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Residual Ridge Resorption A Challenge To Conquer: A Review

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Abstract:
Background: *The residual ridge resorption is a term used to describe the continuing bone loss that takes place in the alveolar bone of maxilla and mandible. The factors affecting ridge resorption play a very vital role in the treatment planning of the patients with long standing edentulism. Mandible is more affected with RRR as compared to maxilla. Our article describes all the aspects of RRR in detail. The consequences that the dentist faces while restoring the missing structures of the oral cavity. The knowledge of pathology and pathophysiology helps in understanding the reason for the etiology that leads to RRR to a step by step approach to the prosthetic management of RRR.*
Conclusion: *The application of the basic concepts and the advances made in the basic sciences will help to keep this trust in the hands of the dental profession. As prosthodontists, we need to perform the most meticulous and intelligent prosthodontic care of the patient within our capabilities*
Key Word*: Bone, maxilla, mandible, resorption, osteoclasts, dentures.*

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I. Definition:

According to GPT-9, Residual ridge resorption is a term used for the diminishing quantity and quality of the residual ridge after the teeth are extracted.[1]

II. Introduction:

Bone is a dynamic, mineralized, vital tissue which undergoes continuous resorption and formation throughout the life. The bones that constitute the maxillofacial complex are unique in their structure and relation. The jaw bones and the temporomandibular joints are subjected to a variety of continuous stresses and strains arising out of physiologic activities such as mastication.[2] The process of skeletal change is known as bone remodelling, which both protects the structural integrity of the skeletal system and metabolically contributes to the body's balance of calcium and phosphorus. Remodelling entails the resorption of old or damaged bone, followed by the deposition of new bone material. The duration, magnitude, and rate of forces applied to the bone dictate the way in which the integrity of the bone is altered. There are primarily 2 cells that are responsible for both the resorption and deposition phases of bone remodelling: osteoclasts and osteoblasts; however, osteocytes have a role in this process as well. The activity of these cells, particularly the osteoclasts, are influenced directly or indirectly by hormonal signals. This interaction between bone remodelling cells and hormones creates the opportunity for a multitude of pathophysiological consequences.[3,4]

The success of the complete denture relies on the fulfilment of the three basic properties which are retention, stability, and support. Mandibular dentures usually faced more difficulties in achieving these three properties than maxillary dentures,[5] because, the mandible ridge has a lesser residual ridge for retention and support[6] and has greater resorption rate than the maxilla. According to some studies by Atwood and Tallgren show that mandibular bone resorption is four times greater than in the maxilla.[7,8] The size of the residual ridge is reduced most rapidly in the first 6 months, but the bone resorption activity continues throughout life at a slower rate, resulting in removal of a large amount of jaw structure. Residual ridge reduction is one of the main causes of loss of denture stability and retention especially in mandibular complete dentures.

III. Consequences of Residual Ridge Resorption:

The following consequences provides a serious problems to the clinicians on how to provide adequate support, stability and retention of the denture.

1. Apparent loss of sulcus width and depth

2. Displacement of the muscle attachment closer to the crest of the residual ridge.
3. Loss of vertical dimension of occlusion.
4. Reduction of lower face height.
5. Anterior rotation of the mandible.
6. Increase in relative prognathism.
7. Changes in inter-alveolar ridge relationship.
8. Morphological changes such as sharp, spiny, uneven residual ridges.
9. Location of the mental foramina close to the crest of the mandibular residual ridge.
10. Resorption of the mandibular canal wall and exposure of the mandibular nerve.

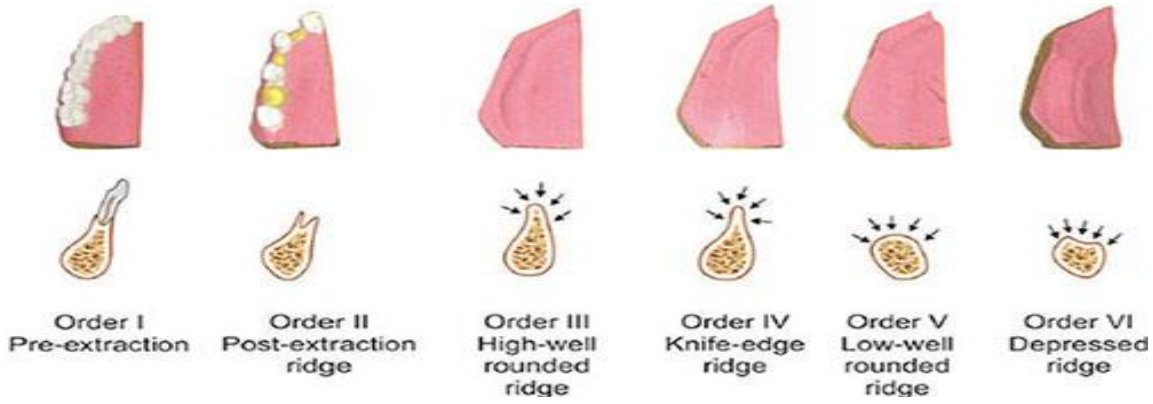
IV. Gross Pathology:

The primary structural change in the reduction of residual ridges is the loss of bone or reduction in the size of the bony ridge under mucoperiosteum. The rate of reduction and the total amount of bone removed in this disease vary from individual to individual, within the same individual at different times, and even at the same 3 time in different parts of the ridge.[9]

In order to provide a simplified method for categorizing the most common residual ridge configurations, a system of six orders of RR form has been described by Atwood in 1963.

A. Atwood classified residual ridge resorption into:

Order 1: pre-extraction
Order 2: post-extraction
Order 3: high, well-rounded
Order 4: knife-edged
Order 5: low, well rounded
Order 6: depressed



B. Neil classified residual ridge resorption in relation with the floor of the mouth and mylohyoid ridge:

Class 1: 0.5inch space exists between mylohyoid ridge and the floor of the mouth.
Class 2: Less than 0.5inch space exists between mylohyoid ridge and the floor of the mouth.
Class 3: the mylohyoid muscle is at the same level as the mylohyoid ridge.

C. Branemark classified residual ridge resorption depending on bone quality and quantity:

i) Bone quantity

Class A- Most utmost of the alveolar bone is present.
Class B- Moderate residual ridge resorption occurs.
Class C- Advanced residual ridge resorption occurs.
Class D- Moderate resorption of the basal bone occurs.
Class E- Extreme resorption of the basal bone occurs.

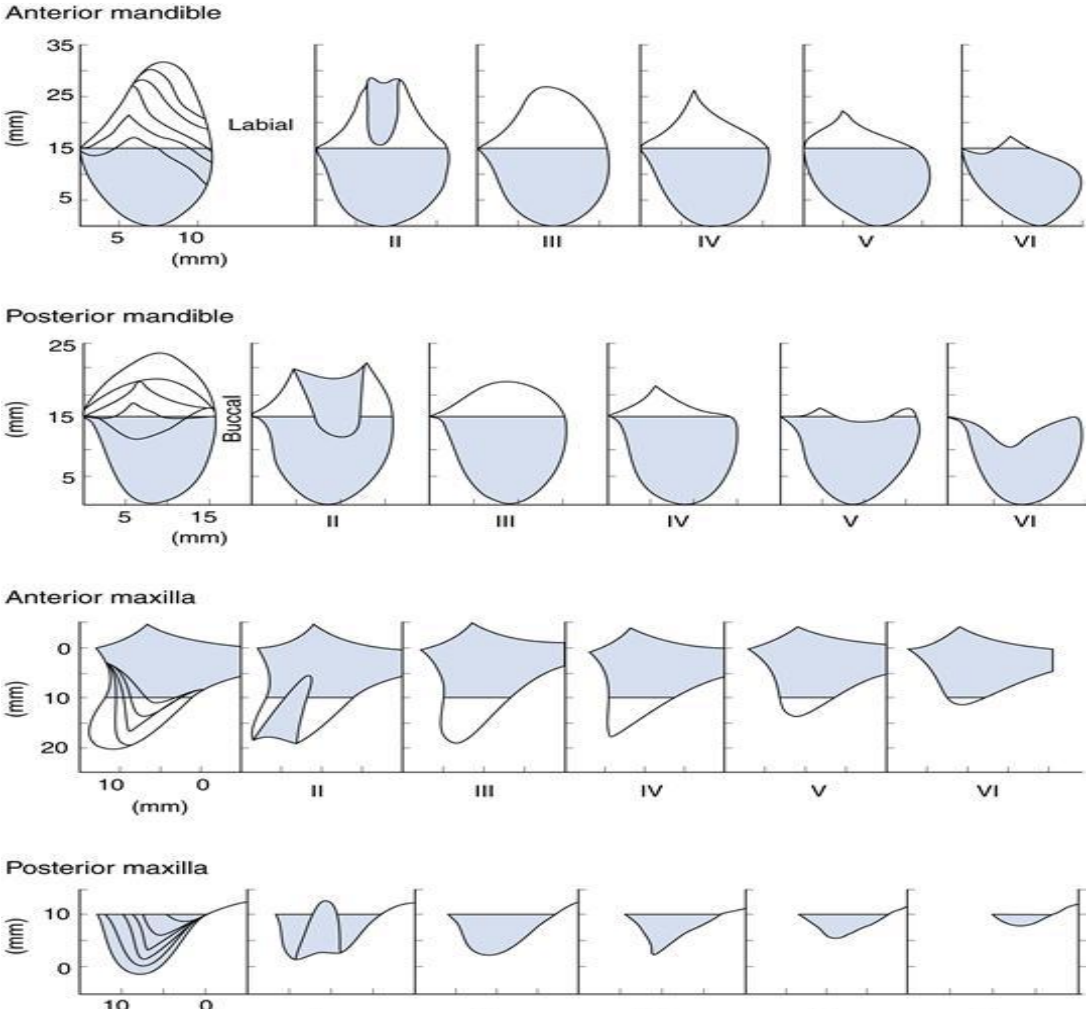
ii) Bone quality

Class 1- Nearly the whole jaw is formed of homogenous compact bone.
Class 2- a thick layer of compact bone encompasses a core of dense trabecular bone.
Class 3- a thin layer of compact bone surrounds a core of dense trabecular bone.
Class 4- a thin layer of compact bone surrounds a core of low-density trabecular bone.

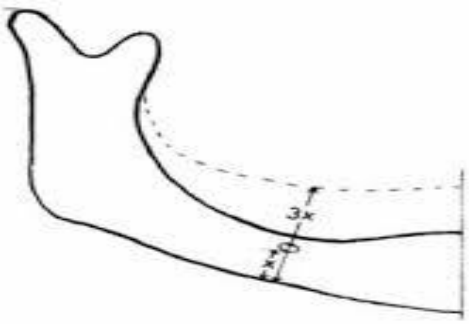
D. Cawood and Hawell classify the residual ridge to basic six classes:

Class I - dentate.
Class II -immediately post extraction.
Class III- well-rounded ridge form, adequate in height and width.

Class IV - knife-edge ridge form, adequate in height and inadequate in width.
Class V flat ridge form, inadequate in height and width.
Class VI - depressed ridge form, with some basilar loss evident.



E. Wical and Swoope have affirmed the relationship of the foramen to the inferior border of the mandible remains relatively constant in spite of increasing age or resorption of the alveolar process above the foramen and classifies residual ridge as:
CLASS I: Up to one third of the original vertical height lost.
CLASS II: From one third to two thirds of the vertical height resorbed.
CLASS III: Two thirds or more of the mandibular height lost



V. Microscopic Pathology:

The primary structural change in the reduction of residual ridges is the loss of bone or reduction in the size of the bony 2 ridge under mucoperiosteum . Numerous Longitudinal cephalometric studies have provided excellent visualization of the gross patterns of the bone loss. The The primary structural change in the reduction of residual ridges is the loss of bone or reduction in the size of the bony 2 ridge under mucoperiosteum . Numerous Longitudinal cephalometric studies have provided excellent visualization of the gross patterns of the bone loss. The Bone resorption is the process by which osteoclasts break down the tissue in bones and release the minerals, resulting in a transfer of calcium from bone tissue to the blood. Osteoclasts are multi-nucleated cells that contain numerous mitochondria and lysosomes and it generally present on the outer layer of the bone, just beneath the periosteum. The hallmark of the resorbing surface is the appearance of scalloped erosion, called Howship's or resorption lacuna[10]. Attachment of the osteoclast to the osteon begins the process. The osteoclast then induces an enfolding of its cell membrane and secretes collagenase and other enzymes important in the resorption process. High levels of calcium, magnesium, phosphate and products of collagen will be released into the extracellular fluid as the osteoclasts tunnel into the mineralized bone. Osteoclasts are prominent in the tissue destruction found in psoriatic arthritis and rheumatologic disorders.[11]

VI. Pathophysiology:

RRR is a localized pathologic loss of bone that is not built back by simply removing the causative factors. It has been shown that remodelling takes place in 3 dimensions such that certain portions of bone become narrower to the extent that all existing cortical bone in that area is removed by external osteoclastic activity and is replaced by a new cortical layer that is formed by simultaneous endosteal bone formation. The amount of bone loss may be greater than the original thickness of the cortical bone. This mean that, in such patients, new bone is laid down internally while resorption occurs externally. The bone remodelling process does not always work with equal success is shown in the many patients in whom residual ridge crest has no cortical layer. This process of external resorption and endosteal deposition is not unique to RRR, for it is similar to one phase of bone growth as described by Enlow.[12]

This narrowing of a portion of a bone is achieved by external rcsorption. Such external resorption does not occur without endosteal deposition. If no new bone were laid downendosteally, the cortex would become progressively thinner until it completely disappears. The structural product of this inward growth is called "endosteal bone" and is characterized either by a convoluted whorled appearance (when growth occurs into a trabecular area) or by a zone of even, regular, uninterrupted circumferential lamellae (when bone is laid down in layers on the endosteal side of smooth cortical bone). In each instance, the configuration of the new bone is dependent upon the configuration of the bony surfaces on which the deposition occurs This narrowing of a portion of a bone is achieved by external rcsorption. Such external resorption does not occur without endosteal deposition. If no new bone

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VII. Pathogenesis:

RRR is chronic, progressive, cumulative and irreversible. Autonomous regrowth has not be reported. The annual increments of bone loss have a cumulative effect leaving less and less residual ridge.

RRR is chronic, progressive, cumulative and irreversible. Autonomous regrowth has not be reported. The annual increments of bone loss have a cumulative effect leaving less and less residual ridge. In general, the rate of RRR varies between different individuals. An interesting history of one patient shows a rapid resorption rate in the early months in both the upper and lower anterior ridge height. Whereas, the upper ridge showed no measurable change after the first 3 years, the lower ridges showed a continuing RRR at a steady rate (0.4 mm. per year) over 15 year period. The vertical bone loss of the anterior part of the ridge in 19 years was 3.mm. in the maxillae and 14.5mm in the mandible.[13] The reduction of residual ridges seems to be potentially unlimited. RRR can go below mucobuccal fold, the muscle attachments, the genial tubercles, the mylohyoid ridge, and the level of periapical bone.

VIII. Changes in the maxilla and mandible:

The maxillary teeth are generally directed downward and outward, so bone reduction generally is upward and inward. As the maxilla becomes smaller in all dimensions, the denture bearing area (basal seat) decreases. The bone of the maxillae resorbs primarily from the occlusal surface and from the buccal and labial surfaces,hence looses height and maxillary arch becomes narrower from side to side and shorter anteroposteriorly. On the contrary, The anterior mandibular teeth generally incline upward and forward to the occlusal plane, whereas the posterior teeth are either vertical or incline slightly lingually. The mandibular ridge resorbs primarily from the occlusal surface. The mandibular arch appears to become wider, while the maxillary arch becomes narrower. Thus, RRR is centripetal in maxilla and centrifugal in mandible.

IX. Etiology of RRR:

It is entirely possible that RRR is a multifactorial disease and that the rate of RRR depends not on one single factor but on the concurrence of two or more factors, which may be called cofactors. Some years ago, it was suggested that, for convenience, possible factors could be divided into four categories: anatomic, metabolic, functional, and prosthetic It is entirely possible that RRR is a multifactorial disease and that the rate of RRR depends not on one single factor but on the concurrence of two or more factors, which may be called cofactors. It was suggested that, for convenience, the possible factors could be divided into four categories: anatomic, metabolic, functional, and prosthetic.

A. Anatomic factors:

It includes size and shape of the ridge, type of bone, type of mucoperiosteum, bone quality and form before extraction. It is postulated that RRR is directly proportional to anatomic factors. RRR varies with quality and quantity of the bone of residual ridge. If there is more bone there will be more resorption. On theoretic grounds, the denser the bone, the slower the rate of resorption because there is more bone to be resorbed per unit of time.

B. Metabolic factors:

They include such things as age, sex, hormonal imbalance, osteoporosis. In older individuals bone resorption is more as compared to bone formation. Residual ridge resorption changes with localized or systemic bone resorptive factors and also affected by certain bone formation factors. It includes vitamin D supplements and calcium osteoporosis preservation of bone. On the crest of residual ridge, there is localized loss of bone. So, local bone resorbing factors are very important. Bone metabolism depends on cell metabolism of osteoblast and osteoclast.[15,16]

Inflammatory mediators like prostaglandins are considered as playing an important role in increasing the rate of residual ridge resorption. For bone cell metabolism, vitamin B complex is necessary. Bone undergoes corresponding changes through its own specific metabolism.[17]

C. Functional Factors:

Bone becomes stronger when it is constantly used during physical activity. The bone that is disused will tend to subside. When limited force is applied to living bone, it leads to some unknown mechanism of remodeling of bone through the periodontal ligament.[17] When force within physiologic limits is applied to bone that force brings about the remodeling of bone through a combination of bone resorption and formation. Some authors postulate that residual ridge resorption is an inevitable 'disuse atrophy'. Disuse atrophy is directly proportional to the extent of disuse. It does not result from the direct loss of non functional bone, but the lack of replacement of bone needed for function. The reaction of bone to pressure can cause both apposition and resorption. Another factor is "Damping Effect/ Energy Absorption". Residual ridge resorption is inversly proportional to damping effect. Maxillary bone (RR) is frequently broader, flatter and more cancellous than its mandibular counterpart. So it is ideally constructed for the absorption and dissipation of energy.[18]

D. Prosthetic Factors:

1. Excessive stress resulting from artificial environment:

Human tissues have not evolved in nature to accept ranges of artificial things and the denture acts as an artificial entity.

2. Abuse of tissues from lack of rest:

Abused tissues are always manifested with a slung, glistering surface. Bone is moldable. It can tolerate masticatory forces within the limits of physiologic tolerance but exceeding that it causes damaging forces which will result in resorption of the alveolar bone and alteration in tissue form .

3. Long continued use of ill fitting dentures:

Ill fitting dentures may be due to :

- Long use
- Loss of bone
- Incorrect occlusion
- Incorrect jaw relation
- Under Extended Dentures: Lead to less retentive dentures and increase load per unit area. Common sites are: Lingual flange,Buccal shelf area, Retromylohyoid area and Retromolar pad area.

4. Faulty improper procedures employing compression forces:

Selection of trays is important because if the tray selected is too large, it will distort the tissues around the borders of the impression, away from the tissues. If it is too small, the border tissues will collapse inward onto the residual ridge. This will reduce the support of the lips by the denture flange. In order to avoid distortion of the mucosa and ridge area which may be under considerable pressure otherwise. The use of minimal and selective pressure impression techniques should be implicated.

5. Error in relating maxilla to the cranial landmarks (orientation relation):

The plane of the maxilla should be oriented to the facial reference line (Camper's plane or ala tragus line). If not, may cause instability of denture leading to resorption.

6. Lack of freeway space due to increased vertical dimension of occlusion:

Freeway space is present in the teeth in the physiologic rest position. It is normally 2-8mm but in complete dentures it is around 2mm. At times, due to lack of freeway space the bone resorbs because of increased vertical height in an attempt to create the space.

7. Incorrect Centric relation record:

If the Centric relation is not recorded properly, the mandibular teeth will not occlude properly with those on the maxillary arch. This proper occlusion is essential to the health of bony support. Otherwise, during eccentric movement, it causes pressure on bone due to failure of denture stability. Hence resorption of base occurs.

8. Faults in selection and placement of posterior teeth:

The selection of proper tooth size is based on :

- Capacity of ridges to receive and resist the forces of mastication.
- Space available for the teeth.
- When the ridge is weak, resorbed and covered by only lining mucosa, then the use of the posterior teeth should be smaller. This will limit the occlusal surface, which in turn will minimize the forces directed to such a ridge.

9. If occlusal corrections are not done:

The errors which may be caused due to processing techniques if not corrected causes premature contacts resulting in increased stress. Selective grinding should be done to minimize lateral stress and resulting tissue trauma.

10. Overclosure

The loss of proper vertical dimension after the insertion of complete dentures results in the triggering of a cyclic series of events detrimental to the health of the residual alveolar ridge.Overclosure causes the mandible to be moved or rotated in an upward and forward direction causing occlusal disharmony and excessive trauma to anterior region.

X. Methods of evaluation of bone loss in RRR:

- Radiographs:
  - Cephalometrics .
  - Panoramic.
- Tetracycline labeling
- Mercury porosimetry
- Anatomic studies
- Remount jig procedure

XI. Management of RRR:

Prosthodontic principles to reduce residual ridge resorption include:

1. Systemic evaluation:

Any systemic condition that can contribute to the degeneration of the bone condition should be corrected and stabilized, for e.g.: osteoporosis, hyperparathyroidism, diabetes mellitus, etc. Any dental treatment should follow only after the condition is under control and the patient is fit for treatment. In cases where limited help can be given, the patient should be counseled about its effect on dental health.

2. Diet:

Patients with bone disease need a diet high in proteins, vitamins and mineral content. Should reduce or stop intake of refined carbohydrates, white flour, and white sugar.In all dietary prescriptions , the consistency of food prescribed must take into account the patients ability to masticate.

3. Tissue treatment therapy:

Soft conditioning materials can be used to rejuvenate the tissue-bearing area. Hypertrophied tissues, previously treated by surgery, can be reconditioned by using this material.

4. Pre prosthetic surgery:

A. Ridge Corrective surgery:

- Soft tissue deformities

i) Labial frenectomy.
ii) Lingual frenectomy.
iii) High buccal frenal attachments.
iv) Hyperplasia of soft tissues.

- Bony deformities

i) Sharp irregular ridge.
ii) Alveoloplasty.
iii) Alveolectomy.
iv) Excision of tori and genial tubercles.

B. Ridge extension surgery/vestibuloplasty:

i) Labial.
ii) Lingual.
iii) High mental foramen.
iv) Zygomaticoplasty.
v) Tuberoplasty.

C. Ridge augmentation.

5. Prosthetic management:

A. Impression techniques.

i) The main aim of the impression procedure is to gain maximum area of coverage. For e.g., in mandibular ridge, obtaining a fairly long retromylohyoid flange helps to achieve a better border seal and retention. Selection of proper trays and the correct impression procedure is very essential for an accurate impression. In patients with severely resorbed ridges, lack of ideal amount of supporting structures decreases support and the encroachment of the surrounding mobile tissues onto the denture border reduces both stability and retention.

ii) Selective pressure technique: This technique is most widely advocated to manage RRR. It makes it possible to confine the forces acting on the denture to the stress bearing areas. This helps in better withstanding the mechanical forces induced by denture wearing. Winkler describes a technique which uses tissue conditioners. An over extended primary impression of alginate is made. Occlusal wax rims are constructed and the borders are adjusted so that the lingual flange and sublingual crescent area are in harmony with the resting and acting phases of the floor of the mouth by an open and closed – mouth technique. 3 applications of conditioning material are used – each application approximately 3-10 minutes. The third and final wash is made with a light bodied material. This technique results in the impression that has tissue placing effect with relatively thick, buccal, lingual and sublingual crescent area borders. Miller used mouth-temperature waxes instead of tissue conditioners.

iii) Special techniques, to determine accurately the denture border extension have been evolved-

Fish recommended a technique where, sublingual fold space, extending from premolar to premolar region on each side was recorded. This horizontal flange acted as 'tongue rest' thereby increasing the stability and support.

Bernard Levin suggests making primary impression with alginate (25% less water). Special tray should be wider and heavier in the buccal shelf area. While border molding tongue should be allowed to extend fully. Patient should make only moderate movements. Final impression should be completed with Elastomeric impression material and exaggerated tongue movements should be made.

iv) Mucodynamic technique: A highly viscous thermoplastic reversible impression material is placed in the custom tray, then carefully adapted to the residual ridge and held with light and uniform pressure while the functional movements are made. As soon as the entire surface is smooth and the buccal and lingual borders are molded to the outer circumference without any folds, the impression is complete. It is intended to integrate the changes in the shape of the vestibules when functional movements are made.

B. Selection of denture bases:

For degenerative ridge patients there are three types of denture bases:

i) Methyl methacrylate resin denture bases- These are the standard bases normally used. These bases are quickly and easily processed and are dimensionally stable. But in a short time the base appears to soften and change color, and is not strong.

ii) Cast metal bases- Main advantage is the great accuracy of fit to the tissues by surface tension, than acrylic denture bases.They maybe of gold, chromium cobalt or aluminium. These are processed resilient , lined denture bases.Its greatest advantage is its cushioning effect on the mucosa and its ability to distort and spring back.

Indications:

- Patients with severely undercut ridges, but for whom surgery is contraindicated.
- Patients with parafunctional mandibular movement habits.
- Patients with flat ridge and delicate tissues.

C. Teeth selection and arrangement:

Teeth can be selected according to their form and size:

i) Anatomic or cuspal teeth

ii) Semi anatomic teeth

iii) Non anatomic or zero degree teeth.

Control of horizontal force by buccolingual cusp height reduction acc. to residual ridge shape and inter arch space. Functional balance by favorable tooth to ridge crest position. Cutting and shearing efficiency. Anterior clearance of teeth during mastication. Minimal occlusal stop areas for reduced pressure during function. Teeth should be placed in neutral zone to create co ordination between the primary and secondary masticatory organs. Non anatomic teeth have known to cause fewer denture sore spots and lesser ridge resorption. Semi anatomic reverse curve posterior teeth favor the lower ridge. Anatomic posterior teeth cause more denture soreness and ridge resorption. Few studies state that anatomic posterior occlusion favors lower dentures and non anatomic posterior teeth favor upper denture.

D. Implant supported prosthesis:

The various problems associated with RRR and stability of removable soft tissue borne dentures have aroused interest in dental implantology to provide stable mechanical support to the dental prosthesis.

Advantages offered by implant supported prosthesis:

i) Maintenance of alveolar bone

ii) Maintenance of occlusal vertical dimension.

iii) Height of alveolar bone is found to be maintained as long as the implant remains healthy.

iv) Improved psychological health.

v) Regained proprioception and increased trabeculation and density of bone.

vi) Increased stability, retention and phonetics.

vii) Maintenance of structure and function of muscles of mastication and facial expression.

Prosthodontic classification of implants.

- FP-1 : Fixed prosthesis replacing only crown.
- FP-2 : Fixed prosthesis replacing crown and portion of root.
- FP-3 : Fixed prosthesis replacing missing crowns and portion of the edentulous site.
- RP-4 : Removable prosthesis : overdenture supported by implants.
- RP-5 : Removable prosthesis : overdenture supported by both soft tissue and implant.

The success of implant supported prosthesis, however, depends on the technical knowledge and mastery of the implantologist, and is directly related to the selection of patient and implant, surgical technique, follow up procedures and patient acceptability.

XII. Summary:

Residual ridge resorption is a chronic, progressive, irreversible, and disabling disease , of multifactorial origin. Much is known about its pathology and pathophysiology, but a lot remains to know about its pathogenesis, epidemiology and etiology. RRR requires a multiple approach for diagnosis and treatment planning. The cause must be detected, by the aid of a physician, and then eliminated or stabilized before dentures are constructed. Construction of a stable functioning denture and a regular follow up treatment can help in the restoration of function, and thus, the restoration of the physical and mental vitality of the patient.

XIII. Conclusion:

The preservation of supporting tissues is a sacred trust that cannot be ignored. The application of the basic concepts and the advances made in the basic sciences will help to keep this trust in the hands of the dental profession. As prosthodontists, we need to perform the most meticulous and intelligent prosthodontic care of the patient within our capabilities.

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