Changes in the form and structure of residual ridges: An Overview

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Introduction:
Residual ridge resorption is a term used to describe the shape of the clinical alveolar ridge formed Post dental extraction after healing of bone and soft tissues. Residual alveolar ridge consists of the denture bearing mucosa, submucosa and periosteum, and underlying bone. After tooth extraction, a cascade of inflammatory reactions is activated and the extraction socket is temporarily closed by blood clot. Epithelial tissue begins its proliferation and migration within the first week and disrupted tissue integrity is restored. The most striking feature of extraction wound healing is that even after healing of the wounds, the residual alveolar ridge undergoes a life long catabolic remodelling\textsuperscript{1,2}. 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 considerable quantity of loss of jaw structure. This unique phenomenon has been described as Residual ridge resorption (RRR). The rate of RRR is different in different persons and as different sites in the same person. The mechanical aspect of bone remodelling is usually associated with Wolff’s law of Bone Transformation (1892) which states that “every change in the form and function of bone, or of their function alone is followed by certain definite changes in their internal architecture and equally definite alteration in their accordance with mathematical laws”. which simply means that bone remodels in response to the forces applied However, the mere reference to Wolf’s law in relation to bone resorption is an inadequate explanation of this complex physiologic process.

Consequences of RRR includes the following
Apparent loss of sulcus width and depth, Displacement of muscle attachment closer to crest of the ridge, loss of vertical dimension, reduction of lower facial height, anterior rotation of mandible, increase in prognathism, changes in interalveolar ridge relationship, morphological changes such as sharp, spiny,uneven residual ridges, resorption of mandibular canal and exposure of nerve and location of mental foramina close to the crest of residual ridge\textsuperscript{1,2}. 

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Accepted: 04/04/2018
Mechanism of Bone resorption

The organic components of intracellular substance are removed by proteolytic action of osteoclasts. The inorganic salts are dissolved by chelating action of osteoclasts as resorption takes place the osteocytes released may revert back to osteoblasts or osteoclasts depending upon physiologic and pathologic demands.

Pathology of RRR:

Gross pathology the basic structural change in RRR is a reduction in the size of bony ridge under the mucoperiosteum. It is primarily a localised loss of bone structure. In some situations, this loss of bone may leave the overlying mucoperiosteum excessive and redundant. In order to provide a simplified method for categorizing the most common residual ridge configurations, a system of six orders of RRR has been described.

It is clear that RRR does not stop with the residual ridge, but may well go below where the apices of teeth are situated, sometimes leaving only a thin cortical plate on the inferior border of mandible or virtually no maxillary alveolar process on the upper jaw. Sometimes a knife edge may be masked by redundant or inflamed soft tissue, which can be detected by palpation or by lateral cephalometric radiographs.

Microscopic pathology: Microscopic pathology indicate the activity of osteoclasts. Studies have revealed evidence of osteoclastic activity on the external surface of the crest of the residual alveolar ridge. The scalloped margins of Howships lacunae sometimes contains visible osteoclasts and total absence of periosteal lamellar bone on the crest of the residual alveolar ridge. Presence of cortical layer consisting of an endosteal type of bone, or medullary type of trabecular bone without cortical layer have alteration around varying degrees of inflammatory cells, including lymphocytes and plasma cells, have also been noticed.

Classifications

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 floor of the mouth and mylohyoid ridge
   - Class 1
     0.5 inch space exists between mylohyoid ridge and the floor of the mouth.
   - Class 2
     Less than 0.5 inch 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 Classification
Bone quality:
Class 1
Almost the entire jaw is composed of homogenous compact bone.
Class 2
A thick layer of compact bone surrounds 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) American college of Prosthodontics classification based on bone height (mandible only)
Criteria for selection of ACP classification:
All prosthodontic procedures should be preceded by the patient’s consent. Informed consent is obtained after the patient has been informed of the indications for the procedures, goals of treatment, the known benefits and risks of the procedures, the factors that may affect the known risks and complications, the treatment options, the need for active maintenance by the patient, the need for future replacements and revisions, and the favourable outcome.

Class 1: Residual bone height of 21 mm or greater measured at the least vertical height.
Class 2: Residual bone height of 16 – 20 mm.
Class 3: Residual alveolar height of 11 – 15 mm.
Class 4: Residual alveolar height of 10 mm or less.

Fig-8: Progressive resorption of maxillary and mandibular ridges makes the maxilla narrower and mandible wider. The lines A and B represent the centers of the ridges. Notice how the distance between them becomes greater as the maxilla and mandible resorb.

Fig-9: Lateral cephalometric radiograph

Fig-10: Panoramic radiograph

Fig-11: a) Food pyramid for adults b) Food pyramid for older individuals above 70+ adults
ACP Classification of edentulous ridge

Residual Ridge Morphology: Maxilla Only

Residual ridge morphology is the most objective criterion for the maxilla, because measurement of the maxillary residual bone height by radiography is not reliable. The classification system continues on a logical progression, describing the effects of residual ridge morphology and the influence of musculature on a maxillary denture.

Type A (most favourable)
- Anterior labial and posterior buccal vestibular depth that resists vertical and horizontal movement of the denture base.
- Palatal morphology resists vertical and horizontal movement of the denture base.
- Sufficient tuberosity definition to resist vertical and horizontal movement of the denture base.
- Hamular notch is well defined to establish the posterior extension of the denture base.
- Absence of tori or exostoses.

Type B
- Loss of posterior buccal vestibule.
- Palatal vault morphology resists vertical and horizontal movement of the denture base.
- Tuberosity and hamular notch are poorly defined, compromising delineation of the posterior extension of the denture base.
- Hyperplastic, mobile anterior ridge offers minimum (support and stability) of the denture base.

Type C
- Loss of anterior labial vestibule.
- Palatal vault morphology offers minimal resistance to vertical and horizontal movement of the denture base.
- Maxillary palatal tori and/or lateral exostoses with bony undercuts that do not affect the posterior extension of the denture base.
- Hyperplastic, mobile anterior ridge offers minimum (support and stability) of the denture base.
- Reduction of the post malar space by the coronoid process during mandibular opening and/or excursive movements.

Changes in Maxilla and Mandible

Maxilla:

Maxillary teeth are generally directed downward and outward. So bone reduction generally is upward and inward. Outer cortical plate is thinner than inner cortical plate resorption from outer tends to be greater and more rapid as maxilla becomes smaller in dimensions, the denture bearing area decreases. The bone of maxilla resorbs primarily from occlusal surface and from buccal and labial surfaces.
**Mandible:**

The anterior mandible teeth generally incline upward and forward to the occlusal plane where as posterior teeth are either vertical or incline slightly lingually. The mandible ridge resorbs primarily from occlusal plane because the mandible is wider at inferior border than residual alveolar ridge in the posterior part of mouth. Resorption effect moves left and right ridges progressively farther apart. The mandible arch appears to be wider while the maxillary arch becomes narrower. Thus RRR is centripetal in Maxilla and centrifugal in Mandible.

**Pathophysiology**

It is a normal function of bone to undergo constant remodeling throughout life through process of bone resorption and bone formation. Osteoporosis is a condition in which resorption exceeds formation. RRR is a localized pathologic loss of bone that is not built back by simply removing the causative factors. Physiologic process of internal bone deposition will be continued even in conditions of external pathologic osteoclastic activity. It has been shown that remodelling takes place in 3 dimensions such that certain portions of bone becomes narrower to the extent that all existing cortical bone in the area is removed by external osteoclastic activity and is replaced by new cortical layer that is formed by endosteal formation.

**Pathogenesis**

Order- I Preextraction : The tooth is in its socket with thin labial and lingual cortical plates merged with the lamina dura.

Order-II Postextraction : The healing period includes clot formation and organization, filling of socket with trabecular bone and epithelisation over socket site. The edges of residual ridge are still sharp.

Order-III High, well rounded : The cortical plates are rounded off by external osteoclastic resorption, narrowing of crest of ridge begins and remodeling of the internal trabecular structure takes place.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Bone mineral density (BMD)</th>
<th>Osteopenia%</th>
<th>Osteoporosis%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-60(75)</td>
<td>14(18.6%)</td>
<td>33(43%)</td>
<td>28(38.6%)</td>
</tr>
<tr>
<td>61-80(105)</td>
<td>4(3.7%)</td>
<td>71(67%)</td>
<td>30(33.5%)</td>
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<tr>
<td>Parity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0(20)</td>
<td>4(20%)</td>
<td>11(55%)</td>
<td>5(25%)</td>
</tr>
<tr>
<td>1-3(106)</td>
<td>25(24%)</td>
<td>66(62%)</td>
<td>15(14%)</td>
</tr>
<tr>
<td>&gt;3(54)</td>
<td>8(15%)</td>
<td>40(74%)</td>
<td>6(11%)</td>
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<tr>
<td>Socioeconomic condition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High(10)</td>
<td>2(20%)</td>
<td>6(60%)</td>
<td>2(20%)</td>
</tr>
<tr>
<td>Middle(65)</td>
<td>18(28%)</td>
<td>39(60%)</td>
<td>8(12%)</td>
</tr>
<tr>
<td>Low(105)</td>
<td>13(12%)</td>
<td>67(64%)</td>
<td>20(19%)</td>
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<tr>
<td>Rural/Urban</td>
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<td></td>
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<tr>
<td>Rural(64)</td>
<td>15(24%)</td>
<td>42(65%)</td>
<td>7(11%)</td>
</tr>
<tr>
<td>Urban(116)</td>
<td>30(27%)</td>
<td>71(61%)</td>
<td>14(12%)</td>
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<tr>
<td>BMI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25(108)</td>
<td>12(10%)</td>
<td>82(76%)</td>
<td>16(15%)</td>
</tr>
<tr>
<td>&gt;25(72)</td>
<td>18(25%)</td>
<td>36(50%)</td>
<td>8(11%)</td>
</tr>
</tbody>
</table>

(Table-2) : Age related changes of bone mineral density in conditions of Osteopenia and osteoporosis
Order-IV Knife edge: Sharp narrowing of labi-lingual diameter of the crest of the ridge with a compensatory internal remodeling leading to a sharp crest of the ridge.

Order-V Low well rounded: Progressive labi-lingual narrowing of knife edge ridge leads to widely rounded and lower residual ridge.

Order-VI Depressed: Eventually further progression of resorption leads to a flat, depressed ridge. (Fig-1)

RRR is chronic, progressive, irreversible and cumulative usually, RRR proceeds slowly over a long period of time flowing from one stage imperceptibly to the next. Autonomous regrowth has not been reported. Annual increments of bone loss have a cumulative effect leaving less and less residual ridge.

Tallgren, Atwood and Coy12,16 found mean ratio of anterior maxillary to anterior mandibular RRR was 1:4. Therefore, on an average, RRR is greater in the mandible than in the maxilla.

**Etiology**

RRR is a multi-factorial biomechanical disease that results from a combination of Anatomic, Mechanical and Metabolic determinants5,6,8.

**Factors affecting residual ridge Resorption**

**Anatomical factors**

The anatomical factors of bone is related to quality of bone.

<table>
<thead>
<tr>
<th>Etiologic factor</th>
<th>Correlation with RRR</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anatomic Factor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Mandible         | 4x more RRR than maxilla | * Tallgren  
* Atwood and Coy |
| Short and square face | Increased RRR | * Tallgren |
| Large alveo-lar process | Increased RRR | * Wictorin |
| Density of Alveolar bone | No correlation of RRR with bone density | * Wilson  
* Atwood and Coy |
| Labial Alveo-loplasty | Increased RRR | * Gazabatt et al  
* Wictorin |

(Table-1) : Various etiological factors and their correlation with bone

**Quality of bone:**

According to previous studies, the denser the bone, the slower the rate of resorption because there is more bone to be resorbed per unit of time.

**Metabolic factors**

It is further postulated that RRR varies directly with certain systemic or localized bone resorptive factors and inversely with certain bone formation factors.

**Local bone resorbing factors include**

Prostaglandins (PGE2) – Prostaglandins has been demonstrated to mediate bone resorption invitro and invivo. PG is not stored in cells in their final form but is quickly released in response to mechanical, physiologic and pathologic stimuli.

Its half life is short (less than 1 min) and its various effects are limited only to adjacent cells, therefore it is important that PG acts as local hormone.

The findings indicate that PG have an important biologic role in the pathophysiology of localized bone resorption in the oral cavity.

Heparin – co-factor in bone resorption secreted by mast cells.

**Others include**

Trauma (especially under ill-fitting denture), which leads to increased or decreased vascularity and changes in oxygen tension. Indeed, some studies have revealed that O2 availability plays a vital role in Endothelial cell differentiation from a variety of stem cell sources, including hESCs, human endothelial progenitor cells, human bone marrow CD133+ cells.

**Systemic factors**

Most dentists consider alveolar bone resorption to be a local problem and systemic factors are considered to be of secondary importance.

But experimental studies and biologic sciences have shown that alveolar bone reduction is basically a systemic disease.

‘Residual Ridge Resorption’ which ATWOOD has termed as major oral disease may also be a common oral manifestations of systemic bone disease’. 

i) **Systemic factors may occur in 3 ways**

Bone loss due to decreased formation.
Bone loss due to increased resorption.
Bone loss due to unknown causes.
ii) Bone loss due to decreased formation

Patients with glucocorticoid therapy and it has detrimental effect on bone formation, turn over and integrity.

Glucocorticoids reduce absorption of Ca from the intestine.

iii) Bone loss due to increased resorption

Hypophosphatemia

It has direct effect of serum phosphorous on bone to enhance bone resorption. Hypophosphatemia enhances the synthesis of 1, 25-dihydroxycholecalciferol which is the active metabolite of vitamin D and stimulates bone resorption.

Parathyroid Hormones (PTH)

Parathyroid hormone indirectly stimulates osteoclasts in pathological state. A slight decrease in serum calcium concentration stimulates the Parathyroid gland to secrete PTH, which causes resorption.

Estrogen deficiencies

Cortical bone thickness is less in early surgical menopause patients. In case of normal menopause there is decrease in bone density. Estrogen appears to antagonize the effect of PTH on bone resorption. So, Estrogen deficiency would be expected to increase the sensitivity of bone to resorption.

Osteoporosis

Epidemiology occurrence in India

According to a study conducted by Yakub Sanga “Prevalence of osteoporosis in postmenopausal women and their risk factors in Indian prospects (A cohort study)

Osteoporosis is characterised by low bone mass and micro architectural deterioration of bone, which leads to increased fragility and risk of fracture.

2 forms:

- Type 1 (Post menopausal) affects women for decade or after menopause
- Type 2 (Senile or Idiopathic) Attacks males and females at any age for no reason.

RRR may be manifestation of Type 1 osteoporosis

Both cortical and trabecular bone are affected

Treatment:

- Estrogen replacement therapy
- Ca supplement
- Good nutrition and exercise
- Bisphosphonate therapy

Toshihiro Hirai showed that osteoporosis strongly affects reduction of the residual ridge in edentulous patients. This can be seen in radiographs as rarefactions in the skeleton. These are more common where heavy loads are present (e.g. in vertebral column, epiphyses of long bones, pelvis, the maxillae and fingers).

Mechanical factors

The reaction of bone to pressure is paradoxical which leads to apposition and resorption of bone. In the presence of teeth the pressure is directly in line with long axis of teeth there is apposition of bone. When the pressure, stress and tension is transmitted to avascular tissues in normal healthy individuals. When the pressure transmitted to vascular tissues mucoperiosteum leads to resorption.

Functional Factors

When considering the force, consider the amount of force, frequency, duration, direction, area over which force is distributed, and the damping effect of the underlying tissue. Woelfel in his study on a patient made maxillary denture of area 4.2 sq.in and 2.3 sq.in on mandible (ratio 1.8:1). If patient bites with a pressure of 501b, So pressure under maxillary denture is 12 lb/in2 and under mandibular denture is 21 lb/in2. So it can be said that there is more of mandibular ridge resorption than in the maxilla.

Prosthetic Factors

1. Excessive stress resulting from artificial environment:

Human tissues have not evolved in the nature to accept ranges of artificial things and denture acts as an artificial entity. Abuse of tissues from lack of rest. Abused tissues are always manifested with slung, glistening surface. Bone is moldable. It can tolerate masticatory forces with in the limits of physiologic tolerance but exceeding that it causes damaging forces which will result in resorption of alveolar bone alteration in tissue form.

2. Long continued use of ill fitting dentures:

In ill fitting dentures, there is an improper relation of the denture base to the supporting tissue. Ill fitting dentures can cause pressure and irritation to the tissues and can lead to bone resorption. Proper fitting dentures are essential to maintain the health of the underlying bone.

Prophylactic measures include proper hygiene, regular dental check-ups, and the use of pain-relief medications. In cases where resorption is severe, surgical interventions such as bone grafting or the use of bone stimulatory devices may be necessary. Regular monitoring of bone density is important to detect osteoporosis early and prevent fractures.
dentures may be due to Long use, Loss of bone, Incorrect occlusion, Incorrect jaw relation.

3. Under extended dentures:
   Lead to less retentive dentures and increase load per unit area common sites are
   - Lingual flange, Buccal shelf area, Retromylohyoid area, Retromolar pad.

4. Faulty improper procedures employing compression forces:
   Before impression procedures, care has to be taken on selection of trays, 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 on to the residual ridge this will reduce the support of the lips by denture flange. The use of minimal and selective pressure impression techniques should be implicated inorder to avoid distortion of the mucosa and ridge area which may be under considerable pressure otherwise.

5. Errors in relating maxilla to cranial landmarks (orientation relation):
   Maxillary can be related to intercondylar axis maxillary cast can be related to FH plane.
   **Advantage:**
   Semiadjustable articulators has adjustable intercondylar distance, condylar path can be matched with patient translatory movement is possible, occlusal plane is adjusted.

6. Lack of free way 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 4mm. At times, due to lack of freeway space during excursive movements the nature attains the free space in dentures by resorption of residual alveolar ridge.

7. Incorrect centric relation record:
   When denture is used if centric relation doesn't match the occlusal plane the usable dentures leads to resorption in mandibular area.

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 posterior teeth should be smaller. This will limit the occlusal surface, which inturn will minimise the forces directed to such a ridge.

9. If occlusal corrections are not done:
   Lingualised occlusion an alternative for occlusal adjustment in severe alveolar bone resorption in edentulous patients.

   **Advantages:**
   - Anatomic and non anatomic forms of teeth are retained.
   - Cusp form is more natural in appearance compared to non anatomic tooth form.
   - Bilateral mechanical balanced occlusion
   - Vertical forces are centralised on mandible teeth
   - Good penetration food bolus is possible

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

**Methods of evaluation of bone loss in RRR**
In cephalometric radiographs the interocclusal distance amount of resorption can be evaluated (Fig-9). Lateral cephalometric radiographs provide most accurate method of determining the amount of residual ridge and the rate of RRR over a period of time.

In panaromic radiographs the bone resorption can be evaluated by opg before the fabrication of dentures and after the follow up of 6 months after the dentures have fabricated.(Fig-10)

**Management**
Systemic evaluation, Diet, Tissue treatment therapy, Pre prosthetic surgery
Prosthetic management (Impression techniques, Denture base selection, Teeth selection and arrangement, Implant supported prosthesis)
Diet chart in geriatric patients:

Vitamin Recommended daily allowance Sources of vitamins

Thiamine 1 mg/day - Whole grain cereals, nuts, legumes, green leafy vegetables, organ meats, pork, liver, and eggs

Niacin 6.5–7.2 mg/day - Foods of animal origin

Riboflavin 1.2 mg/day - Flesh foods, poultry, dairy products, legumes, nuts, and green leafy vegetables

Pyridoxine 2 mg/day - Meat, fish, poultry, pulses, nuts, and wheat

Folic acid 200 μg/day - Leafy vegetables, fruits and yeasts, cereals, and pulses

Vitamin B12 2.4 μg/day - Liver, meat, egg, and milk are good sources

Vitamin C 40 mg/day - Fresh amla, citrus fruits, guava, banana, and certain vegetables like tomatoes

Vitamin A 600 mg/day - Fruits and vegetables green or deep yellow/orange in color, like green leafy vegetables, carrots, tomatoes, sweet potatoes, papaya, mango, etc.

Vitamin D 5 μg/day - Sun exposure, fortified dairy products (27).

Food pyramid for elderly patients

Systemic evaluation

Any systemic condition that can contribute to the degeneration of the bone condition should be corrected and stabilized.

e.g.: osteoporosis, hyperparathyroidism, diabetes mellitus.

Diet

Dietary guidelines for patients risk of losing bone

• Maintain a high quality Ca intake
• Consume about 6 ounces of protein
• Use small amounts of processed foods high in sodium.
• Obtain 4000I.U of vit-D daily.
• Less intake of caffeine.

Ca, phosphorous and albumin, copper are essential minerals for bone Matrix.

Tissue Treatment Therapy

Tissue conditioning materials can be used to rejuvenate the tissue-bearing area.

Hypertrophied tissues, previously treated by surgery, can be reconditioned by using tissue conditioners.

Prosthetic management

Impression technique

In patients with severely resorbed ridges the main aim of the impression procedure is to gain maximum area of coverage.

e.g: In mandibular ridge, obtaining a fairly long retromylohyoid flange helps to achieve a better border seal and retention.

Selective pressure technique

Masticatory load should be decided depending upon the forces on which maxillary load is applied.

Muco-dynamic technique

It is intended to integrate the changes in the shape of the vestibules when functional movements are made. As soon as the entire surface is smooth and the buccal and lingual borders are molded using highly viscous thermoplastic impression material.

According to a study conducted by Humaira Tanvier et al in this An Innovative Wire impression techniques for highly resorbed ridges in this study a customised orthodontic wire was used for fabrication of custom tray and a preliminary impression was made and after the primary cast was made border molding and secondary impressions were made and denture was fabricated for mandibular edentulous ridge.

Indications:

Patients with severely undercut ridges.

Patients with Parafunctional mandibular movement habits.

Patients with flat ridge and delicate tissues.

A study by Himanshi Aggarwal et al Lost salt technique for severely resorbed alveolar ridges: An innovative approach in this study dentures were fabricated using lost salt technique by making hollow dentures to reduce the weight of the dentures of severely resorbed ridges.

According to a study conducted by Nair.C et al presents a technique for making impressions of the resorbed and flabby mandible ridge using elastomeric materials and a modified custom tray.
**Technique:**

1. The mandibular primary impression is made with irreversible hydrocolloid in a stock tray modified with putty-consistency elastomeric impression material.

2. The primary cast is poured in Type III dental stone (Kalstone, Kalabhai Karson Pvt. Ltd., Mumbai, India), and a tray devoid of spacer or relief wax is fabricated over the primary cast using autopolymerizing resin (Rapid Repair, Dentsply India Pvt. Ltd., Noida, India).

3. After evaluation in the mouth, the custom tray is adjusted to be 2 mm short of the functional depth of the labial and lingual sulci.

4. The crest of the ridge is marked using an indelible pencil and is transferred to the tray via placement of the tray on the ridge.

5. A window is cut in the tray using a straight bur (HM 33T, Meisinger, Centennial, CO) outlining the marked area, corresponding to the crest of the ridge (Fig 1).

6. The tray is then seated onto the cast, and softened modelling wax (Y-Dents Modeling Wax, MDM Corporation, Delhi, India) is placed into the window, thereby replacing the eliminated acrylic resin, and shaped to form a handle.

7. Putty consistency elastomer (Affinis) and tray adhesive (Universal Tray Adhesive, Zhermack Clinical) on the borders and intaglio surface of the custom tray are placed on the tray. The tray is seated onto the ridge, and the labial and lingual borders are molded.

8. Areas of overextension indicated by exposure of the tray borders are corrected by removing the putty in the corresponding area and trimming the tray.

9. A second application of putty is made over the first, and the borders are molded again.

10. The borders of the impression are carefully re-examined for any over- or under-extensions and are corrected accordingly.

11. The borders of the impression are trimmed by 0.5 mm using a sintered diamond bur (Taper Round End, Fukuiken Saimeng LLC, Fukuiken, Japan) mounted in a micromotor handpiece.

12. The wax handle is removed, and the putty material over the window is cut out using a sharp Bard-Parker knife.

13. Light-body elastomeric impression material (Affinis) is loaded into the tray, which is then seated on the ridge. Additional light-body material is then expressed into the window. Lingual and facial borders are molded, ensuring the tray remains steady until the impression material sets.

14. Once set, the impression is removed, disinfected, and inspected. Beading and boxing is performed, and the impression is poured using Type III dental stone.

**Physiological impression technique for Residual ridge:**

1. A preliminary impression of the edentulous arch was made using McCord’s technique (3 parts impression compound +7 parts green stick compound in a metal stock tray).

2. The impression was refined using irreversible hydrocolloid i.e. alginate over existing mandibular impression.

3. The impression was poured using dental stone. The casts were retrieved and the spacer wax extending from left canine to right canine region was adapted.

4. A custom impression tray on the preliminary cast using self-cure acrylic resin was adapted.

5. Soften modelling plastic impression compound (green stick) was heated over the flame and was loaded over the anterior third of the intaglio surface of the special tray. The tray was tempered and seated over the denture bearing area, the labial and buccal borders were molded and the patient was asked to perform various tongue movements to mold the lingual flange.

6. The procedure was repeated for middle third, followed by posterior third of the impression tray on either side Simultaneously.

7. The wax spacer was removed.

8. The adhesive was applied on the impression and tray borders and was allowed to dry. The final wash impression was made with light body Poly Vinyl Siloxane impression material, by performing lip, cheek and tongue movements.

**Teeth selection and arrangement**

*Teeth can be selected according to their form and size:*

Anatomic or cuspal teeth
Semi anatomic teeth
Non anatomic or zero degree teeth

Relative to each other, the maxillary and mandibular residual ridges are known to be in a favorable position for normal arrangement of posterior teeth.

If the connecting line between the midridge line of the max. and mandibular residual ridges are at an angle of more than 80 degrees.

An angle less than 80 degrees necessitates a cross bite or reverse occlusion arrangement of posterior teeth (Fig11).

1) The following requirements have to be met during teeth arrangement:
   Stability of occlusion in centric relation.
   Balanced occlusion for eccentric contacts.
   Unlocking of the cusps mesiodistally to accommodate the settling of denture bases.
   Control of horizontal force by buccolingual cusp height reduction according to residual ridge shape and inter arch space.¹⁷

Overdentures
Overtdentures are designed to distribute the masticatory load between the edentulous ridge and the abutments. The overdenture transfers occlusal forces to the alveolar bone through the periodontal ligament of the retained tooth roots.

Proprioceptive feedback, from the periodontal ligament to the muscles of mastication, may act to prevent occlusal overload and thereby prevent bone resorption because of excessive forces. Crum and Rooney measured a mean vertical bone loss in the anterior of the mandible of 5.2mm after 5 years for immediate dentures compared with 0.6mm for immediate overdentures.

Frost’s Mechanostat theory
Accordingly, Frost described the hypothesis of “minimum effective strain” (MES), which predicts the time and the site of bone architecture changes, as a result of adaptation to mechanical loads (Fig-9). The MES describes the minimum effective signal of mechanical loads that convert their effect to bone architectural adaptation. Strains below the MES are not considered to produce adaptive bone modeling, whereas those above it change bone architecture, in order to reduce subsequent strains under loads, similar to or below the lower limit of the MES. If the strain is 0-50μ strains it leads to Acute disuse atrophy if it is 50-1500μ strains bone gets adapted to resorption and deposition if it is 1500-3000μ strains overload on bone occurs if it is 3000-10,000μ strains results in pathological overload leads to increased osteoclastic activity more than 10,000 leads to fracture of bone¹³.

Implant supported over dentures
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.

- Maintenance of alveolar bone.
- Maintenance of occlusal vertical dimension.
- Height of alveolar bone is found to be maintained as long as the implant remains healthy.
- Improved psychological health.
- Regained proprioception.
- Increased stability, retention and phonetics.
- Maintenance of structure and function of muscles of mastication and facial expression.
- Efficiency to take up stress and strain.

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 multiple approach for diagnosis and treatment planning. The cause must be detected by aid of a physician, and then eliminated or stabilised before dentures are constructed.

Conclusion
The preservation of supporting tissues is a sacred trust that cannot be ignored.

As Prosthodontists, we need to perform the most meticulous Prosthodontic care of the patient within our capabilities and then, it would not seem a nebulous hope that some day there will be control over residual ridge resorption.
References