Resorptive Changes of Maxillary and Mandibular Bone Structures in Removable Denture Wearers

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Summary

Residual ridge resorption is a result of the influence of many different local and systemic factors (patient's age, traumatic damage, different pathological conditions, mineral metabolism disorders, osteoporosis, hyperparathyroidism and hormone disbalance).

Some parts of the skeleton react differently to the mentioned factors. The resorptive changes are not always the same intensity in all the parts of the skeleton.

There are many different results in the investigation of the relationship between maxillary and mandibular resorption and the resorption of the rest of the skeleton.

Alveolar ridge resorption is correlated with removable denture wearing. The resorption of the edentulous alveolar ridge is more extensive in full or partial denture wearers with mucosa- or mucosa-gingival support than in partial denture wearers with gingiva-mucosal support.

One of the easiest methods for early diagnosis of bone structure changes in the upper and lower jaws is clinical microdensitometry, using a standardised intraoral or panoramic radiograph.

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Introduction

Alveolar ridge resorption after teeth extraction is a chronic, progressive and cumulative disease of bone reconstruction. Extensive residual ridge resorption is one of the many problems in prosthetic dentistry rehabilitation (1-5).

Many local and systemic factors are related with residual ridge resorption. Local factors are:

- Conditions after teeth extraction (quality, quantity and shape of the residual ridge, muscle attachment, etc.),
- Edentulousness,
- Bite stress from the denture to the edentulous ridge.

Systemic factors are:

- Patient's age,
- Gender,
- Ca deficiency,
- Ca and P metabolism disorders,
- Systemic osteoporosis,
- Hormone disbalance.

All these factors together cause resorptive changes in the edentulous parts of the maxilla and mandible (6).

Relationship between skeletal resorption and residual ridge resorption

Some studies investigated the differences between bone mass in different parts of the skeleton (7-10). The most frequently studied parts of the skeleton compared with the mandible are forearm bones (radius (8, 11-14), femur (15, 16), vertebra (7, 14-16) and metacarpal bones (13, 14),).

A significant difference was found between the mandible and skeletal bone mass in postmenopausal women with osteoporosis (7, 8, 17), (one of the most frequent causes of skeletal resorption in women of that age) and in healthy older women (7, 8).

The most frequently used region for investigation of bone density is the distal part of the forearm, consisting of 87% cortical and 13% trabecular bone (11, 18). The same relation is in the region of the dentulous premolar part of the mandible (19). Mandibular bone mass is related to the mineral content of the forearm (13, 16) and to the total body calcium of radius (8). Von Wowern (12) measured mineral loss of the mandible and the forearm, which was 5.6% per year and was almost equal on both sides (left and right side).

The results of some measurements of mandibular bone density and bone density of the femur in edentulous and partially edentulous menopausal women showed no relationship between mandibular trabecular bone density and density of the neck of (16, 20). The patient's weight could also be related to bone density of the femur and vertebra (15) - thinner bone, lower density (21). Without weight as a factor, the differences in bone loss are even greater (lighter women with small bones are more predisposed to osteoporosis).

Mandibular bone mass is significantly related to the vertebral mineral content (7), particularly its lumbal part (22). However, in healthy individuals the iliac bone density is not related to mandibular bone mass density (23).

Previous studies have proved that osteoporosis can cause changes on metacarpals (13, 24). Von Wowern's results show correlation between iliac and metacarpal bone density in healthy individuals (23).

Correlation analysis in Southard's studies revealed a relationship between maxillary and mandibular bone density in the alveolar region, in the frontal and lateral regions of the lumbal vertebra, in the hip region and in the forearm.

Alveolar ridge resorption after teeth extraction

After tooth extraction the alveolar ridge is in the process of resorption (Figure 1). In this situation there is insufficient support of the remaining tissues for correct denture function (14). Therefore, due to the extensive loss of denture support bone mass there is no retention and stability of the dentures.

Loss of the distal teeth leads to neuromuscular disorders in the mandible, decreases the bite effect and the vertical dimension of the denture, resulting in changes on the alveolar ridge (26).

Many studies have investigated the relationship between the size of the alveolar ridge and osteoporosis.

Residual ridge resorption starts with the tooth and its periodontal membrane loss, responsible for the bone formation (14). Periodontal membrane loss leads to decreasing metabolism in the alveolar ridge and to biochemical resorption of the bone caused by the dental plaque endotoxines, prostaglandines and human stimulating factors of alveolar ridge resorption (14, 27).

After the extraction all the changes on the residual ridge can be divided into two phases. In recent studies, general skeletal loss is very important for residual ridge resorption in the first phase (7, 28). In the final phase of resorption, trabecular bone mineral density and the higt of the alveolar ridge do not change, both in healthy individuals and those with osteoporosis (15).

Tooth loss causes resorption of the upper part of the mandible (alveolar ridge) and is the main factor influencing the clinical height of the residual mandible (29).

According to Klemetti initially resorption starts on the alveolar part of the mandible, and the rest of the mandible remains unchanged (15). Factors such as resorption, postmenopaus or osteoporosis do not change the lower part of the mandible. The main reason for this may be the function of the chewing muscles (30).

After tooth extraction the resorptive changes on the alveolar ridge depend on the number and position of the remaining teeth in the jaw. According to Klemetti's investigation, if frontal teeth remain in the mandible, the bite forces in the distal part of the mandible are not strong enough to produce greater resorption, both in denture wearers and non-wearers (31).

Therefore, after mandibular frontal teeth extraction, the distal part of the mandible is more in use and the resorption process is more extensive. The main reason for this is the influence o muscle activity on mandibular bone density in parts of the muscle attachments, after tooth extraction (31).

Also the patient's age is very important and bone metabolism which can increase the resorption process. Frontal parts of the maxillary alveolar ridge, edentulous for a long period, are less exposed to the chewing trauma of the mandibular frontal incisors during the increasing bone metabolism, than those which are edentulous for a short period (27). This is due to the smaller amount of resorption and greater amount of bone formation process along the positive bone metabolism (the formation is greater than the resorption).

The resorption process increases during the first year after tooth extraction (32-36). According to some measurements in Van Waas's studies, average bone loss in the region of the mandibular canines was 0.9 mm in the first year after tooth extraction in immediate cover-denture wearers, and 1.8 mm in immediate complete denture wearers (37). In the distal parts of the mandible bone loss ranged from 0.7 to 1.9 mm. During the second year, no statistically significant difference was found between these two studied groups (37).

Some authors reported extensive bone loss within the first two years after tooth extraction (38) which later gradually stabilized. During that period, alveolar ridge reduction is more like resorptive atrophy, fundamental and physiological reaction to the loss of function and inactivity, caused by the tooth and bone loss (39).

After tooth extraction the resorption process on the alveolar ridge is not of the same intensity in all parts of the bone. Namely, resorption is faster in the labial and buccal parts of the alveolar ridge (40).

Bone density in the region between the foramen mentale and the second molar (mesial part) is lower than in the frontal and most distal parts (behind the third molar) after the tooth extraction (38). Bone density is higher in the region of the mandibular ramus, linea obliqua externa and linea mylohyoidea because of the biomechanical (38). This confirms the fact that the bone structure is less resorptive under the strong bite forces produced by the chewing muscles. The frontal parts of the mandible reduce by 25%, and during 20 years after tooth extraction, the mandible reduces by 50% of the volume, occasionally even by 60% (38).

Relationship between alveolar ridge resorption and removable denture therapy

Removable denture wearing, particularly complete denture wearing can cause some problems to the health of the supporting tissues (41).

Atwood reported that continuous ridge resorption in complete denture wearing causes major oral disease (42). Resorption is the result of the bone remodelling process and the main factors related to the resorption are gender, age, facial structure, edentia, denture wearing habits, number of wearing dentures, oral hygiene, oral parafunctions, occlusion, denture quality, food, general health, usage of medications, systemic diseases and osteoporosis (41). The individual variations in the quantity of bone loss are connected with the different period of edentia, as one of the most important factors related to residual ridge resorption in removable denture wearers. The so-called combination syndrome (combination of complete and partial removable dentures) can also cause the resorption process. Patients with an upper complete and lower partial denture, combined with lower frontal natural teeth risk bone structure loss in the frontal part of the maxilla caused by the loading of the lower frontal natural teeth on the upper complete denture (31). In patients with an upper complete and lower partial denture (Kennedy class I) decrease in the vertical dimension is about 50% less than in upper and lower complete denture wearers (35).

The period of edentia is also related to alveolar ridge resorption, especially in the mandible. Alve-

olar bone loss in the edentulous jaw is permanent process during the period of denture wearing (35, 42). Patients with long periods of edentia often loose more mandibular bone than those with a shorter period of edentia (43, 44).

Denture wearing is also very important in alveolar ridge resorption (45-48). The number of lower dentures worn is very often related with the period of edentia and alveolar ridge resorption (43). The individuals who wear their complete dentures continuously day and night, have more resorptive changes in the jaws compared to those who wear dentures daily.

With regard to bone resorption under the denture base is also the kind of denture very important. Patients with lower frontal natural teeth have greater resorption of the edentulous maxilla than patients with lower complete dentures or patients with natural teeth (49). The number of dentures worn and oral hygiene are related to alveolar ridge resorption (50, 51).

There are some opposite results of the investigations.

Xie reported no relationship between the period of edentia and resorption of the mandible, and the influence of lower partial dentures on maxillary resorption under the upper complete denture was insignificant (45). Alveolar ridge resorption was higher only in those patients with long period of wearing non-adapted dentures.

Resorption in the frontal part of the mandibular alveolar ridge is highest in the first year of denture wearing, and thereafter, for a period of seven years it is lower (52). After that period alveolar ridge resorption starts to decrease (52).

According to Crum and Rooney, bone reduction in the frontal part of the mandible is 0.6 mm in immediate cover-denture wearers, and 5.2 mm in immediate complete denture wearers during a period of five years of denture wearing (53).

Steen's studies proved that resorption of all parts on the mandible is 50% lower in cover-denture wearers compared to complete denture wearers during the first year after tooth extraction (54).

Extensive resorptive changes in one jaw do not necessarily cause resorption in the opposite jaw.

Tallgren found a negative correlation between bone mass loss in the maxillary and mandibular alveolar ridge during a seven year follow-up study (35). When resorption was extensive in one jaw it was low in the opposite jaw. The results of Talgren's studies indicated that changes under the denture base more often occur in the mandible. The relation between mandibular and maxillary reduction is 4:1 because of the higher reduction of the lower jaw during the period of seven years of denture wearing (the mandible is 4 times more reduced), (35).

The difference in resorption of the jaws increases within the first year of denture wearing, which proves that the mandible cannot resist the strong bite forces under the denture base (35). This is because of the smaller surface of the lower jaw. At the same time, the maxilla is less reduced because of the anatomical shape of the upper jaw (palatum durum resists the bite forces) and because of the greater surface of the denture base and better guidance of the bite forces (smaller amount of force on the unit of the ridge).

In upper and lower complete dentures average pressure on the unit of the mandible is twice as high as the pressure on the maxilla because of the smaller contact surface with the supporting tissue (31). The shape of the maxilla, thin parts of the corticalis and thick parts of the trabecular bone structure, absorb the bite impulses from the bone structures better than the mandible (31).

The average amount of jaw reduction during seven years of wearing complete dentures was less than 1/10 of the jaw reduction within the first year of complete denture wearing (35).

Investigations on bone mass resorption of the maxilla and mandible under the partial denture base revealed similar results.

In cases with Kennedy class I (bilateral edentulous areas located posterior to the natural teeth) changes on the alveolar ridge appear within one year of denture wearing (50). After two months of wearing partial removable dentures bone loss on the alveolar ridge amounted to 10% (50).

In comparison to alveolar ridge resorption in complete denture wearers (mucosa support), alveolar resorption under the partial denture base depends on the kind of denture support (tooth or mucosa support). Alveolar ridge resorption within one or two

months of wearing partial removable dentures confirms the clinical expectation of changes appearing faster on the edentulous ridge transimitting the bite forces as in complete dentures (mucosa support), (50). Therefore, in the edentulous regions transmission of the bite forces through the natural teeth, with the help of the rests and retainers (tooth and mucosa support), resorptive changes are not so (50).

Bone measuring techniques for the assessment of alveolar ridge changes

While a large number of methods for assessment of the amount of bone loss have been proposed, such as absorptiometry (32, 55-58), quantitative computed tomography (59-61) and neutron activation analysis (62, 63) they are very expensive and demand expensive equipment. One of the simplest methods for dental evaluation of mandibular bone loss is intraoral microdensitometry (64, 65), using a dental periapical or panoramic radiograph.

Linear measurements are often used in dental panoramic radiography to assess bone quality and to detect signs of resorption and osteoporosis (66--69).

Conclusion

Evaluation of edentulous alveolar ridge status is very important during the process of fabricating removable dentures, for the dentist as well as for the denture wearer.

Early diagnosis of bone structure changes in the upper and lower jaw can result in the of the resorption process in the skeleton.