted in a longer mean healing time of 8.5 months in the maxilla and 4.5 months in the mandible (compared to the conventional healing time of 6 months in the maxilla and 4 months in the mandible). The average duration of follow-up was 3 years and 4 months (range: 6 months to 11 years). Intraoral radiographs were used to assess marginal bone height (by taking the mean value of the mesial and distal implants), and bone loss was measured at 0.6 + 0.6mm at the one-year follow-up. Following increased healing time and bone compaction, a 97% success rate was observed. They concluded that implant placement in patients with osteoporosis may be successful for many years if the bone site preparation technique is adapted for primary stability and the healing time is increased for secondary stability. They did not specify whether there was a history of smoking, and no information on concurrent medication use was provided [18]. von Wowern and Gotfredsen (2001) [19] analyzed a sample of 22 long-term (> 5 years) edentulous healthy individuals (mean age 65 years) who were divided into an osteoporosis (n=7) and non-osteoporosis (n=11) groups based on bone mineral content intraoral radiographs were taken on a regular basis using a standardized technique to measure bone levels, and the osteoporosis sample had significantly more marginal bone

loss. They concluded that bone loss around dental implants may be exacerbated by mandibular osteoporosis at the time of implant placement. They did, however, observe a reduction in bone mineral content loss following treatment with dental implants. In a retrospective case-control study by Amorim et al [20], which aimed to evaluate osseointegration in patients with osteoporosis, data from 19 osteoporosis patients diagnosed on the basis of DEXA values at the lumbar spine and femoral neck and 20 controls were compared. Patients on glucocorticoid and bisphosphonate therapy, as well as those with chronic disease, current smokers, chronic alcohol use, and other immunosuppressive drugs, were excluded. At 9 months of follow-up, they found no statistically significant difference in survival between the 39 implants placed in osteoporosis patients and the 43 implants placed in controls. However, it should be noted that their sample consisted of 19 osteoporosis patients, and the follow-up period was only 9 months, which is a very short duration of follow-up to address the question comprehensively.

Holahanet al. (2008) [21] published a retrospective longitudinal 5-year follow-up study to investigate whether osteoporosis affects the treatment outcome of dental implants in terms of their survival. To identify patients with osteoporosis and osteopenia, a retrospective review of female patients aged 50 and up was performed. The implant's arch location, smoking status at the time of implant placement, and implant failure were all noted. Implant failures were defined as dental implants that had to be removed for reasons other than infection. They found 57 patients with osteopenia (197 dental implants), 41 patients with osteoporosis (143 dental implants), and 94 patients without osteoporosis (306 implants). They discovered a ten-year survival rate of 92.5% in general, with no significant difference between groups, and no association of failure with arch location. However, they discovered that implants were 2.6 times more likely to fail in smokers than in nonsmokers. They concluded that patients with osteoporosis or osteopenia were no more likely than non-osteoporosis patients to develop implant failure. They did not, however, go into detail about osteoporosis medications, and their exclusion criteria were not specified. In addition to 16 animal studies, Tsolaki et al. (2009) [22] identified six prospective and six retrospective human studies. In addition, these researchers reached the conclusion that osteoporosis may not be a contraindication for dental implant placement if the surgical technique is modified and longer healing time is allowed. The researchers identified frequent flaws in the studies, including small sample sizes (commonly fewer than 20 patients) and brief follow-up periods. Several longitudinal implant studies [23] have reported an increased rate of implant failure when the implants were placed in jaws with type 4 bone. Type 4 bone is the typical bone quality seen in osteoporosis patients [24]. Analysis using multivariate statistics revealed osteoporosis to be a significant variable associated with early dental implant failure in a large retrospective cohort consisting of 2004 patients who had 6946 implants [25]. On the other hand, a histological study that evaluated the bone-implant contact of retrieved failed implants found no differences between patients who had osteoporosis and patients who did not have osteoporosis in the patients who received the implants [26]. It has also been hypothesized that the placement of dental implants in patients with osteoporosis may aid in the preservation of alveolar bone due to the more favorable mechanical loading and stimulation of the bone provided by the implants [27]

Giro et al. 2015 [28] conducted a systematic review of a total of 708 healthy patients, 133 patients diagnosed with osteoporosis, and 73 patients with osteopenia were evaluated. In these patients, a total of 367, 205, and 2981 dental implants, respectively, were put in osteoporotic subjects, osteopenic subjects, and healthy subjects. In patients with osteoporosis, the rate of dental implant failure was 10.9%, whereas in osteopenic patients it was 8.29%, and in healthy patients it was 11.43%. The percentage of bone that was in contact with the implant, as measured by retrieved implants, ranged from 49.96% to 47.84% for both osteoporotic and non-osteoporotic patients. They concluded that there is little evidence to either support or deny the concept that osteoporosis may have adverse effects on bone repair. Osteoporotic patients reported greater rates of implant loss.

Joe Merheb et al.2016 [29] examined how skeletal osteoporosis and local bone density affected initial dental implant stability in 73 participants. Osteoporotic Group (63.3 6 ±10.3 ISQ) had lower primary stability than group Osteopenia (65.3 6± 7.5 ISQ) and control group (66.7 6 ±8.7 ISQ). At abutment placement, Osteoporotic Group (66.4 6± 9.5 ISQ) scored lower than group Osteopenia (70.7 6± 7.8 ISQ), whereas control group scored highest (72.2 6 ±7.2 ISQ). Osteoporotic and Control groups differed significantly. RFA stability was unaffected by implant length or diameter. They concluded that local bone density significantly correlated with implant stability in all sites of interest. . The lower stability ratings in skeletal osteoporosis patients support safe protocols and prolonged healing times for dental implants.

Tabrizi et al [30] in prospective cohort research, osteoporotic and non-osteoporotic female patients were evaluated for marginal bone loss (MBL) surrounding posterior maxillary dental l implants. MBL was measured twelve months following loading. There were 90 female patients investigated, 44 with osteoporosis and 46 without. The mean MBL for osteoporotic patients was 1.20±0.29mm and 0.87±0.15mm for non-osteoporotic patients; this difference was statistically significant (P=0.001). There was a link between T-score and MBL (P=0.001), but this study did not give sufficient data to indicate that MBL causes osteoporosis.

Impact of systemically administrated bisphosphonates have on oral implant therapy

Bisphosphonates are commonly used medications to treat osteoporosis and other bone diseases. Systemic bisphosphonate administration can have an effect on oral implant therapy, specifically on implant success rates and healing times. some of the potential effects of bisphosphonates on oral implant therapy include:

- **Delayed osseointegration:** Bisphosphonates can disrupt the normal bone remodelling process, leading to delayed osseointegration (the process of bone

integration with the implant). This increases the likelihood of implant failure or complications.

- **Poor bone quality:** Patients receiving long-term bisphosphonate therapy frequently have poor bone quality, making implant placement more difficult. Additional procedures to augment the bone or modify the implant placement may be required.
- **Osteonecrosis of the jaw:** Bisphosphonate therapy has been linked to osteonecrosis of the jaw, a rare but deadly disorder in which bone tissue in the jaw bone becomes dead. This can happen on its own or as a result of trauma, like dental surgery, and it can have a big impact on oral implant therapy.

Grantet al [31] reported that in the 115 patients who reported having received oral bisphosphonate therapy, 468 implants were placed. There was no evidence of bisphosphonate-associated osteonecrosis of the jaw. All but two of the 468 implants were integrated completely and met the criteria for implant success. Patients receiving oral bisphosphonate therapy and those not receiving oral bisphosphonate therapy had comparable implant success rates. Madrid etal 2009 based on the analysis of one prospective and three retrospective series (217 patients), implant placement may be considered a safe procedure in patients taking oral BPs for 5 years in terms of the occurrence of BRONJ, as no BRONJ was reported in these studies and implant survival rates ranged from 95% to 100%. Furthermore, oral-BP intake had no effect on implant survival rates in the short term (1-4 years) [32].

Treatment modifications for implant placement in osteoporotic patients:

Dental implant placement in poor quality osteoporotic D4 type bone can be challenging due to the lack of support and stability [33]. For patients with D4 bone, there are still possibilities if they want to get dental implants. To improve the bone volume and density in the region where the implant will be put, bone grafting is one possibility. This can be a drawn-out process that calls for multiple appointments [34].

Short implants: Short dental implants, typically those with a length of less than 10mm, can be a viable option for patients who have limited bone height or density [35]. Since these implants need less bone to be successful, they may be more suitable for individuals with D4 bone. When there is insufficient bone height to support a regular-sized implant, short dental implants are frequently utilized to replace missing teeth. However, due to their shorter length, they have a smaller surface area for osseointegration (the process by which the implant fuses with the surrounding bone). Several surface treatments have been developed to make up for this and improve the implant's capacity to integrate with the bone [36].

With short dental implants, the following surface treatments are frequently used:

In order to increase the surface area of the implant and improve bone attachment, sandblasting and acid etching entails roughening the implant surface using abrasive particles and an acid solution. SLA, or large grit sandblasted and acid-etched, is a surface treatment method commonly used in dental implants to promote osseointegration and improve long-term stability [37].

SLA involves roughening the implant surface by sandblasting it with large grit particles, typically aluminum oxide. This rough surface increases the surface area available for bone cells to attach and grow, promoting osseointegration. To further modify the surface and remove any contaminants, the implant is then treated with an acid solution, typically hydrochloric or sulfuric acid. When compared to smoother implant surfaces, SLA treatment has been shown to improve bone growth and osseointegration. Sandblasting creates a rough surface that increases the contact area between the implant and bone, resulting in a stronger and more stable implant.

Plasma spraying: With this technique, a biocompatible substance, such as titanium or hydroxyapatite, is applied to a target surface [38].

Anodization is the process of passing an electric current through an implant to create an oxide layer on its surface, which improves biocompatibility and promotes bone adhesion [39].

Laser treatment: This involves using a laser to modify the implant surface by melting or vaporising the metal, resulting in a roughened surface that improves bone adhesion [40].

Nanotexturing is the process of creating a pattern of tiny features on the implant surface at the nanoscale level, which can improve cell adhesion and proliferation, resulting in better osseointegration [41].

Osseo densification

In dental implantology, the Osseo densification procedure is used to widen the accessible bone and increase the bone-to-implant contact surface area (BIC) in a low-density bone. Osseodensification may improve implant primary stability and lessen micromotion when compared to standard implant drilling methods. A wider-diameter implant could be inserted into a narrow ridge without causing bone dehiscence or fenestration, according to the Osseo densification approach. By compressing and compacting the bone tissue using specialized tools, microfractures are created that trigger the body's natural healing process and promote the development of new, denser bone [42]. These include;

- Osteotomes: In this method, the bone tissue is compressed and compacted using specialised surgical instruments called osteotomes. Once the osteotomes are in place, the bone is gently tapped with a hammer to cause compression and compacting [43].
- Piezoelectric surgery: This procedure uses ultrasonic waves to make tiny micro-fractures in the bone tissue. This promotes the body's natural healing process and the development of new, denser bones [44].
- Ridge expansion: This procedure widens the jawbone where the implant will be placed to give it more room and increase bone density.

- Bone grafting: To enhance bone density prior to placing dental implants, bone grafting may occasionally be required. In order to increase the jawbone's quality and density where the implant will be placed, this includes either extracting bone from another region of the body or utilizing artificial materials.

The magnetic mallet: it is a relatively recent device that is utilized for bone densification during dental implant insertion. It uses a magnetic field to impart moderate, precise vibrations to the bone tissue, facilitating densification without producing micro-fractures [45]. By creating a magnetic field, the magnetic mallet causes a small, light piston to vibrate at a high frequency, which is how it works. The piston generates gentle, controlled vibrations as it comes into touch with the bone tissue, which aid in compressing and densifying the bone without causing any harm. Precision is one of the main advantages of the magnetic mallet. The vibrations can be tailored to certain frequencies and amplitudes and are highly regulated, enabling accurate and targeted bone densification. This can lower the risk of problems and increase the success rate of dental implants. The softness of the magnetic mallet is another advantage. There is less chance of generating bone micro-fractures or causing damage to the surrounding tissue because the vibrations are controlled and precise. As a result, the patient may have quicker healing and less pain and discomfort. It's crucial to remember that the precise technique employed for bone densification will depend on the requirements of each patient and the location of the dental implant. Your dental implant specialist will assess your articular circumstance and suggest the most appropriate course of action for your requirements [46].

2. Discussion

Implant osseointegration is a wound healing process that depends on host bone quality, quantity, healing capacity, and other systemic conditions. Healing creates intimate bone–implant contact for osseointegration. Thus, any condition affecting bone quality or quantity, or microarchitectural changes in bone structure, including reduction in cancellous bone volume and bone-to-implant contact (which reduces bone tissue around the implant), could theoretically affect the survival and function of an endosseous implant. Osteoporosis can affect dental implant placement as osteoporotic individuals have greater alveolar ridge resorption, altered trabecular patterns mostly in the anterior maxilla and posterior mandible, erosion of the inferior mandibular border, and increased resorption and thinning of the inferior mandibular cortical margin. Osteoporosis decreases the trabecular number and their thickness. Bone changes that are evident on panoramic radiographs can be correlated with general osteoporosis, and routine dental CBCT scan often done prior to implant placement can serve as a reliable indicator of bone loss in osteoporosis as well as can be a useful tool for predicting skeletal osteoporosis. Dental implants require a certain level of bone density to remain stable during the healing phase, so severe osteoporosis may endanger the implant's stability and its success. However, each case is different, and the decision to proceed with dental implants in a severely osteoporotic patient should be made on an individual basis by the surgeon in consultation with their primary care physician. If the patient's osteoporosis is severe enough to significantly reduce bone density, the dental implant may fail to properly integrate with the bone, resulting in implant failure. Alternative treatments, such as dentures or bridges, may be more appropriate in such cases.

Dental implants, on the other hand, may be a viable option if the patient's osteoporosis is mild to moderate and their bone density is sufficient to support the implant. To help support the implant and promote proper healing, the dentist or oral surgeon may use techniques such as bone grafting, bone densification using an osteotome technique, bone densifications drills such as Densah or Versahdrills. Finally, in a severely osteoporotic patient, the decision to proceed with dental implants should be made on a case-by-case basis, taking into account the patient's overall health, bone density, and other factors that may affect the implant's success.

Also the effect of bisphosphonates on oral implant therapy because of its complexity, must be carefully considered and managed by the dental and medical teams. Before receiving oral implant therapy, patients on bisphosphonate therapy should discuss their prescription use with their dentist. Also, to control the patient's medication use and guarantee proper bone health, dental practitioners should collaborate closely with the patient's doctor.

According to the findings of the review of the relevant research literature on this topic, it is abundantly clear that additional clinical studies are required to precisely determine whether or not the outcomes of dental implant surgery are affected in patients who have osteoporosis. Previous reports are scant and do not shed any light on this topic because several aspects of the osteoporosis experience spectrum, such as the effect of treatment and the length of time the disease has been present, have been ignored. Additionally, a more in-depth consideration needs to be given to the standardization of surgical procedures used for implant placements, location of the implants, the total number of implants, as well as the dentate and implant status of the opposing arch.

3. Conclusion

The current review of the relevant literature does not provide a convincing theoretical or practical basis to confirm that osteoporosis is a risk factor for the osseointegration of dental implants. Consequently, denying implant treatment to a patient whose diagnosis of osteoporosis is based on a reduction in bone mass is not a correct course of action. It is vitally important that the treatment planning for dental implant therapy be based on a local assessment of the potential surgical site. A large prospective multicenter trial involving a greater number of patients and utilizing standard procedures would be helpful as a reliable predictor for prognosis of dental implants placed in poor quality osteoporotic alveolar bone.

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