CONVENTIONAL AND ADVANCED TECHNIQUES IN PROSTHODONTIC PRESERVATION AND SURGICAL MANAGEMENT OF RESIDUAL ALVEOLAR RIDGE – A REVIEW

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SUMMARY

Prevention of alveolar bone loss and maintenance of alveolar bone structure are mandatory for long-term stability of conventional or implant-supported complete dentures. Extraction of teeth may result in 40% to 60% alveolar bone loss in a period of two to three years. Several conditions, including aging, facial lines, unaesthetic dental restorations and loss of vertical dimension, are often accelerated by premature loss of facial bone. Bone maintenance is the procedure of preserving bone after tooth loss. Every attempt should be made at the time of tooth loss to preserve the height and width of the jawbone.

An unsatisfactory ridge morphology may result from periodontal disease, trauma or endodontic complications. Consideration must be given, during tooth extraction, to the final shape of the alveolar ridge and overlying soft tissue and to the optimal esthetic and functional result of the final tooth replacement. Soft and hard tissue complications can lead to unsatisfactory results for the patient, including unacceptable tooth morphology, poor phonetics and lack of confidence in denture stability. These problems may be prevented at the diagnosis and consultation stage.

This review mainly includes various conventional and advanced prosthodontic and surgical techniques to enhance the residual alveolar ridge preservation

Key words: Distraction Osteogenesis, Osteotome Technique, Bone Morphogenic Protein, Block Autogenous Graft.

INTRODUCTION

Bone is a specialized connective tissue that together with cartilage, makes up the skeleton. These tissues serve three functions: Mechanical support and site of muscle attachment for locomotion, Protection of vital organs and bone marrow. A metabolic reserve of ions for the entire organism, especially calcium and phosphate.

The fundamental constituents are the cells and a calcified extra cellular matrix. The later is particularly abundant and is composed of collagen fibers and a ground substance rich in glycosaminoglycans. The osteoblasts and osteoclasts have evolved to regulate the growth and turnover of bone and mediate ion fluxes between the bone and the blood. The osteoclasts solubilise the mineralized organic matrix, and the osteoblasts are capable of forming bone and synthesizing the various structural proteins and growth factors1. Except during growth, a balance between bone resorption and formation is maintained. The activities of the bone formation and resorbing cells are regulated by local and systemic humoral factors, such as parathyroid hormones, cytokines,1,25, dihydroxy cholecalciferol (Vit D) and the eicosanoids. Any dysfunction of either the local or systemic regulatory system will lead to pathological changes in the rate of bone formation or resorption and ultimately clinical disease of the skeleton. The resorptive changes in the mandible and the maxilla occur in different directions: In the maxilla a
centripetal resorption occurs, while in the mandible a centrifugal resorption takes place. The result is a discrepancy in the intermaxillary relation. The counterclockwise autorotation of the edentulous mandible is well known. The result is a reduction of facial height and a secondary prognathism, although the mechanisms of resorption after tooth extraction are well known; there are a lot of intraindividual and interindividual differences. Therefore it is necessary to carry out precise clinical, radiographic, or computed tomographic measurements to determine height and width of remaining bone and to give information about possible treatment strategies.

Clinical investigation and model analysis\(^2\); Clinical investigation is carried out to record the remaining teeth, the space between the jaws, occlusion, and articulation. By measuring the thickness of the mucosa with a graduated probe, first information about the transverse bone extent can be gained. By indicating points for measurement on the cast model, mucosal thickness can be recorded in the area of interest within the alveolar process and the vestibulooral bone quantity can be documented. By placing the cast models into an articulator, the models provide evaluation of the relation of the mandible to the maxilla. The amount of bone to be augmented can be estimated. Furthermore, surgical and prosthodontic treatment can be planned. Especially in partially edentulous jaws, the necessity of augmenting procedures has to be evaluated.

The panoramic radiograph\(^3\) gives a good overview of the relevant structures in the maxillary and mandibular jaws, ie., the location of the mandibular nerve canal and the outline of the maxillary sinus floor and nasal cavity.

The mandibular occlusal radiographs may give an idea about bone width. In the maxilla, however, the bone width cannot be easily assessed on conventional radiographs.

Tomography;\(^4\) To gain information about ridge width and height, conventional tomography can be applied. Scanora\(^5\) (Soredex, Orion) is one of these multimodal radiography systems that utilizes the principles of narrow-beam radiography and spiral tomography. All imaging procedures are computer controlled and executed automatically. Blurred images, time-consuming procedures, and relatively high radiation exposure are considered to be disadvantages of the tomography technique.

Computed tomography;\(^4\) Resorbed maxillae are still a challenge in implantology. To decide whether augmentation of the alveolar ridge is necessary, i.e., in case of atrophy or due to esthetic demands, or if implant placement in the local bone is possible, CT is a helpful device. Data from the direct axial CT layers can be transformed into secondary reformations to assess a coronal image of the alveolar ridge.

**ALVEOLAR BONE RESORPTION-Precautionary measures and maintenance**

Amount of Alveolar (Residual Ridge) Resorption after extraction of teeth depends\(^7\), in part, upon the extent of infection and the type of surgical operation performed. Although alveolar resorption is not under the control of the dentist, certain precautionary measures may be taken to minimize its extent.

Alveolar bone resorption may be of systemic origin (disease, faulty metabolism, or dietary deficiencies) or may be the result of trauma. The biologic factor may be disclosed through a complete and careful dental examination. The traumatic element may be reduced by a revision or modification of the mechanics of denture construction\(^8\).

**ORAL EXAMINATION**

A thorough examination of the edentulous patient includes history, psychologic investigation, visual and digital survey of the oral cavity, and complete mouth roentgenograms. Although systemic disease may influence the rate and determine the type of alveolar bone resorption, the patient’s history is often neglected.

**VITAL BONE CHANGES**

Vital changes in the bone are caused by interplay of destruction and formation of bone. The osteoblasts and the osteoclasts are the cells which participate in bone equilibrium. During growth and development, formation exceeds destruction.

A balance is maintained in the healthy adult, and in old age, the osteoclastic element is in ascendance. We might conclude then that the most constant systemic factor of bone loss is the aging process.

**DIETARY FACTORS**

Protein is necessary to build and maintain tissue and to supply energy. Aged persons need more than the minimum amount of protein for the maintenance of tissue health. Carbohydrates (starches and sugars) provide the chief source of energy. They are related only indirectly to bone resorption through association with diabetes and by substitution for more favorable foods. Fats are organic substances that yield heat and energy and only secondarily build or repair tissue.

Calcium salts (calcium carbonate and calcium phosphate) form the rigid supporting structure of bones. Phosphorus in the form of calcium and magnesium...
phosphates, gives hardness to bone. Abnormalities of calcium phosphorous elements of the blood stream may be associated with alveolar resorption or rarefaction.

The body requires 0.7 gm of calcium per day, which can be obtained from 1 quart of milk. Other sources of calcium are dairy products, fruits and vegetables like oranges, spinach, carrots and lettuce. The phosphorus requirement is 1.5 to 3 gm daily, dependent upon the form. These requirements may be filled by dry beans, milk, leafy vegetables, and carrots. Since about 70 per cent of the magnesium in the body is in bone tissue, the structure of bone is dependent upon this mineral. It is not a dietary problem, however, since it is contained in nearly all foods.

In addition to proteins, carbohydrates, fats, and minerals, the diet must contain vitamins for development, growth, and function of the body. Deficiency of vitamin A may result in poor development of calcification of the bone. However, it would seem to have no direct relation to the prosthodontist’s problem. Deficiencies of vitamin B complex are related to bone resorption only so far as they may affect the general health of the individual. Lack of vitamin C causes decalcification of bone has been held responsible for diffuse alveolar atrophy. Deficiencies of vitamin D disturb the calcium-phosphorus balance and promote bone resorption. Edentulous patients should follow a prescribed dietary regimen. This diet should be low in carbohydrate and high in protein intake. The diet should include at least a quart of milk or substitute dairy products daily, vegetables, fruits, and a multiple vitamin supplement.

ROENTGENOGRAPHIC EXAMINATION

Roentgenograms aid in predicting the rapidity of bone destruction and the probable prognosis of the dentures. A healthy and thoroughly healed alveolar process presents the following picture; Underlying the mucosa is a layer of wear-resistant compact bone of varying thickness. Beneath this compact layer are bars, plates, or tubules of bone of varying thickness and length. The spaces between the trabeculae communicate throughout the spongy bone. The bony trabeculae of the alveolar process are vertical to the stress forces, and this formation affords maximum resistance to masticatory effort. The rapidity of bone destruction is in inverse proportion to the density of the alveolar support.

AMOUNT AND FREQUENCY OF STRESS

Numerous investigators have stated that under the most favorable ridge conditions, patients can tolerate only one-eighth of the masticatory pressure on dentures as compared to their natural dentition. Although the total amount of the necessary masticatory stress cannot be diminished the unit work load may be lessened by increasing tissue coverage and decreasing the length and width of the occlusal table. Full advantage should be taken of hard compact bone such as the palate and the mylohyoid and external oblique ridges (palatal relief is not indicated unless a maxillary torus is present). Posterior teeth that have been narrowed in both dimensions will more easily penetrate food, and the cusp form is superior to the flat occlusal type for the same reasons.

The frequency of the stress application modifies the reaction of alveolar bone to external forces. Constant pressure on bone causes resorption, while intermittent forces favor bone formation. Since recurrent forces over short intervals of time have essentially the same resorbing effect as constant pressure, a rest period between meals is beneficial. For this reason, the patient should be warned that gum chewing is a destructive habit to the bone. Bruxism is an expression of nervous tension which manifests itself in gnashing, grinding, or clamping of the teeth while the patient is asleep or awake. Since most denture patients do grind their teeth in sleep, the dentures should not be worn during that period. Thus, the supporting structures are afforded the rest period potential to the maintenance of alveolar bone. Grinding of the teeth while awake may be a habit of tension, it may also be caused by a lack of interocclusal distance.

DIRECTION OF FORCE

Histologically, the trabeculation of the denture-bearing bone is arranged so that it will tolerate considerable force in the direction of the long axis of the teeth or at right angles to the base and horizontal forces should be avoided. The principal concern should be in the pattern and position of the posterior teeth.

There are two mandibular movements associated with mastication: A closing or cutting movement and a lateral or grinding movement. A sharp cusp will penetrate the bolus of food with less force than a flat occlusal form. However, a law of physics explains that forces applied to an incline plane produces a resultant force or vector, perpendicular, or at right angles to the plane. Applying this principle to occlusal form, the resultant force of the steep inclines of high cusps would produce a lateral force which might cause alveolar resorption. Certainly a compromise is indicated. A low cusp inclination in a narrow buccolingual width provides a comparatively sharp cusp with more favorable bone direction. Horizontal forces are further mini-
mized by placing the teeth as far lingually as possible without causing tongue interference or restriction.

**STRESS CONTROL**

Wolff’s law postulates that all changes in the function of bone are attended by definite alterations in its internal structure. Forces within the physiologic limits of bone are beneficial in their massaging effect. On the other hand, increased or sustained pressure, through its disturbance to the circulatory system produces bone resorption. The amount and frequency of stress and its distribution and direction are important factors in treatment planning.

**STRESS DISTRIBUTION**

Stress distribution favorable to healthy alveolar bone maintenance is dependent principally upon bilateral balanced occlusion. Balanced occlusion is that arrangement of the teeth which will permit the necessary mandibular movements without tending to dislodge the denture or traumatize the supporting structures.

The degenerative denture ridge is the scourge of prosthodontists. To successfully construct dentures on a degenerated denture ridge requires all of the skill and imagination possible. The complexity of the problem is enhanced when such patients are elderly and suffer, as they frequently do from degenerative diseases that lower host resistance.

**PREPARATION OF THE MOUTH**

Patients with degenerative denture ridges need careful oral health restoration before construction begins; a denture is doomed to failure if the prosthodontist too quickly starts making impressions. Any systemic illness that is contributing to degenerate the bone condition must be corrected or stabilized. This will often take weeks or months of medical care. In cases where only limited help can be rendered, the patient must be carefully counseled as to the effect this will have on dental health. One of the most neglected facets of treatment in degenerative denture ridge patients is the prescribing of the diet. We should no longer rely on the patient’s judgment for following standard written diets.

Individual dietary counseling should be given stressing the importance of the diet and the reason it must be followed. Dietary customs, habits, ethnic choices, cast, and ease of preparation too often dictate the patient’s selection of food. Oral surgical procedure is often necessary and can be of great benefit to a degenerated denture ridge. Particularly, it can help eliminate the undesirable undercuts or reduce the bony spines in a knife-edge ridge. The use of mucosal grafts can be beneficial. A totally resorbed ridge can be helped by extension of the borders, as described by Heartwell. The use of soft conditioning material to rejuvenate the tissue-bearing area has been well established. Many tissues, such as hyper-trophied tissue, treated previously by surgery, can now be reconditioned by the judicious use of this material.

**MASTICATORY APPARATUS THERAPY**

Older edentulous patients frequently suffer from problems involving the temporomandibular joints and imbalance with spasms of the muscles of mastication. These conditions should be treated, alleviated, and corrected if possible before jaw recordings are attempted and new dentures constructed. Fortunately, this can accompany the tissue treatment. When these problems exist, the old dentures are duplicated. The duplicated dentures are then lined with soft resin for impression purposes. The soft-lined dentures are then articulated with a face-bow and centric relation records. The upper denture is converted via a laboratory duplicator to a self-curing resin base. The occlusal corrections are made with an acceptable vertical dimension. The dentures are ground-in to a balanced occlusion.

When the occlusion is less than acceptable, the lower denture is removed from the cast and the lining removed. The lower denture is positioned into centric occlusion against the upper denture and luted to it with sticky wax. The lower cast is lubricated. Soft lining resin is placed on the basal surface of the lower denture, the articulator is closed to a predetermined vertical dimension, and the resin is allowed to cure. The sticky wax is removed, the occlusion is checked, and minor imperfections are eliminated. By this means, the old lower denture, which has often moved forward into a prognathic relation with collapsed vertical dimension, can be corrected. In so doing, we have supported the mandible and maxillae and established a good centric occlusion and occlusal vertical dimension. We have relieved the strain on the musculature and the temporomandibular joints.

**PREPARATORY DENTURES**

When the old dentures do not possess any of the desirable or convertible factors needed, they cannot be used. “Preparatory dentures” should then be made. Pounds excellent technique has been well explained, its use in many patients with the above mentioned problems has proved very helpful. Perhaps its greatest use is in meno-pausal and postmenopausal women. These women with degenerated denture ridges usually are conscious of esthetics and phonetics. It is impossible to predict whether their high demands for service to restore their “youth” can be met. The preparatory
denture is the only route to take. It leaves both patient and doctor satisfied even if the attempt is not successful.

**SELECTION OF THE DENTURE BASE**

For degenerated denture ridge patients, there are three types of denture bases. The resin base, the cast metal base and the processed resilient, lined denture base. An aid in selection of the best denture base or combination of bases for patients with degenerative denture ridge is shown in table 1.

**TREATMENT MODALITIES FOR COMPROMISED BONE QUANTITY**

**Augmentation Techniques**

If the local bone volume is too small, grafting procedures have to be considered to increase the bone quantity prior to implant placement. To increase the success rate in the augmented maxilla, modified insertion techniques such as the osteotome technique can be recommended.

**Zygoma implants**

For rehabilitation of the posterior maxilla without augmentation, a new implant system has been introduced recently. It allows for placement of implants in the zygomatic bone. The abutment is thereby placed in the region of the second premolar. In combination with four anterior implants, prosthesis can then be attached. Indications for this procedure are patients with tumors and those having extreme resorption of their posterior maxillae, especially in individuals where bone grafts are not possible or have already failed.

**Surgical Techniques**

Four categories of “site development” will be addressed, making the discussion relevant to the management of the elderly and/or osteoporotic patient where possible:

- Ridge retention procedures at the time of tooth extraction
- Techniques to manage-existing deficiencies in ridge width
- Techniques to manage existing deficiencies in ridge height
- Techniques to manage existing deficiencies in bone quality, (i.e., sites with low bone density)

**Ridge retention procedures**

This approach seems highly appropriate especially where there has already bone loss of buccal and/or lingual/palatal cortical plate(s) of bone, or where esthetics and/or final bone volume are critical.

BIOOSS is generally held to be osteoconductive at best and is very slowly resorbed. If ridge retention were to be employed in a diagnosed osteoporotic patient a better choice of graft may be one that contains growth factors such as bone morphogenetic proteins (BMP), insulin-like growth factors, and/or platelet-derived growth factors, all known to stimulate local bone formation in animal models and humans. It is speculated that ridge retention procedures may be appropriate at the time of tooth extraction in elderly and/or

**TABLE 1: TYPE OF DEGENERATIVE DENTURE RIDGE**

<table>
<thead>
<tr>
<th>Type of tissue</th>
<th>Severe Undercuts</th>
<th>Mild Undercuts</th>
<th>V-shaped</th>
<th>Knuckle shaped</th>
<th>Flat ridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yielding tissue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxilla</td>
<td>A-R*</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>AL</td>
</tr>
<tr>
<td>Mandible</td>
<td>A</td>
<td>AL</td>
<td>A</td>
<td>AL</td>
<td>AL</td>
</tr>
<tr>
<td>Unyielding tissue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxilla</td>
<td>A-R</td>
<td>A</td>
<td>AL</td>
<td>AL</td>
<td>AL</td>
</tr>
<tr>
<td>Mandible</td>
<td>A</td>
<td>A</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Delicate tissue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxilla</td>
<td>A-R</td>
<td>A</td>
<td>A-R+</td>
<td>A</td>
<td>AL</td>
</tr>
<tr>
<td>Mandible</td>
<td>R</td>
<td>R</td>
<td>A-R</td>
<td>R</td>
<td>R</td>
</tr>
</tbody>
</table>

* KEY A. Acrylic Resin. G, Cast Gold Base.
AL, Cast Aluminum Base. R, Processed Resilient Base
A-R, Acrylic Resin Base with Processed Resilient Liner undercuts Only
A-R+, Acrylic Resin Base with Processed Resilient Liner on Sharp Spines
osteoporotic patients in sites where implants may later be placed. Because of the poor bone quality likely to exist in these patients, osteoinductive bone graft materials may be preferable.

Existing deficiencies in ridge width

The next category of site development is that dealing with deficiencies of ridge width, (i.e., less than 4 mm) in established edentulous sites. Although the majority may be unsuitable for the elderly and/or osteoporotic patient, a variety of surgical techniques has been proposed, including:

- Distraction osteogenesis vertical and/or horizontal
- Ridge-splitting techniques
- Block autogenous grafts
- Definitive ridge augmentation via guided bone regeneration16
- Narrow-diameter implants

The following techniques may be used in dealing with existing inadequate alveolar ridge height:

- Distraction osteogenesis
- Block autogenous grafts
- Vertical augmentation during initial implant
- Site healing
- Nerve repositioning, posterior mandible
- Caldwell-Luc sinus elevation
- Ostotome-mediated sinus elevation, simultaneous or separate
- Short implants
- Combinations of the above

Managing low bone density

Low bone density, a situation likely to exist in the elderly and/or osteoporotic patient. In situations where thin cortical bone surrounds low-density trabecular bone success with endosseous dental implants will most certainly be compromised.

Following are some hypothetical ways of dealing with this clinical problem for which there are some relevant data:

- Longer first-stage healing intervals
- Implants coated with osteoinductive factors
- Pharmacologic management
- Appropriate implant surface geometries.

CONCLUSION

The current advances in the studies of oral and maxillofacial tissue reconstruction have led to significant understanding about tissue regeneration in terminally differentiated cells, such as osteoblasts and osteoclasts, and extra cellular matrix substrata. The effect of each of these essential components on tooth socket healing has been investigated extensively but no effective therapeutic regime allowing regeneration of the residual ridge yet exists.

Further molecular biologic advancement in this field may lead to the regeneration and maintenance of the alveolar bone of residual ridges quicker osseo integration of implants and structural and functional healing of large orofacial bone defects.

REFERENCES

1 Roberts WE et al: bone physiology; evaluation of bone metabolism, J Am Dent Assoc1991; 122: 59