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Management of compromised ridges in recent trends

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Abstract
Prosthodontic rehabilitation of patients with compromised edentulous ridges using conventional methods poses significant clinical challenges due to factors such as severe ridge resorption, flabby tissues, bony undercuts, shallow vestibules, and unfavorable jaw relations. These anatomical limitations adversely affect the retention, stability, and support of complete dentures, making it challenging to meet both functional and aesthetic expectations. To overcome these issues, modifications in treatment protocols are essential. Techniques such as selective pressure or mucostatic impressions help accurately record the tissues. In contrast, special approaches like the window technique for flabby ridges and the neutral zone technique for severely resorbed ridges enhance denture stability and muscle harmony. Pre-prosthetic surgeries, such as alveoloplasty or vestibuloplasty, may be indicated to improve the denture-bearing area. Additional measures like the use of soft liners, tissue conditioners, denture adhesives, and reinforced bases can further improve comfort and function. Each case demands individualized planning based on ridge anatomy, tissue health, and patient expectations. Thorough patient education and regular follow-up are vital for long-term success. This comprehensive approach allows clinicians to address common compromised situations encountered in daily practice effectively, leading to improved patient satisfaction even with conventional complete denture therapy.

Keywords: Edentulous ridges, complete dentures, ridge resorption, flabby ridge

Introduction
Complete denture therapy remains one of the most established methods for rehabilitating edentulous patients. Its success depends on careful treatment planning based on thorough patient history and clinical examination. Following Devan's principles, the focus should be on preserving existing oral structures rather than merely replacing the missing ones [1]. A major challenge in denture fabrication is ridge atrophy, which can lead to a sunken facial appearance, unstable and non-retentive dentures, and associated discomfort [2]. Residual ridge resorption is a progressive biophysical process that occurs rapidly in the first year after tooth extraction and continues more slowly thereafter [3, 4].

Compromised ridges, commonly encountered in clinical practice, may be classified as atrophic ridges, flabby ridges, and knife-edge ridges [2]. Each presents unique challenges in achieving denture stability and retention. The impression technique plays a key role in managing such cases. The aim is to achieve maximum coverage with minimal pressure using techniques like selective pressure or mucostatic impressions [1]. Extending the retromylohyoid flange improves the border seal and enhances retention, especially in mandibular dentures. Patient education is equally important training patients to maintain a forward tongue posture, resting on the lower anterior ridge, helps stabilize the denture. These combined strategies significantly improve the function, comfort, and long-term success of conventional complete dentures [5].

Compromised ridges may be broadly classified as
Residual ridge morphology greatly influences the success of complete denture therapy. Certain altered forms atrophic, flabby, knife-edge, and abused ridges pose significant challenges to prosthodontic rehabilitation.

An atrophic ridge results from progressive alveolar bone resorption after tooth loss, particularly severe in the mandible. These ridges are characterized by reduced height and width, causing poor denture retention, stability, and esthetics due to increased inter-arch space. Management involves impression techniques that maximize tissue coverage and

evenly distribute loads. In advanced cases, pre-prosthetic surgical augmentation or grafting may be required [6].

A flabby ridge develops when bone is replaced by hypermobile fibrous tissue, most commonly in the anterior maxilla. Often associated with combination syndrome, it complicates impression making because distortion leads to unstable dentures. Special impression methods such as window or mesh trays with elastomeric materials help record tissue without displacement. Surgical excision or implant-retained prostheses are alternative solutions [7].

The knife-edge ridge is produced by disproportionate buccolingual resorption, leaving a thin, sharp bony crest, frequently in the mandibular anterior region. Dentures over such ridges cause pain and instability. Management includes ridge recontouring, implant-supported prostheses, or modified impression techniques to minimize trauma [8].

Abused ridges arise from prolonged or ill-fitting denture use. Trauma from over-extended flanges, faulty occlusion, or continuous wear leads to tissue changes such as epulis fissuratum, stomatitis, and hyperplasia. Treatment involves removing etiological factors, relining or replacing dentures, and using tissue conditioners for healing. Persistent lesions may require surgical excision before prosthetic rehabilitation[9]

Residual Ridge Resorption (RRR) is a chronic, progressive, and irreversible biological process that occurs following the extraction of natural teeth [10]. Once the alveolar bone loses its functional stimulation from the periodontal ligament due to tooth loss, it begins to undergo atrophic changes. This resorption is not a singular event but a continuous phenomenon that varies in rate and pattern among individuals [11]. Understanding the etiology and pattern of RRR is critical in prosthodontics, as it greatly influences the design and success of prosthetic rehabilitation [12].

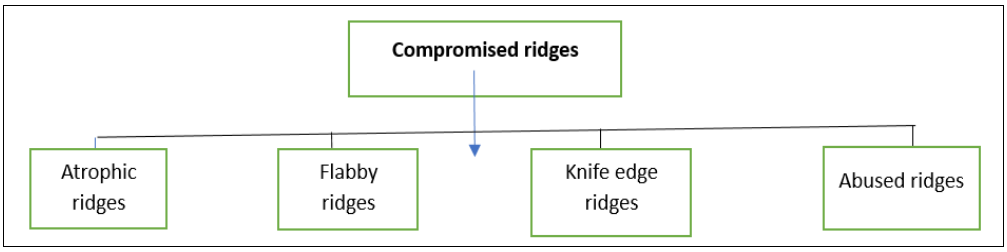

Fig 1: Compromised ridges classification diagram shown

Etiological Factors of RRR

1. Mechanical Factors

One of the primary contributors to RRR is mechanical stress. Ill-fitting or poorly designed complete dentures exert uneven pressure on the denture-bearing tissues, leading to localized bone loss. Dentures that lack proper support and stability tend to shift during function, causing microtrauma to the underlying bone and accelerating the resorption process. Excessive occlusal forces or parafunctional habits such as bruxism further contribute to the mechanical wear of the ridge [13].

2. Anatomical Influences

The morphology of the residual ridge, along with bone quality and density, plays a significant role in the rate of resorption. Patients with thin cortical plates and low-density trabecular bone are more prone to rapid bone loss. The initial shape of the ridge whether broad and well-rounded or narrow and knife-edged also determines how it resorbs over time [14].

3. Systemic Factors

Several systemic conditions affect bone metabolism and resorption:

- **Age:** Bone resorption increases with age due to reduced osteoblastic activity.
- **Gender:** Females, particularly post-menopausal women, experience accelerated bone loss due to estrogen deficiency.
- **Osteoporosis:** Systemic bone demineralization results in a weakened jawbone more susceptible to resorption.
- **Nutritional Deficiency:** Lack of calcium, vitamin D, and protein impairs bone remodeling and repair.

Hormonal Changes

Disorders involving parathyroid hormone or thyroid imbalance can disturb bone homeostasis [15].

4. Genetic Predisposition

Some individuals have a genetic tendency toward higher bone turnover rates or reduced bone mass, predisposing them to faster and more extensive resorption. Genetic expression of cytokines, hormones, and growth factors that regulate bone remodeling plays a role in this variability [16].

Pattern of Ridge Resorption

The pattern of resorption differs between the maxilla and mandible, which directly impacts the prosthetic plan.

- **Maxillary Ridge:** Resorption occurs in an upward and inward direction. This leads to a reduced arch width and height over time, often resulting in a constricted maxillary denture-bearing area. As the alveolar ridge moves toward the palate, support for the upper denture diminishes, leading to compromised stability and esthetics (e.g., sunken midface appearance).
- **Mandibular Ridge:** Resorption follows a downward and outward pattern. This broadens the mandibular arch but significantly reduces its vertical height, making it difficult to achieve adequate retention and support for the lower denture. As a result, mandibular dentures often become unstable and mobile [17].

This differential resorption alters the interarch relationship, often leading to an increased interarch space, loss of vertical dimension of occlusion, and sometimes a pseudo Class III jaw relation where the mandible appears to protrude due to maxillary collapse. These changes present complex challenges in denture fabrication, requiring careful occlusal planning, ridge-mapping, and sometimes surgical or implant intervention [18].

Conventional techniques

Effective impression making is critical in the prosthodontic management of compromised edentulous ridges. Traditional and advanced techniques aim to capture the oral tissues

accurately while preserving their health and ensuring optimal denture fit.

Selective Pressure Impression Technique involves selectively applying pressure to primary stress-bearing areas (e.g., buccal shelf, palate) while relieving non-stress-bearing areas (e.g., mid-palatal raphe, flabby tissues). This method improves support, distributes functional loads evenly, and minimizes tissue trauma, making it suitable for ridges with uneven resorption patterns.

Mucostatic Impressions are made with minimal or no pressure, capturing the soft tissues in a passive state. This technique is particularly useful for flabby or mobile ridges, as it avoids tissue distortion during impression making. Retention is achieved through intimate contact and capillary attraction between the denture base and mucosa [19].

Tissue Conditioners and Soft Liners are used to manage abused, inflamed, or atrophic ridges. These materials temporarily adapt to the mucosa, promote tissue healing, and improve the fit of existing dentures until definitive impressions can be made.

Modified Flange Design, especially in the mandibular arch, involves extending the denture into the retro mylohyoid space. This improves the border seal, enhances retention, and stabilizes the denture during function.

Recent technological advancements

These have significantly enhanced the precision and predictability of impression techniques, especially in patients with compromised ridges.

Digital intraoral scanners

Such as TRIOS (3Shape) and Medit i700 are increasingly being utilized for edentulous arches. Though historically challenging due to the absence of distinct anatomical landmarks and the compressibility of soft tissues, newer scanners incorporate improved image stitching algorithms, faster scanning speeds, and enhanced surface capture capabilities. These advancements now enable more accurate digital recording of mobile mucosa and flabby tissues, particularly when combined with auxiliary scanning aids or scanning sprays. However, achieving full functional impressions digitally still requires further development, particularly in capturing dynamic tissue behaviour.

CAD/CAM custom trays are another innovation that contributes to better outcomes. These trays are digitally designed based on intraoral or extraoral scan data and then fabricated using 3D printing. This approach allows precise customization of tray extensions, border relief areas, and material thickness. Clinicians can predetermine pressure zones and incorporate design modifications tailored to the anatomical features of the patient, reducing errors and chairside adjustments.

3D printed impression techniques extend beyond trays to include the fabrication of try-in bases and even final denture bases with exceptional detail and reproducibility. These methods use biocompatible printable resins that maintain dimensional stability, particularly useful for severely resorbed or irregular ridges.

Functional pressure mapping systems represent a breakthrough in impression accuracy. These systems utilize embedded sensors to record pressure distribution between the tray and oral tissues in real-time during impression making. This data guides the clinician in modifying impression techniques, identifying areas of excessive pressure, and ensuring even load distribution. Such objective feedback significantly improves prosthesis comfort, fit, and longevity, especially in cases with delicate or uneven ridge morphology.

Innovative Prosthesis Designs

Modern advancements in materials science and denture fabrication methods have transformed the clinical outcomes for patients with compromised ridges. These innovations enhance prosthesis comfort, fit, strength, and esthetics, even in challenging oral anatomies.

Lightweight Denture Base Materials

High-impact polymethyl methacrylate (PMMA) resins, enhanced with nano-fillers or glass fiber reinforcement, provide increased durability while reducing the weight of the prosthesis. In patients with severely resorbed ridges, minimizing denture weight reduces stress on fragile tissues, improving comfort and retention.

Injection Molding Techniques

Injection molding ensures even distribution of denture base resin into molds under pressure. This results in dentures with fewer internal voids, superior adaptation to tissue surfaces, and enhanced mechanical strength. These features are particularly beneficial for patients with thin mucosa or minimal ridge support.

Monolithic CAD/CAM Milled Dentures

Milled from pre-polymerized PMMA blocks, monolithic dentures exhibit minimal polymerization shrinkage, superior strength, and excellent surface finish. They offer a precise fit for patients with flat or knife-edge ridges, ensuring stable and comfortable wear.

3D Printed Dentures

Additive manufacturing allows quick production of customized dentures from digital designs. These dentures can be adapted to unique ridge morphologies, including asymmetries and irregular contours, and reduce laboratory turnaround time while ensuring consistency in quality.

Implant-Supported Solutions for Compromised Ridges

Dental implants have revolutionized prosthodontics by offering increased stability, retention, and patient satisfaction especially critical in cases of severe ridge resorption.

Mini and Narrow-Diameter Implants (MDIs and NDIs)

MDIs and NDIs are ideal when residual ridge width is limited. These implants can be placed with minimal invasive techniques and often avoid the need for grafting. They provide effective support for overdentures in elderly or medically compromised patients who may not tolerate extensive surgeries[20].

All-on-4 and Zygomatic Implants

The All-on-4 concept strategically places two anterior axial implants and two posterior tilted implants to support a full-arch fixed prosthesis, bypassing the need for ridge augmentation. In extremely atrophic maxillae, zygomatic implants anchor into the dense zygomatic bone, offering a predictable and stable solution without sinus lifting or bone grafting[21]

Patient-specific implants (PSIs)

PSIs and scaffolds provide effective solutions for compromised ridges. A randomized trial showed similar

outcomes between milled and 3D-printed PSIs[22], while CBCT-guided subperiosteal implants demonstrated long-term success[23]. Customized β-tricalcium phosphate scaffolds[24] and polycaprolactone scaffolds[25] enabled precise bone regeneration with reliable implant integration. These advances minimize grafting, improve precision, and enhance predictability in ridge-deficient cases.

Guided Surgery and Digital Planning

The use of Cone Beam Computed Tomography (CBCT) and intraoral scanning allows for precise virtual planning of implant placement. Surgical guides generated through CAD/CAM ensure exact positioning, reduce chair time, enhance esthetic results, and significantly minimize intra-operative complications. These protocols are invaluable when working in compromised anatomical regions.

Tissue Augmentation and Pre-Prosthetic Surgery

When prosthetic compensation alone is insufficient, surgical intervention can optimize the ridge for better support, retention, and esthetics.

Ridge Augmentation Techniques

Ridge augmentation through autogenous (patient's own bone), allograft (donor bone), xenograft, or synthetic substitutes helps rebuild lost bone volume. It can be done via onlay grafts, block grafts, or particulate grafts with membranes. This procedure improves support for both removable prostheses and implants.

PRF/PRP in Soft Tissue Enhancement

Platelet-rich fibrin (PRF) and platelet-rich plasma (PRP) are biologic preparations that promote soft tissue healing and angiogenesis. When applied during surgery or impression making, they enhance tissue thickness and resilience, leading to better denture bearing surfaces and fewer sore spots[11].

Vestibuloplasty

This surgical technique deepens the oral vestibule to increase denture-bearing area and expose more attached mucosa. It is especially effective in resorbed mandibular ridges where flange extension improves denture stability.

Removal of Tori and Undercuts

Bony prominences like palatal or mandibular tori and sharp undercuts can interfere with denture path of insertion and cause discomfort. Their removal helps in achieving better adaptation of the denture base and avoids denture fractures or ulcerations.

Patient Education and Functional Training

The long-term success of complete dentures in patients with compromised ridges relies heavily on patient cooperation, education, and neuromuscular adaptation.

Tongue Positioning

Correct tongue posture plays a critical role in mandibular denture retention. Training patients to keep the tongue tip forward, resting against the lower anterior ridge when the mouth is open, helps stabilize the lower denture and prevents dislodgement during speech and mastication.

Myofunctional Therapy

This therapy focuses on retraining the orofacial musculature. Exercises targeting lip seal, swallowing, tongue thrust correction, and speech articulation help improve muscular coordination, which is crucial for denture function and retention, especially in patients with neuromuscular deficits or post-surgical adaptation.

Maintenance Protocols

Educating patients on daily denture cleaning, handling, and storage helps prevent infections like denture stomatitis. Instruction on proper insertion and removal techniques, and the need for periodic relining as the ridge changes over time, ensures optimal prosthesis function.

Periodic Recall

Regular follow-up appointments are essential to assess soft tissue health, bone resorption, and denture condition. Adjustments, relining, or even refabrication may be necessary over time. Early intervention reduces complications such as ulceration, overloading, and ill-fit[5].

Conclusions

The management of compromised ridges in prosthodontics has evolved significantly with advancements in materials, techniques, and digital technologies. While traditional methods laid the foundation, recent trends such as digital impressions, CAD/CAM fabrication, implant support, and tissue engineering have vastly improved outcomes for patients with challenging ridge conditions. A customized, multidisciplinary approach combining surgical, prosthetic, and educational strategies is essential for long-term success. As the field continues to advance, prosthodontists must stay updated with these innovations to provide optimal care for patients with compromised ridges.

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