

1

Assessment of Edentulous Patients

Introduction

A critical and somewhat perplexing aspect of the management of the edentulous condition is the prediction of therapeutic outcomes and patient satisfaction. The most fundamental factor determining a precise prognosis is a thorough and accurate pretreatment examination [1–3]. Even though patients may receive the best therapy, the treatment will fail if underlying conditions remain undiagnosed.

This chapter reviews a method for the pretreatment evaluation of edentulous patients and existing prostheses to arrive at a sound understanding of factors that will affect therapy and the probability that the treatment's objective can be achieved. Using appropriate assessment tools, the practitioner can better determine if the patient's expectations can be met.

Much has been published in the dental literature regarding anatomic [4, 5] and psychological variations [6, 7] in edentulous patients. Before considering management of these challenging patients, objectives include thorough examination, diagnosis of existing conditions, consideration of available therapy, and assessment of the prognosis of each available treatment option [1, 2]. Both subjective and objective patient factors must be taken into consideration [1]. A rational stepwise pretreatment protocol will help to prevent critical diagnostic information from being overlooked. Detailed documentation

of findings is essential from a dento-legal standpoint.

The pretreatment protocol provided is relatively easy to follow, quick to perform, and easy to reproduce. It yields summary findings that correspond with specific prognostic conclusions. The protocol is divided into: (i) patient interview; (ii) examination of existing facial characteristics; and (iii) examination of edentulous conditions, i.e., anatomic, morphologic, and muscular status.

The Patient Interview

Successful therapy is facilitated by the provider coming to know the patient, from both personal and logistical perspectives; this includes how the patient arrived in the practice. If the patient was referred, the referral source should be known and contacted, and the reason for the referral noted. If the patient arrived due to marketing of the practice, care must be taken to investigate if the patient's needs are consistent with therapy provided by the practitioner.

The initial patient interview permits the patient and the practitioner to know one another [8]. Quality time spent at the beginning sets the stage for an optimized patient-provider relationship. Both the physical and psychological status of the patient should be triaged during the first appointment [8]. Anticipation of communication problems and interception of commonly encountered interpersonal

problems are frequently as important as clinical findings. Discerning the primary etiology of existing patient dissatisfaction is essential for breaking the cycle of unsuccessful treatment attempts. Complaints and expectations expressed by the patient, and treatment obstacles encountered by previous dentists, can provide a critical influence on the acceptance of the patient into the practice and the treatment offered.

Be aware that the pretreatment protocol provided might initially appear to consume an inordinate amount of time and effort. Some might say that this is financially unjustifiable. However, once understood and skillfully conducted, the protocol reduces overall management time, permits appreciation of the treatment rendered, and significantly contributes to overall therapeutic success.

Some patients may be fearful, nervous, or shy, and inadvertently fail to respond directly to questions. Recognition of these individuals early in the interview process is critical. In many cases, a dental auxiliary can better elicit patient responses than the practitioner. Obtaining honest and accurate patient responses will affect outcomes. The pretreatment protocol and associated electronic documentation presented incorporate data-gathering processes designed to elicit thorough, concentrated, and accurate answers from patients.

Patient Interview: Age

The patient's chronological age should be critically compared with general physical health and existing oral conditions. Older patients may be afflicted with poor neuromuscular coordination [9, 10], suboptimal nutritional status [11, 12], diminished adaptability [9, 10], and salivary secretion (both quantity and quality) [11], and highly vulnerable denture-bearing tissues [10, 11]. These factors adversely influence aging edentulous patients' ability successfully to tolerate and function with conventional complete dentures, which should be discussed prior

to initiating treatment [8]. Analogies such as "when dentures move and there's limited saliva, the pink plastic acts like sand paper against your gums creating irritation" help patients to understand better the problems that they face.

Patient Interview: Attitude

Coming to appreciate patient attitude may be as simple as presenting nonleading questions and permitting the patient time to respond. Questions that may be used to gauge patient attitude include:

- *How are you feeling today?*
- *How was your experience with the previous dentist that treated you?*
- *What do you think about your current and previous dentures?*

Based on patient responses and ensuing discussions, qualifications of patient attitude as good, average, or poor may be made. Of course, additional questioning may be necessary to arrive at a reasonable determination.

Patient Interview: Expectations

If not thoroughly investigated prior to initiating treatment, patient expectations may not be apparent until problems unexpectedly emerge in the course of therapy, and the patient's demeanor begins to decline [9, 13]. Direct and specific questioning of the patient regarding expectations will permit documentation of responses and qualification of expectations as high, medium, low, or still unsure. Patients can also be asked the following questions to understand further the nature of their expectations:

- *What kind of improvement in appearance do you expect from your new dentures?* In response to this question, a 50-year-old patient may provide a picture of an 18-year-old celebrity stating, "I want my teeth to look like hers." This would indicate that the patient possesses unrealistic expectations. A subsequent patient may suggest, "I want perfect teeth,"

necessitating a better understanding of what is meant by “perfect.”

- *What kind of improvement in chewing ability do you expect from new dentures?*
- *What kind of improvement in fit do you expect from the new dentures?*
- *How long do you expect new dentures to last?*
- *How often do you expect to return to the dentist for examinations and adjustments?*

The nature of the patient’s desires and demands relative to proposed treatment must be considered by the practitioner within the context of his/her level of experience and expertise. If the patient expects more than the practitioner can comfortably provide, definitive treatment should not commence and referral to a more experienced colleague should be in order. Additionally, if the patient is unable to appreciate the limitations of the therapy offered, it is inappropriate to initiate treatment.

It is the responsibility of the practitioner to address unattainable expectations fairly and honestly, through frank discussion with the patient, communicating what can and cannot be accomplished with treatment; this is particularly true with complete denture therapy. Failure to address unrealistic expectations often leads to treatment failure and rapid deterioration of the patient-provider relationship. Patients that refuse to accept known limitations of therapy and express inflexibility in this regard are generally challenging to manage successfully. Not initiating definitive treatment for these individuals is ethically, professionally, and financially appropriate.

Patient Interview: Chief Complaint

Providing state-of-the-art treatment that does not manage the patient’s main concerns may provide a level of personal satisfaction for the provider but is rarely successful in the long run. It is therefore important to: (i) request that patients specifically voice their greatest dental concern / concerns; (ii) document these chief concerns using the patients’ exact words, and (iii) review the chief

concern / concerns, as documented, with the patients to confirm accuracy [13].

Most dental patients are not familiar with professional and dental terminology. It is therefore important to ensure that the practitioner understand clearly the patient’s chief concerns as expressed. Asking the following questions may permit a greater appreciation for the nature of the chief concerns:

- *Are your dentures loose?*
- *Can you eat most foods?*
- *Do your gums get sore?*
- *Do you have pain now?*
- *Are you happy with the appearance of your smile?*
- *Is there anything else that bothers you?*

Patient Interview: General Health

General health is a significant factor that can affect the overall success of dental therapy [9]. A thorough medical history questionnaire is an essential tool in pretreatment diagnosis. Patients with complicated medical conditions (e.g., uncontrolled diabetes, Parkinson’s disease, Huntington’s disease, Tourette’s syndrome, other neuromuscular disorders, etc.) should be informed that these conditions may affect their ability to retain and function with conventional complete dentures [14]. Many systemic conditions (e.g., iron deficiency anemia, Sjogren’s syndrome, pemphigus / pemphigoid, erythema multiforme, etc.) can adversely affect oral tissues, oral function, and in turn the success of complete denture therapy [14]. Obtaining information regarding current medication type and dosage is important, particularly because so many medications significantly contribute to xerostomia. Patients should be referred to their primary physicians for review of medical conditions or medications expected to affect dental therapy adversely.

Patient Interview: Complete Denture Experience

In order to assess patients’ ability to wear removable prostheses and the apparent rate of alveolar bone resorption, they should

report the number of years they have worn complete dentures [9, 13]. They should be questioned if the maxillary and mandibular dentures were fabricated at the same time or at different times. It is also important to note the reasons for tooth loss. As a general rule, longer durations of edentulism correspond to greater alveolar bone loss and increased complexity of treatment.

Patient Interview: Denture Remake Frequency

Information should be collected on the number of different complete dentures worn by the patient since loss of the natural teeth. The date of fabrication of the most recent complete dentures should be determined. Reasons for seeking new prostheses, both historically and currently, should be noted. The American Dental Association recommends that complete dentures be replaced every 5–7 years, or when they can no longer be worn comfortably [15]. Acquiring one new denture over the past 10 years is reasonable; two new dentures in 10 years may be justifiable, but three or more complete dentures within a 10-year period may indicate particularly challenging conditions or a challenging patient who is difficult to treat successfully.

Patient Interview: Patient Satisfaction

Satisfaction level with previous complete dentures is important diagnostic information [9]. Satisfaction should be qualified as successful, reasonably successful, or unsuccessful. The following specific questions should be asked:

- *Describe your satisfaction with previous dentures?*
- *What is your opinion regarding your smile with your existing dentures?*
- *Were you able to function with previous dentures?*
- *Did your dentures fit well in your mouth?*

Patient Interview: Photographs, Diagnostic Casts, and Radiographs

Photographs, diagnostic casts accurately mounted in an articulator, and radiographs are essential to complete the patient interview and information gathering. Properly composed photographs help to visualize smile symmetry, incisal display, lip support, size and form of edentulous ridges, and presence of undercuts. Mounted diagnostic casts present three-dimensional information on oral contours of the edentulous jaws, ridge relationships, and available restorative space.

Important objective diagnostic information is discernable with panoramic radiology. Relative alveolar height and resorptive patterns can be assessed. Hypertrophied tuberosities, pneumatized sinuses, and extruded ridge segments may be identified. Approximately 20% of edentulous patients present with radiographic signs of bone cysts, retained root tips, impacted teeth, and residual pathology [13, 16]. Incorporation of a properly made, diagnostic-quality panoramic radiograph early in the pretreatment protocol is essential in identifying these treatment concerns.

The Facial Analysis

Esthetic outcomes in modern dentistry are essential to perceived success [9]. Unfortunately, appreciating patient esthetic expectations and determining esthetic prognosis during initial assessment can be challenging. A detailed facial analysis involving patient interaction and acceptance is a critical element of the pretreatment protocol. Identification of dental midline asymmetries, lip irregularities, tooth and excess denture base displays, face shape, and vertical/horizontal residual ridge relationships influence both the treatment rendered and prognosis. Patient and dentist appreciation for these esthetic factors prior to initiation of treatment is best accomplished using carefully composed clinical photographs.

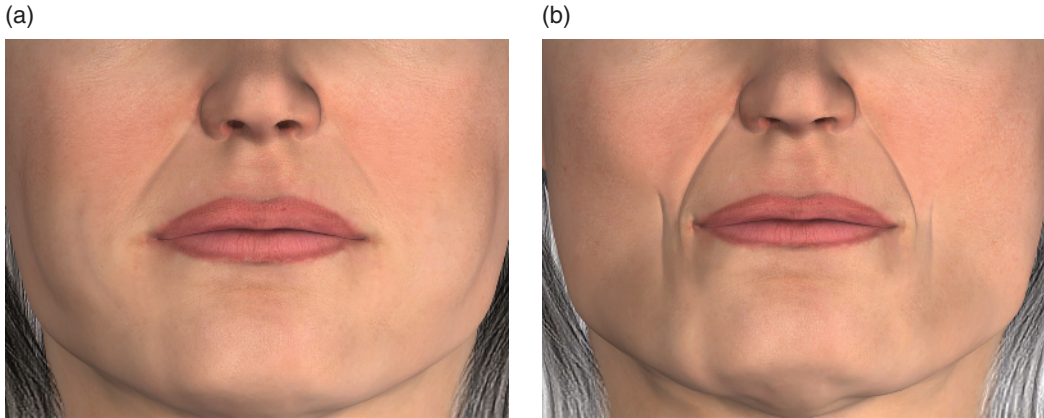


Figure 1.1 (a) A female patient with convex appearance; (b) a female patient with concave appearance.

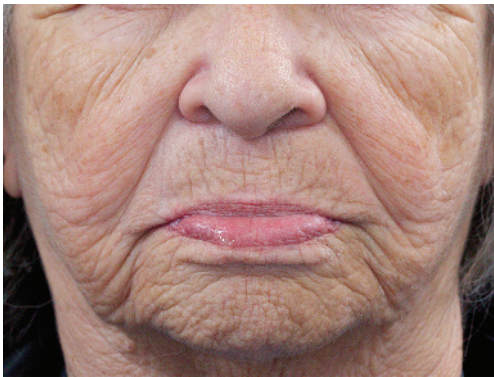


Figure 1.2 Patient demonstrating presence of deep wrinkles, nasolabial folds, poor muscle mass and tone.

Facial Analysis: Facial Tissue Tone

Aging and the loss of teeth correspond to deterioration of tonicity in facial tissues and masticatory muscles. Decreasing muscle mass alters the appearance of the face from relatively convex to concave (Figure 1.1a and b). Development of surface wrinkles, deep nasolabial folds, and concave cheek contour (Figure 1.2), are indicative of poor skin tone and underlying muscle mass. Digital palpation and patient history (e.g., complaint of reduced bite force) provide information on the tone and functional capacity of facial and

masticatory muscles. When performing digital palpation, a thumb is placed near the commissures (Figure 1.3a) and the index and middle fingers on the opposite cheek surface (Figure 1.3b). The patient is asked to pucker the lips (Figure 1.3c) and then smile (Figure 1.3d). If these movements displace the fingers and the thumb, muscle tone is deemed adequate.

The tone of the oral and facial muscles following the loss of teeth may be near normal or subnormal but never normal [3]. The masticatory force and efficiency for complete denture wearers are therefore substantially reduced compared to those with natural dentitions [3]. The timing and sequence of tooth loss will affect muscle groups to varying degrees. If anterior teeth have been missing for some time, the muscles of facial expression will exhibit a poor tone. If posterior teeth have been missing for a long time, the muscles of mastication are more likely to exhibit a poor tone [3].

Adequate muscle tone contributes to denture stability. Patients with substantially poor muscle tone may find it difficult to stabilize complete dentures. Normal tension, tone, and placement of muscles in the absence of degenerative changes is ideal. However, muscle degeneration in edentulism is common.

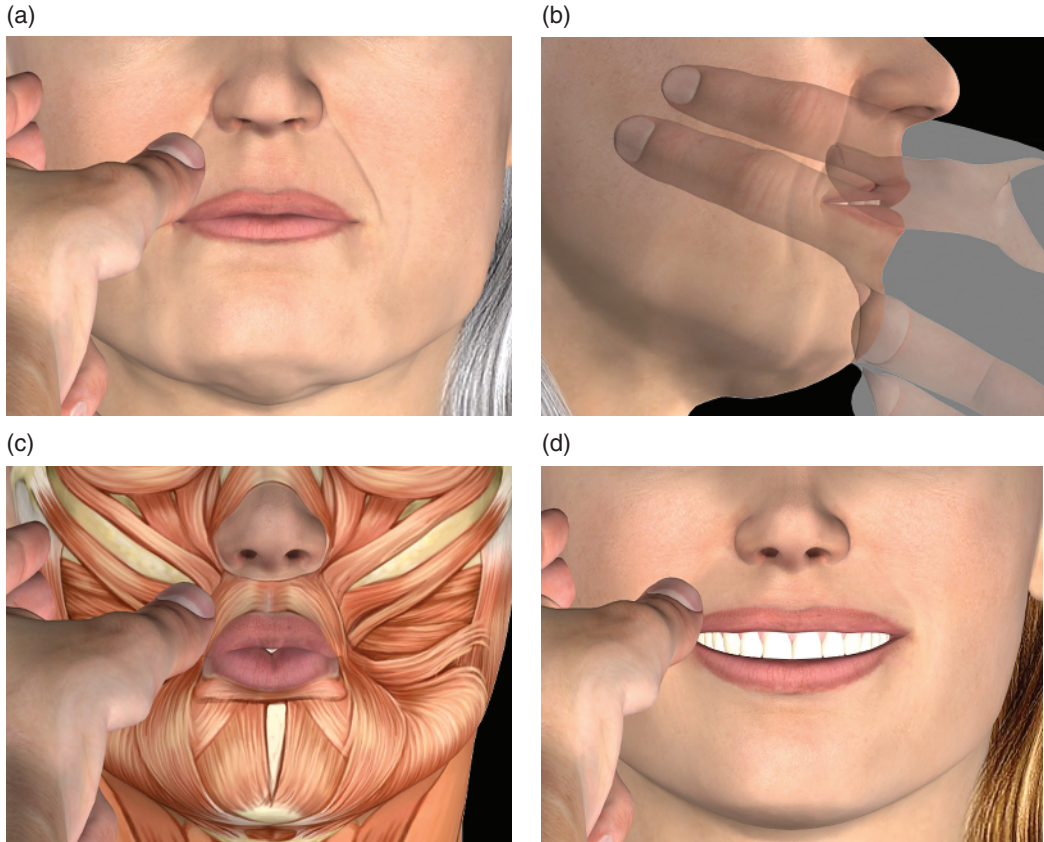


Figure 1.3 (a) Evaluation of muscle tone by digital palpation; (b) evaluation of muscle tone by placing the index finger and middle finger on the cheek; (c) evaluation of muscle tone by asking patient to pucker their lips; (d) evaluation of muscle tone by asking patient to smile.

An important function of complete dentures is to provide support for the muscles and soft tissues of the cheeks and lips. Denture flange borders and cameo surface contours should be developed to facilitate this support.

Facial Analysis: Tooth and Denture Base Display

Lip length and lip mobility affect tooth and soft tissue (denture base) display during both repose and smile. A long upper lip and reduced lip mobility during smile results in minimal maxillary tooth and gingival display (Figure 1.4a). A short upper

lip and excessive lip mobility lead to maximum maxillary tooth display, particularly during full smile (Figure 1.4b). Tooth and denture base display of the existing prostheses during repose and full smile should be recorded to indicate no show, slight show, average show, or excess show. Recording this information helps to improve vertical denture tooth positioning in planned prostheses.

Facial Analysis: Midlines

The patient's maxillary denture midline should coincide with the facial midline. Deviations should be noted.

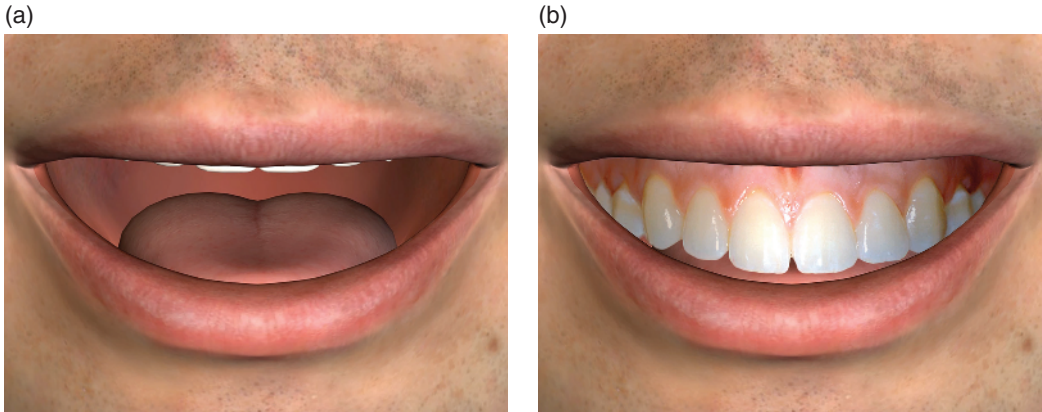


Figure 1.4 (a) Inadequate maxillary incisal display in smile; (b) excess maxillary incisal display during full smile in an old male patient.

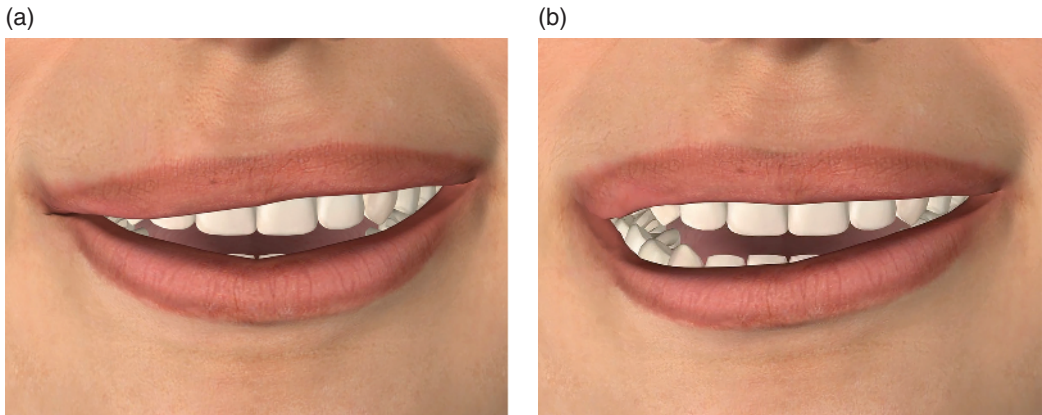


Figure 1.5 (a) Asymmetric movement of the upper lip; (b) asymmetric movement of the lower lip.

Facial Analysis: Lip Mobility

Symmetrical lip movement should be assessed during smile and full animation. Asymmetric lip movements should be classified as normal, slight, medium, or extreme. Photographs (e.g., repose and smile) and patient history (e.g., complaints of asymmetric tooth display) are valuable aids. Unilateral reduction of mobility (Figure 1.5a and b) and unilateral irregular contours should be noted (e.g., stroke or Bell's palsy) [9]. The position of anterior denture teeth and the cameo denture base contour can be manipulated to modify asymmetric lip positions and movements subtly, although

complete correction may not be possible. Patients should be made aware of any lip asymmetries and the potential for corrective measures prior to initiating treatment. Referral for tissue fillers and plastic surgical procedures may be indicated.

Facial Analysis: Lip Dimension

Both upper and the lower lip dimension should be examined and classified as full, reduced, or minimal. Thin lips and vermilion borders become less visible with age (Figure 1.6). Labial inclination of maxillary anterior teeth can enhance the upper vermilion display. However, significant forward



Figure 1.6 Inadequate display of the vermilion border of upper and the lower lip in a male patient.

positioning of maxillary incisal edges can thin the upper vermilion border, similar to stretching a flat rubber band, the greater it elongates the more it thins. Vermillion display can also be enhanced by tissue fillers.

Prosthetic Factors

Prosthetic Factors: Vertical Dimensions

With the current complete dentures in place, the patient's occlusal vertical dimension (OVD) and rest vertical dimension (RVD) should be compared. The RVD is recorded by marking a dot on the tip of the patient's nose and on the forward prominence of the chin [17]. The patient is asked to take a deep breath and relax. Once relaxed, a caliper is used to record the distance between dots (Figure 1.7a) [17]. It may help to have patients breath in and out several times, close their eyes as if to fall asleep/relax, and permit jaw muscles to relax in order to obtain RVD. This technique may be particularly helpful for patients who present with an apparently overreduced vertical posture. This measurement represents the patient's RVD or the physiological rest position. Next, the patient's existing OVD is recorded by having the patient occlude their denture teeth. Once again the caliper is

used to record the distance between the two dots (Figure 1.7b) [17, 18].

Subtracting the OVD from the RVD yields the dimension commonly known as freeway space. It is generally accepted that physiologically acceptable interocclusal distance (freeway space) for complete denture patients ranges from 2.0 to 4.0mm [17]. Inadequate or excessive OVD/interocclusal distance can adversely affect the success of complete denture therapy [17, 18]. Inadequate OVD may result in mandibular overrotation with relative forward positioning, known as pseudo-Class III relationship (Figure 1.7c), compromising esthetics, masticatory efficiency, and denture stability [17, 18]. Management of patients with reduced OVD may be complex (this topic will be discussed in Chapter 2). Excessively increasing OVD beyond physiologically acceptable limits may lead to esthetic and phonetic problems, irritation of the denture foundation, generalized patient discomfort, and neuromuscular symptoms [18].

Prosthetic Factors: Existing Dentures

Critical appraisal of existing prostheses may indicate what should be designed into the new complete dentures and what should be avoided. This information also helps to gauge the limitations of such treatment and determine if patient complaints related to existing complete dentures are justified.

The existing dentures should be assessed carefully for comfort, retention, stability, and support. Occlusion, denture tooth arrangement, and any discrepancy between centric occlusion and maximum intercuspal positions should be evaluated critically. Dental midline placement, arrangement of anterior denture teeth, shade, and type of teeth, occlusal plane orientation, border extensions, cameo surface contours, phonetics, and incisor display should be evaluated and noted in detail. The occlusal surfaces, the intaglio surface, and the cameo surface should be examined for evidence of deterioration and previous repair and/or relines.

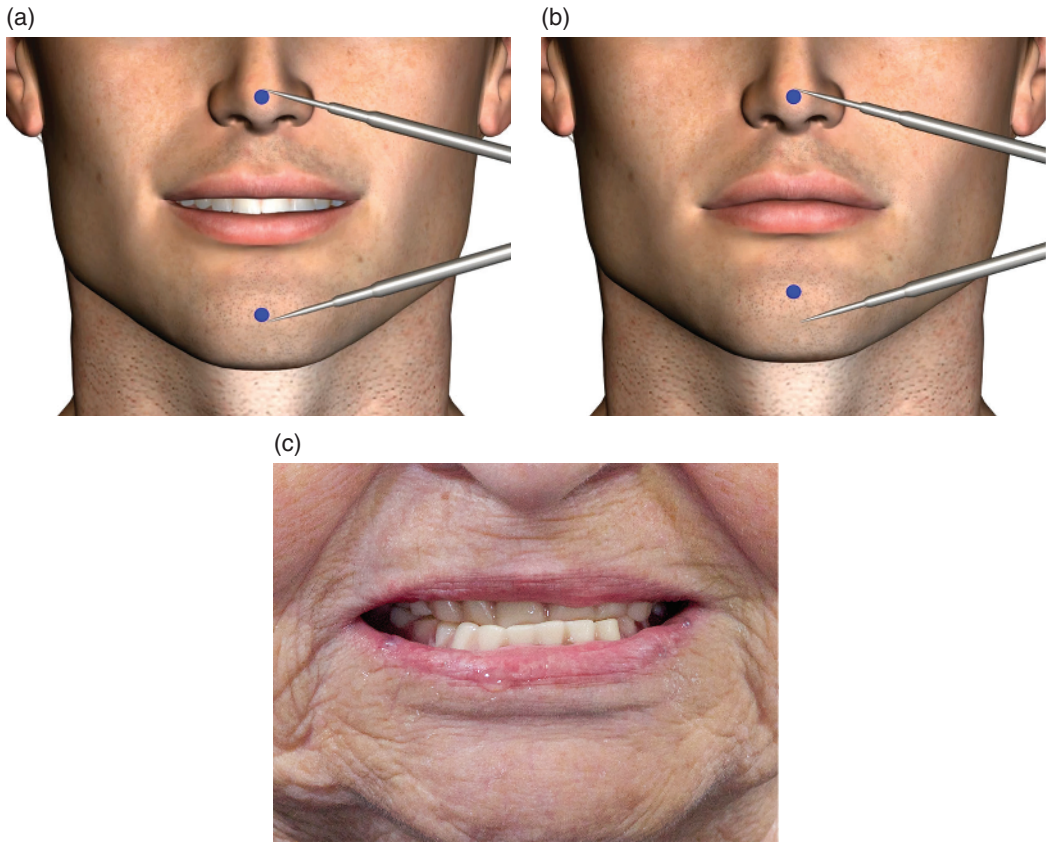


Figure 1.7 (a) Measurement of RVD using calipers to gauge distance between nose and chin in rest position; (b) measurement of OVD using calipers to gauge the distance between nose and chin when teeth are in contact; (c) patient presenting with pseudo class III appearance due to inadequate OVD.

Current dentures should also be examined to assess the patient's capacity and motivation for meticulous denture hygiene [3, 13]. Limitation in this area must be addressed.

Prosthetic Factors: Skeletal Relationship

The anterior-posterior relationship of the maxilla to the mandible should be evaluated in profile to ascertain the relative class I, class II, or class III skeletal relationship [19]. Interarch discrepancies in size and position typically lead to problems establishing adequate occlusion and denture stabilization [19, 20]. For patients with severe Class II, Class III, or transverse skeletal relationships, it is critical to achieve adequate

posterior tooth occlusion to avoid denture instability during empty mouth random occlusal contact [20].

Prosthetic Factors: Saliva

Clinical examination must include assessment for xerostomia (e.g., quality and quantity of saliva, dry lips, shiny and dry intraoral mucosa, angular cheilitis, dorsal fissuring of the tongue). A dental mouth mirror adhering to the tongue or buccal mucosal surfaces during intraoral examination indicates dry mouth. Generally, the patients with significant medical histories including multiple prescribed medications will demonstrate signs of reduced salivary flow [21]. A reduction in salivary flow may be associated with

local factors (e.g., salivary gland disorders), systemic factors (e.g., Sjogren's syndrome, AIDS, systemic lupus erythematosus, rheumatoid arthritis, scleroderma, uncontrolled diabetes, thyroid dysfunction, and some neurological disorders), and / or prescription medications [22].

The quantity and quality of saliva affects denture success. Reduced salivary output will interfere with complete denture retention and cause generalized soreness in the denture-bearing soft tissues due to frictional irritation [2, 22, 23]. The quality of saliva should also be considered. Saliva that is ropy, viscous, and mucinous has poor cohesive and adhesive properties prohibiting optimal denture retention. Patients should be informed about these conditions, educated regarding implications, and instructed about necessary treatment, to include the use of denture adhesives, saliva substitutes, and implants for improving the prognosis [13].

Prosthetic Factors: Oral Tolerance

To gauge the patient's oral tolerance (i.e., tendency to gag), a large stock impression tray can be inserted in the patient's mouth. The tray should be inserted gradually, keeping contact / pressure on the ridge crest until the posterior aspect of the tray contacts the soft palate. Reaction of the patient should be observed closely. Slight reaction is normal, but hypersensitivity is a concern. Areas typically related to reflexive gagging include posterior palate, base of tongue, and posterior-lateral tongue borders. Various distraction techniques have developed over the years to overcome the tendency to gag, including asking the patient to lift one of their legs off the chair, or having them chew on ice immediately prior to dental procedures. Prescription of anti-anxiety medications or application of topical anesthetic (sprays, lozenges, and lollipops) to the soft palate and tongue has been recommended and may be useful in patients with extreme gag reflex.

Prosthetic Factors: Temporomandibular Joints

The temporomandibular joints (TMJs) must be carefully assessed via patient history, joint auscultation, digital palpation, and manual load testing. Radiographs may also be used to investigate symptomatic TMJs. Often patient accommodation and joint adaptation permit relatively normal and pain-free function of TMJs with clinically discernable clicking, popping, and crepitus. The presence of prolonged and debilitating symptoms necessitates further evaluation and referral to a practitioner specializing in the diagnosis and management of temporomandibular dysfunction (TMD).

TMD can be associated with instability of occlusal relationships, oro-facial pain, and functional discomfort. It may also be associated with decrease oral opening (i.e., <60 mm from maxillary anterior ridge to mandibular anterior ridge in edentulous patients is considered to be reduced opening) and deviation of the mandible upon opening. It has been proposed that openings of less than 35–40 mm warrant further investigation [24].

Patients experiencing TMD and TMJ pain are less likely to adapt favorably to new complete dentures. It is therefore important to resolve TMJ pain before initiating definitive complete denture therapy [25]. The TMJ position, range of motion, and function should be appropriate, comfortable, and stable before definitive dental rehabilitation is attempted [25].

Prosthetic Factors: Oral Cancer Review

The lips, cheeks, lateral / ventral tongue surfaces, floor of the mouth, tonsils, soft palate, oropharynx, and neck must be carefully examined and palpated for suspected lesions. Lymph nodes draining the head and neck are of particular interest. Suspected lesions should be digitally palpated to identify bumps, roughness, irregularities, and induration. Not all lesions need to be biopsied, but suspicious findings must be regularly monitored by a dental professional, knowledgeable

in pathologic disease progression. Oral cancer screenings should be accomplished periodically for all patients, not just new patients.

Oral Characteristics

Oral Characteristics: Palatal Throat Form

To examine the character, location, and extent of the tissue contour at the junction of the hard and soft palate (i.e., palatal throat form) the patient is asked to open the mouth widely so that this critical palatal area can be observed at relative physiological rest. In order to appreciate the importance of this clinical determination, two concepts must be understood. The first, postpalatal seal area (PPS area), is the soft tissue area at or beyond the junction of the hard and soft palate on which pressure, within physiologic limits, can be applied by a complete denture to aid in denture retention [26]. The second concept, postpalatal seal (PPS), is the region along the posterior border of a maxillary complete denture specifically contoured to facilitate peripheral seal of the prosthesis [26].

Palatal throat form affects peripheral seal of the maxillary complete denture along its posterior border or PPS [3]. Patients possessing a broad band of relatively immovable tissues at junction of the hard and soft palate (Class I) (Figure 1.8a) present a good opportunity to develop a sound PPS facilitating excellent retention of the maxillary denture [3]. Those having a narrower band of immobile tissue and more significant soft palate drape (Class II) (Figure 1.8b) have reduced surface area upon which to develop an effective PPS [3]. Patients that demonstrate severe soft palate drape, even at physiologic rest (Class III) (Figure 1.8c), have minimal surface area at the hard and soft palate junction available for an effective PPS, thus jeopardizing peripheral seal and maxillary denture retention [3]. For individuals with Class III palatal throat form,

precise positioning and careful development of the PPS is critical to achieving and maintaining predictable maxillary denture retention.

Oral Characteristics: Arch Size

Arch size can be measured intraorally or on a cast. A ruler or a Boley gauge can be used to measure the crest-to-crest width and the anterior-posterior length of the edentulous ridges. Large arches (>45 mm width and >55 mm anterior-posterior) offer the potential for optimal retention and stability of complete dentures. Medium-sized arches (approximately 40 mm width and 50 mm anterior-posterior) provide good, but not ideal, characteristics for denture retention and stability. Small arches (<35 mm width and <45 mm anterior-posterior) do not lead to predictable denture retention and stability. A small edentulous arch where the teeth must be positioned facial to the ridge for optimal esthetics and soft tissue support, presents a substantial challenge to prosthesis retention and stability. Arch-size measurements also aid in impression tray selection.

Oral Characteristics: Maxillary Ridge Height

To assess maxillary residual ridge height, a measurement is made from the depth of the labial vestibule to the crest of the edentulous ridge at the midline with the lip gently retracted (Figure 1.9) [4, 5, 27–29]. The vertical ridge dimension undergoes a continuous resorption once the teeth are lost. The amount and rate of ridge resorption in the anterior maxilla depends in large part on the presence of teeth in the mandible. If only anterior mandibular teeth are present, resorption in the anterior maxilla may be significant due to increased and continuous loading forces [30]. This is believed to be the case for patients affected by combination syndrome [31].

Reduced residual ridge height adversely impacts the potential for maxillary denture

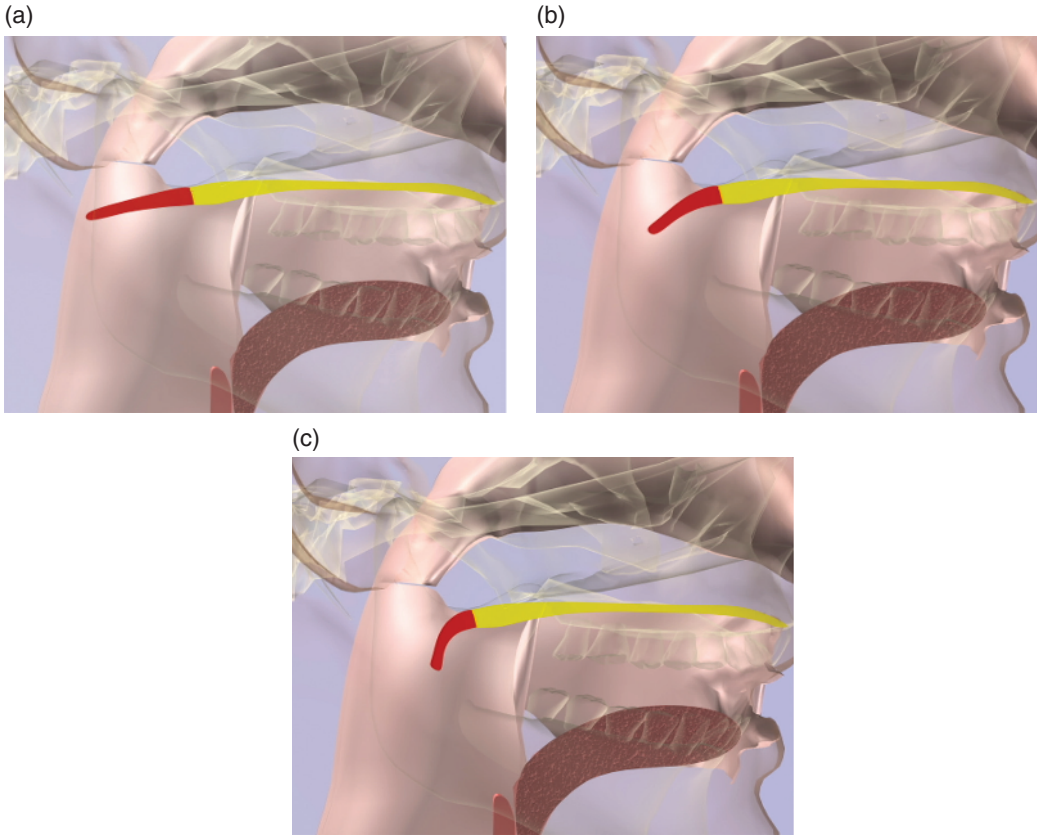


Figure 1.8 (a) Broad palatal throat form, Class I; (b) class II palatal throat form; (c) class III palatal throat form.

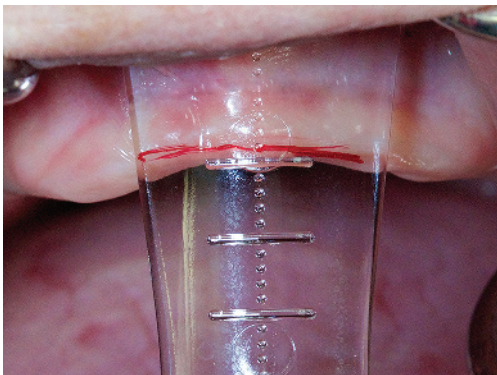


Figure 1.9 Maxillary anterior ridge height measured from depth of labial vestibule to crest of edentulous ridge.

retention and stability [5, 32], which, in turn, has a detrimental effect on muscle tone and esthetics of the patient. Complete

denture prognosis could be affected by anterior and posterior maxillary ridge height.

Oral Characteristics: The Palate

Tooth loss and alveolar resorption may lead to alteration of the depth and contour of the palatal vault. Depth and cross-sectional contour of the palatal vault can be evaluated on a dental cast, by intraoral observation, or through intraoral photographs. A flexible transparent ruler is used to record the distance between the deepest aspect of the palate and the most reduced aspect of the ridge crest (Figure 1.10). Broad (i.e., U-shaped) palatal vaults are ideal, offering the potential for excellent support and stability of the maxillary complete denture.

Tapered (i.e., V-shaped) palatal vaults provide less denture stability and are associated with increased processing distortion (i.e., increased denture tooth movement and reduced palatal contact). Flat palatal form provides adequate vertical denture support, but contributes minimally to complete denture stability [20]. Maxillary complete dentures made to fit flat palatal form, particularly when accommodating large labial frenula, render the prosthesis susceptible to fracture. The presence of tori may complicate prosthesis structural integrity and retention. Conventional or zygomatic implants may be necessary to provide adequate prosthesis support, stability, and retention for these patients.

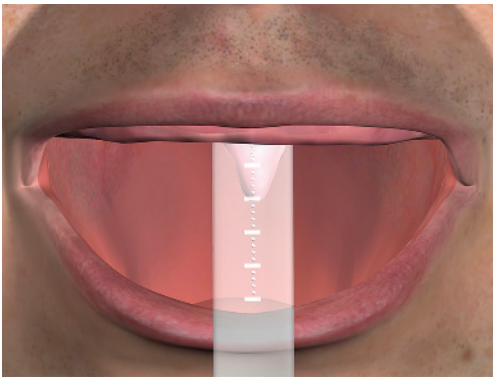


Figure 1.10 Use of a transparent ruler to measure depth of palatal vault.

Oral Characteristics: Maxillary Ridge Contour

Ridge resorption or surgical intervention can affect the cross-sectional form of the residual ridge. Residual ridge resorption (RRR) progressively alters ridge form and size from relatively U-shaped (Figure 1.11a) to knife edged (Figure 1.11b). Further RRR may lead to flat ridges, eventually resulting in depressed or negative ridge form [5]. Maxillary ridge cross-sectional form can be characterized as U-shaped, V-shaped (tapered), round (bulbous), flat, depressed (negative), or any combination of these forms [3, 20, 33]. The shape and contour of the ridge affects retention and stability of the complete dentures.

U-shaped ridges with medium to tall parallel walls and broad, flat ridge crests provide excellent denture retention and stability. U-shaped ridges with short parallel walls and flat ridge crests provide less stability. V-shaped ridges with thin crests or extremely short to flat ridges are typically associated with relatively poor denture support, stability, and retention [33].

Oral Characteristics: The Maxillary Denture Foundation

Oral examination, digital palpation, diagnostic casts, and intraoral photographs (occlusal views) are used to evaluate characteristics of

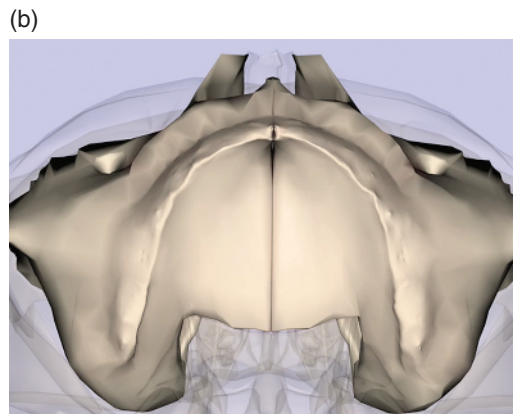
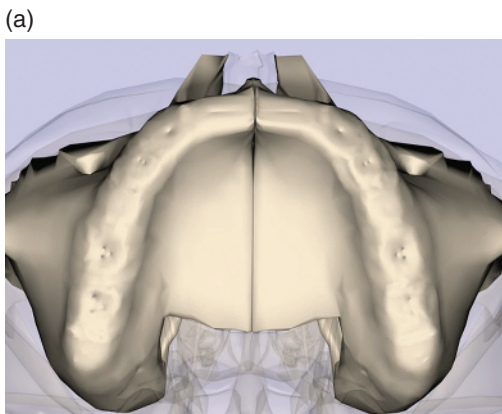


Figure 1.11 (a) U shaped maxillary residual ridge; (b) knife edged maxillary residual ridge.

the denture foundation. The presence of depressed irregularities, exostoses, palatal tori, hypertrophic tuberosities, and significant undercut areas in the maxillary denture foundation should be noted. Surgical intervention should be considered for defects expected to cause chronic soft tissue irritation, restrict normal function, prohibit optimal impression making, or interfere with proper denture border extensions [31, 34].

Oral Characteristics: Mandibular Ridge Height

To assess mandibular residual ridge height, a measurement is made from the depth of the labial vestibule to the crest of the edentulous ridge at the midline with the lip gently retracted (Figure 1.12) [4, 5, 27–29]. It is important to avoid distending the vestibule while recording this measurement. The amount of force imparted to the mandible during normal functional loading may be twice that for the maxilla due to the reduced surface area of the denture foundation. This, in part, is believed to account for the increased RRR experienced by the mandible as compared to the maxilla [5, 29].

Loss of residual ridge height adversely affects the complete denture retention and stability [5]. For some patients, mandibular RRR can be so extreme that the mandible is susceptible to pathologic fracture. Advanced RRR complicates both the dentist's ability to

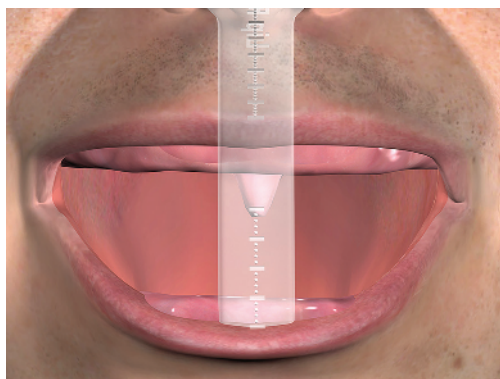


Figure 1.12 Measurement of height of mandibular anterior ridge using transparent ruler.

fabricate adequate complete dentures and the patient's ability to manage new prostheses successfully. It is therefore always prudent to consider means of maintaining and improving the denture foundation by the retention of natural tooth roots for conventional complete overdentures to slow the rate of RRR, or strategically place dental implants to improve the mechanics of denture support, retention, and stability.

Complete denture prognosis on the basis of radiographic mandibular bone height may be determined as follows: ≥ 21 mm (Class I) favorable, 16–20 mm (Class II) acceptable, 11–15 mm (Class III) compromised, and ≤ 10 mm (Class IV) guarded [4].

Oral Characteristics: Mandibular Ridge Contour

Ridge resorption or surgical intervention can affect the cross-sectional form of the mandibular residual ridge. RRR progressively alters ridge form and size from relatively robust (inverted U-shape) (Figure 1.13a), to significantly diminished (inverted V-shape), to knife edged (Figure 1.13b) [5]. Further mandibular RRR resorption may produce flat (Figure 1.13c) or even depressed (negative) ridge form [5].

Therefore, mandibular ridge cross-sectional form can be characterized as square (inverted U-shape), tapered (inverted V-shape), round (bulbous), flat, depressed (negative), or any combination of these forms [3, 20, 33]. The shape and contour of the ridge affects expected retention and stability of the complete dentures.

Oral Characteristics: Mandibular Muscle Attachments

Muscle attachments affect the contour and extension of mandibular complete denture flanges [2]. Unfavorable location of muscle attachments will have a detrimental effect on denture stability. In such circumstances, surgical correction should be considered [14, 35]. The amount of RRR alters the relative relationship of the muscle attachments

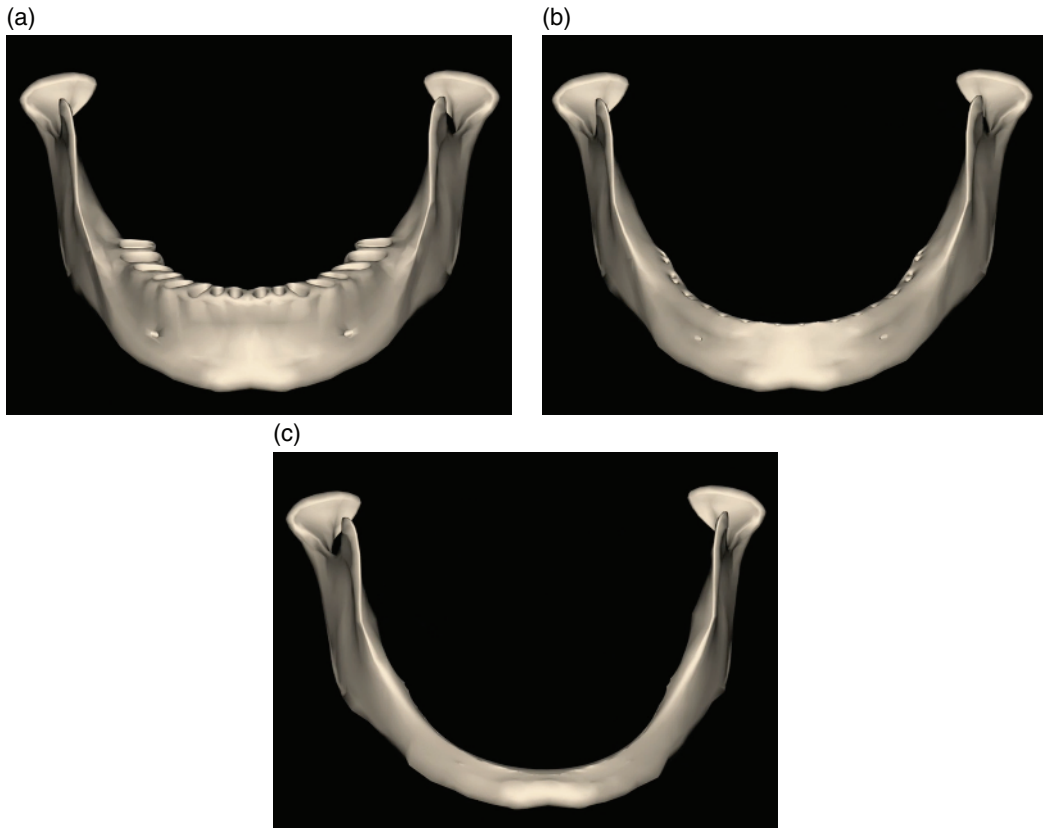


Figure 1.13 (a) Inverted U shaped mandibular residual ridge; (b) knife edged mandibular residual ridge; (c) flat mandibular residual ridge.

to the residual ridge crest. It is important to appreciate that this relationship changes with ongoing ridge resorption [3]. Mandibular muscle attachments are therefore classified as low (near the vestibular reflection), middle, or high (near the ridge crest) [3].

Oral Characteristics: Mandibular Denture Foundation

The existence of depressed irregularities, exostoses, lingual tori, and significant undercut areas within the mandibular denture foundation should be noted. Surgical correction is considered for defects expected to cause chronic soft tissue irritation, restrict with normal function, prohibit optimal impression making, or interfere with proper denture border extensions [31, 34].

In extreme cases, mandibular resorption is so advanced that the ridge appears flat, or even concave, and palpation of the mylohyoid ridge reveals a sharp spinelike projection with thin soft tissue covering. This area is highly susceptible to functional stress imparted by the denture, and surgical correction must be considered [35].

Oral Characteristics: Maxillary Tuberosity Curve

Contours of the maxillary tuberosities, from ridge crest to vestibular depth, are assessed by digital palpation or dental mirror placement into the distal extent of the maxillary vestibule and instructing the patient to open their mouth and move their jaw from side to side. This space has been called the retrozygomatic space or the corono-maxillary

space [36]. The vertical height and width of this space varies with mouth opening and must be carefully considered when molding borders and making impressions [36]. Definitive denture borders in this area should account for the dynamic nature of this space during mandibular movements. Failure to do so will result in an inadequate peripheral seal. Excessive flange thickness in this area will result in discomfort and/or denture displacement as the coronoid process impinges on the denture flange during lateral mandibular movements. Maxillary tuberosity curvature in this region is characterized as flat, moderately curved, steep, or undercut.

Oral Characteristics: Vestibule

Both RRR and the location of the muscle attachments affect relative vestibular depth [2, 5]. Unfavorable (shallow) vestibular depth has a detrimental effect on the complete denture stability and due consideration should be given to corrective preprosthetic surgery (i.e., vestibuloplasty) [35] or dental implant placement. The vestibular depth is classified as deep, average, or short.

Oral Characteristics: Frenula Attachments

Frenula attachments affect the shape and the extension of the complete denture flanges [2]. Frenula attached near the edentulous ridge crest can be a focus of irritation if not accommodated by flange contour [35]. Overrelief of the flange during denture adjustment may lead to the ingress of air, loss of peripheral seal, and compromised denture retention [35]. Excessive flange notching to accommodate frenula attached near the ridge crest can concentrate loading stress, resulting in premature denture-base failure [35]. Therefore, corrective preprosthetic surgery for frenulum attachments near the ridge crest should be considered [14]. Maxillary frenulum/muscle attachments are therefore classified as high (near the vestibular reflection), middle, and low (near the ridge crest).

Oral Characteristics: Pterygomandibular Raphe

The pterygomandibular raphe is a vertically positioned tendinous band coursing bilaterally from the hamuli of the medial pterygoid plates to the posterior limit of the mandibular retro-molar trigones. It serves as a facial raphe between a portion of the buccinator muscle and the ipsilateral superior pharyngeal constrictor. The nature of attachment of the pterygomandibular raphe within the pterygomaxillary (hamular) notch will affect the shape and the extension of the posterior-lateral aspects of the maxillary complete denture. Unfavorable pterygomandibular raphe attachment (i.e., near the ridge/tuberosity crest) will have a detrimental effect on the stability and retention of the denture. Attachment of the pterygomandibular raphe is therefore classified as high (deep in the pterygomaxillary notch), average, or low (near the ridge/tuberosity crest).

Oral Characteristics: Denture Bearing Soft Tissues

Compressibility of the soft tissues of the denture foundation can be assessed by digital palpation and qualified as severely compressible, moderately compressible, slightly compressible, or thin and delicate (Figure 1.14a).

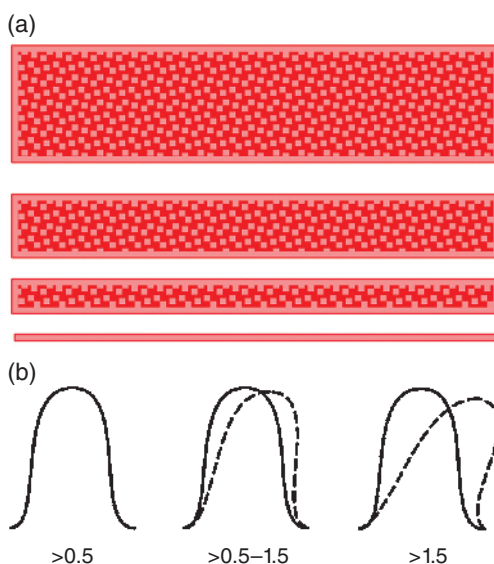


Figure 1.14 (a) The compressibility of denture-bearing soft tissues based on thickness. (b) Characterization of soft tissue displaceability.

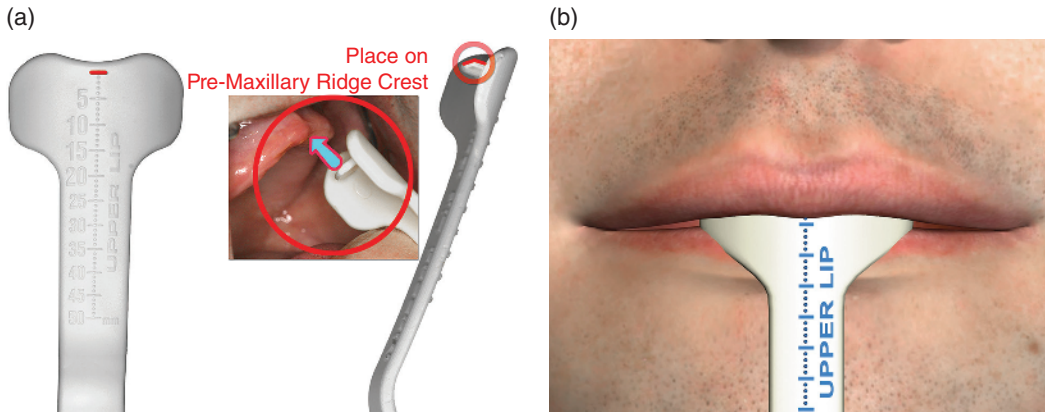


Figure 1.15 (a) Lip ruler; (b) Measurement of maxillary esthetic space made with a lip ruler at rest.

Mobility or soft tissue displacement may be characterized as severely displaceable (>1.5 mm), moderately displaceable (between 0.5–1.5 mm), or slightly displaceable (<0.5 mm) (Figure 1.14b). Mobilizing the tissue using two mouth mirror handles permits assessment of soft tissue displacement. Clinical soft tissue thickness may be qualified as severely compressible and easily displaceable (thick and spongy), moderately compressible and moderately displaceable (2–3 mm thick), or noncompressible and nondisplaceable (relatively thin). Soft tissues that are noncompressible and nondisplaceable offer little denture support, are highly susceptible to irritation under pressure, and compromise denture retention [10]. Severely compressible and easily displaceable tissues are associated with excessive denture movement and should be considered for surgical correction [27].

Oral Characteristics: Retromolar Pads

Compressibility of the retromolar pads can be assessed through digital palpation or exploration with a blunt instrument, as severely compressible, moderately compressible, slightly compressible, or thin and delicate. Lateral mobility or displacement of retromolar pads can be classified in similar fashion as severely displaceable (>1.5 mm),

moderately displaceable (between 0.5–1.5 mm), or slightly displaceable (<0.5 mm).

Oral Characteristics: Maxillary Ridge Crest to Resting Lip Length (Esthetic Space)

A lip ruler (Figure 1.15a) is used to measure the distance between the maxillary edentulous ridge crest at the midline and upper lip at rest (Figure 1.15b) and during smile [37]. This measurement provides information on the potential for and extent of maxillary anterior denture tooth display and provides information to laboratory technician regarding wax rim length and denture tooth setup [37].

Oral Characteristics: Mandibular Ridge Crest to Resting Lip Length (Esthetic Space)

A lip ruler is used to measure the distance between the mandibular edentulous ridge crest at the midline and the lower lip at rest and during smile [37]. This measurement permits the practitioner to gauge the display of the mandibular anterior denture teeth, and provides important information for the laboratory technician [37].

Oral Characteristics: Maximal Oral Opening

A triangular measuring gauge is used to measure the interarch distance at the midline during maximum oral opening (Figure 1.16a,

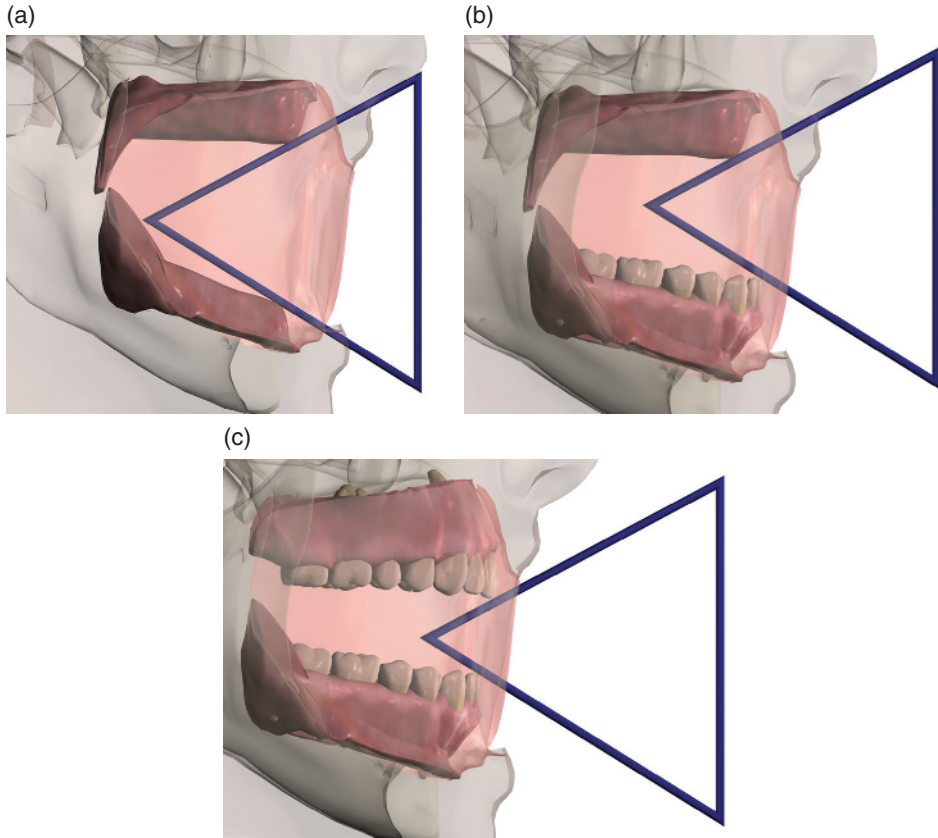


Figure 1.16 (a) Triangular shaped measuring gauge used to measure interarch (ridge to ridge) distance during maximum oral opening; (b) triangular shaped measuring gauge used to measure interarch (ridge to tooth) distance during maximum oral opening; (c) triangular shaped measuring gauge used to measure interarch (tooth to tooth) distance during maximum oral opening.

b and c). Maximum interarch (ridge-to-ridge) distance of ≥ 60 mm is considered acceptable for edentulous patients. An interarch (ridge-to-tooth) distance of ≥ 50 mm is considered acceptable for patients edentulous in one arch. An interarch (tooth-to-tooth) distance ≥ 45 mm is considered acceptable for dentate patients [38].

Oral Characteristics: Retromylohyoid Space

The retromylohyoid space, commonly referred to as lateral throat form, is a bilateral potential space immediately lingual to the retromolar pads bounded anteriorly by the mylohyoid ridge and muscle, posteriorly by the retromylohyoid curtain, inferiorly by the

floor of the lingual vestibule, and lingually by the anterior tonsillary pillar, when the tongue is relaxed [39, 40]. The degree to which this potential oral space can be occupied by posterior extension of the mandibular complete denture lingual flange will influence mandibular denture stability [39].

Lateral throat form is evaluated by placing a dental mirror into the retromylohyoid space (Figure 1.17), instructing the patient to project the tongue tip to the contralateral oral commissure, and observing the degree of mirror displacement. Lateral throat form is qualified as deep (no mirror displacement), medium (minor mirror displacement), or shallow (maximal mirror displacement). Extension of the mandibular

denture lingual flange deep into the lateral throat form contributes favorably to denture stability [39, 40].

Oral Characteristics: Tongue Size

To examine tongue size and characterize it as extra large, large, average, or small, the patient is instructed to open the mouth as if to receive food [41–43]. Patients who have been edentulous for an extended time tend to develop a flat and broad (large) tongue [2]. Placement of a mandibular complete denture in such patients results in complaints of crowding, discomfort, and inadequate tongue space [44]. Initially, these patients find it

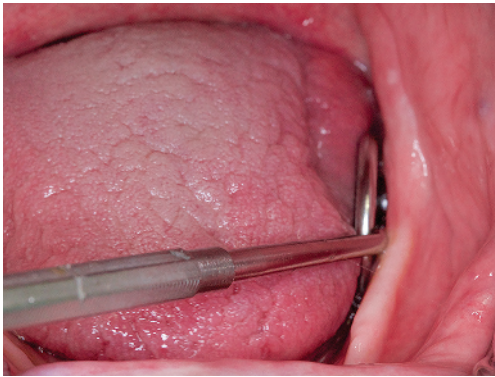


Figure 1.17 Head of the mirror placed in retromylohyoid space for assessing lateral throat form.

difficult to adjust to the new mandibular denture and constantly dislodge the denture through uncoordinated tongue movements. Fortunately, with the passage of time and experience in denture wearing, patient and tongue adaptations permit relatively successful mandibular denture stability and function.

Oral Characteristics: Tongue Position

To observe the natural tongue position, the patient is instructed to open the mouth as if to receive food [41–43]. Care should be taken to avoid mention of the word “tongue” so as not to draw the patient’s attention to the purpose of the examination [41–43]. Observation of tongue position will permit qualification as normal or retracted. Normal position is demonstrated when the tongue completely fills the floor of the mouth, the lateral borders rest over the posterior edentulous ridges, and the tip of the tongue rests on or just lingual to the anterior mandibular ridge crest (Figure 1.18a). Retracted posture is indicated when the tongue is pulled back into the mouth exposing the floor of the mouth and lateral tongue borders lie medial or posterior to the edentulous ridge (Figure 1.18b). In addition, the tip of the tongue in retracted posture is either located in the posterior aspect of the oral cavity or withdrawn into the body of the tongue. Approximately two-thirds of patients present with normal

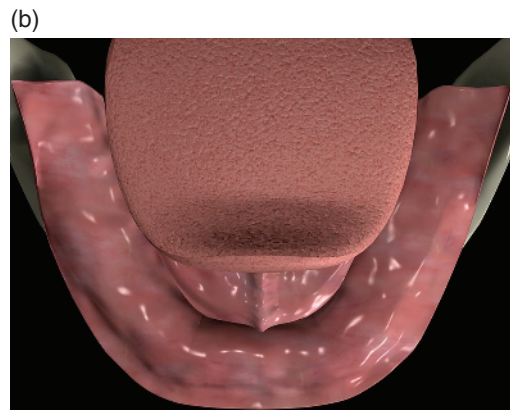
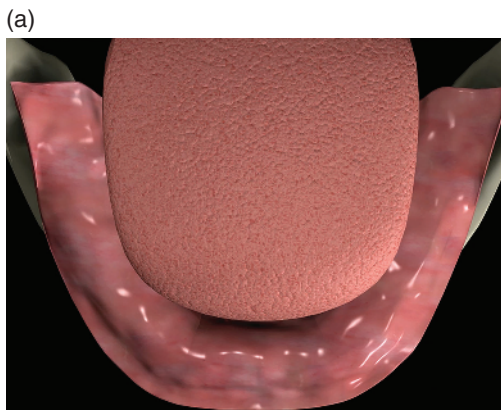


Figure 1.18 (a) Normal tongue position; (b) retracted tongue position.

tongue posture and one-third with retracted tongues [41–43].

Tongue position influences mandibular complete denture flange design and general denture stability [41–43]. Normal tongue position favorably postures the floor of the mouth for predictable lingual flange extension and contour, permitting maintenance of peripheral denture seal, and increasing denture stability and retention. Denture prognosis for patients with retracted tongues may be improved by making the patient aware of this condition and instructing them to consciously maintain normal tongue posture for improved denture retention and stability. The use of tongue exercises and training contours have been suggested to aid in improved tongue posture [41–43, 45].

Oral Characteristics: The Neutral Zone

The neutral zone is an area within the oral cavity where outward forces originating from the tongue are neutralized by inward forces originating from the lips and cheeks [46–49]. The approximate facio-lingual width of the neutral zone can be evaluated by instructing the patient to open the mouth, permitting assessment of available space between the tongue and adjacent lips/cheeks. In so doing, the neutral zone may be qualified as restricted (Figure 1.19a), reduced (Figure 1.19b), or optimal (Figure 1.19c). As will be detailed later in this text, the neutral zone is used as a convenient guide to develop physiologic contours for the polished surfaces of the mandibular denture and for determining physiologically appropriate facio-lingual tooth positions.

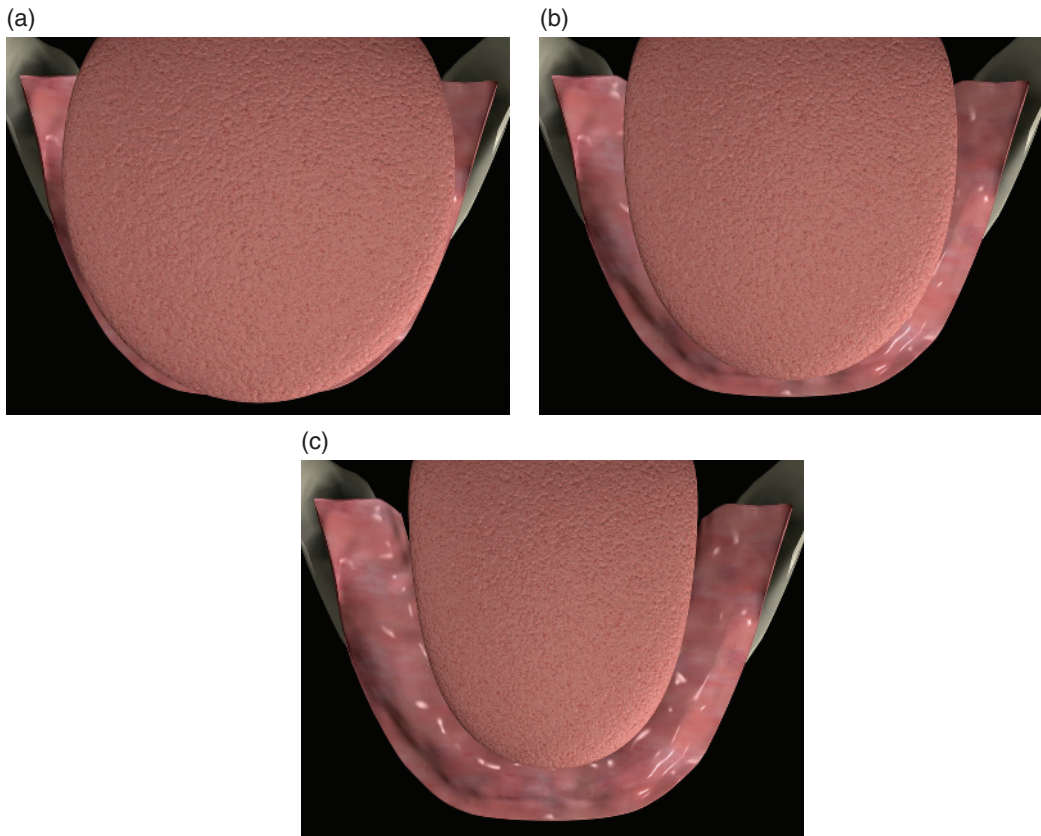


Figure 1.19 (a) Restricted neutral zone; (b) reduced neutral zone; (c) optimal neutral zone.

Summary

Specific factors discernible during careful and detailed examination of edentulous patients permit development of an accurate therapeutic prognosis and provide critical information for optimal treatment. Following thorough patient assessment, the treatment prognosis should be classified as optimal, moderate, compromised, or guarded. Improvement of the denture foundation by tissue conditioning, preprosthetic surgery, and/or placement of dental implants may enhance the prognosis. Healthy and stable temporomandibular joints improve the overall prognosis and are a prerequisite for definitive prosthodontics therapy.

The assumption that patients understand our diagnostic findings and treatment recommendations can be a major cause of patient dissatisfaction. Patients must be thoroughly educated and regularly reminded

with respect to compromising factors identified during the initial assessment that will adversely affect treatment and expected outcomes. Patients informed early in the therapeutic process appreciate obstacles to optimal treatment, whereas explanations provided only after problems are encountered tend to be looked upon as excuses. It is important to avoid initiating therapy for patients who do not understand, or refuses to accept, limitations of proposed treatment. Additionally, patients must appreciate fees, prosthesis replacement frequency, and regular maintenance requirements as a critical element of informed consent prior to initiating treatment. To this end, a software application incorporating a carefully organized examination form has been developed by the authors to aid in examination, diagnosis, treatment planning, and prognosis for complete denture patients.

References

- 1 Sato, Y., Tsuga, K., Akagawa, Y., and Tenma, H. (1998) A method for quantifying complete denture quality. *J Prosthet Dent*, **80**, 52–57.
- 2 Barone, J. V. (1964) Diagnosis and prognosis in complete denture prosthesis. *J Prosthet Dent*, **14**, 207–213.
- 3 House, M. M. (1958) The relationship of oral examination to dental diagnosis. *J Prosthet Dent*, **8**, 208–219.
- 4 McGarry, T. J., Nimmo, A., Skiba, J. F. et al. (1999) Classification system for complete edentulism. *J Prosthodont*, **8**, 27–39.
- 5 Atwood, D. A. (1971) Reduction of residual ridges: A major oral disease entity. *J Prosthet Dent*, **26**, 266–279.
- 6 Neil, E. (1932) *Full Denture Practice*. Marshall & Bruce, Nashville, TN, pp. 14–16, 81–83.
- 7 Winkler, S. (2005) House mental classification system of denture patients: The contribution of Milus M. House. *J Oral Implantol*, **31**, 301–303.
- 8 Koper, A. (1970) The initial interview with complete-denture patients: its structure and strategy. *J Prosthet Dent*, **23**(6), 590–597.
- 9 Engelmeier, R. L., and Phoenix, R. D. (1996) Patient evaluation and treatment planning for complete-denture therapy. *Dent Clin North Am*, **40**, 1–18.
- 10 Jamieson, C. H. (1958) Geriatrics and the denture patient. *J Prosthet Dent*, **1**, 8–13.
- 11 Pickett, H. G., Appleby, R. G., and Osborn, M. O. (1972) Changes in the denture supporting tissues associated with the aging process. *J Prosthet Dent*, **27**(3), 257–262.
- 12 Silverman, S. (1958) Geriatrics and tissue changes – problem of the aging denture patient. *J Prosthet Dent*, **8**, 734–739.
- 13 Lang, B. R. (1994) A review of traditional therapies in complete dentures. *J Prosthet Dent*, **72**, 538–542.
- 14 Niiranen, J. V. (1954) Diagnosis for complete dentures. *J Prosthet Dent*, **4**, 726–738.

- 15 Ettinger, R. L. (2014) Dentures, in *The Encyclopedia of Elder Care. The Comprehensive Resource on Geriatric Health and Social Care*, 3rd edn (eds.: E. A. Capezutti, M. L. Malone, P. R. Katz, and M. D. Mezey). Springer, New York, NY, pp. 211–214.
- 16 Gibson, R. M. E. (1967) Panographic survey of edentulous mouths. Thesis. University of Michigan, Ann Arbor, MI, p. 43
- 17 Niswonger, M. E. (1934) The rest position of the mandible and the centric relation. *J Am Dent Assoc*, **21**, 1572–1582.
- 18 Massad, J. J., Connelly, M. E., Rudd, K. D., et al. (2004) Occlusal device for diagnostic evaluation of maxillomandibular relationships in edentulous patients: a clinical technique. *J Prosthet Dent*, **91**, 586–590.
- 19 Angle, E. H. (1899) Classification of malocclusion. *Dent Cosmos*, **41**, 248–264.
- 20 Jacobson, T. E., and Krol, A. J. (1983) A contemporary review of the factors involved in complete dentures. Part II: Stability. *J Prosthet Dent*, **49**, 165–172.
- 21 Wiener, R. C., Wu, B., Crout, R., et al. (2010) Hyposalivation and xerostomia in dentate older adults. *J Am Dent Assoc*, **141**, 279–284.
- 22 Sreebny, L. M. (1968) The role of saliva in prosthodontics. *Int Dent J*, **18**, 812–822.
- 23 Kawazoe, Y., and Hamada, T. (1978) The role of saliva in retention of maxillary complete dentures. *J Prosthet Dent*, **40**, 131–136.
- 24 Sheppard, I. M., and Sheppard, S. M. (1965) Maximal incisal opening – a diagnostic index? *J Dent Med*, **20**, 13–15.
- 25 McHorris, W. H. (1974) TMJ dysfunction – Resolution before reconstruction. *J Eur Acad Gnathology*, **1**, 16–32.
- 26 The glossary of prosthodontic terms, 8th edition (2005) *J Prosthet Dent*, **94**, 63.
- 27 Carlsson, G. E. (1998) Clinical morbidity and sequelae of treatment with complete dentures. *J Prosthet Dent*, **79**, 17–23.
- 28 Costello, B. J., Betts, N. J., Barber, H. D., and Fonseca, R. J. (1996) Preprosthetic surgery for the edentulous patient. *Dent Clin North Am*, **40**, 19–38.
- 29 Tallgren, A. (1972) The continuing reduction of the residual alveolar ridges in complete denture wearers: a mixed-longitudinal study covering 25 years. *J Prosthet Dent*, **27**(2), 120–132
- 30 Smith, D. E., Kydd, W. L., Wykhuis, W. A., and Phillips, L. A. (1963) The mobility of artificial dentures during comminution. *J Prosthet Dent*, **13**, 839–856
- 31 Kelly, E. K. (1966) The prosthodontist, the oral surgeon, and the denture-supporting tissues. *J Prosthet Dent*, **16**, 464–478.
- 32 Jahangiri, L., Devlin, H., Ting, K., and Nishimura, I. (1998) Current perspectives in residual ridge remodeling and its clinical implications: a review. *J Prosthet Dent*, **80**(2), 224–237.
- 33 Appleby, R. C., and Ludwig, T. F. (1970) Patient evaluation for complete denture therapy. *J Prosthet Dent*, **24**, 11–17.
- 34 Yrastorza, J. A. (1963) Surgical problems in edentulous jaws associated with denture construction: a review. *J Oral Surg Anesth Hosp Dent Serv*, **21**, 202–209.
- 35 Miller, E. L. (1976) Sometimes overlooked: preprosthetic surgery. *J Prosthet Dent*, **36**, 484–490.
- 36 Arbree, N. S., Yurkstas, A. A., and Kronman, J. H. (1987) The coronomaxillary space: literature review and anatomic description. *J Prosthet Dent*, **57**(2), 186–190.
- 37 Massad, J. J., Ahuja, S., and Cagna, D. (2013) Implant overdentures: selections for attachment systems. *Dent Today*, **32**(2), **128**, 130–132.
- 38 Sheppard, I. M., Sheppard, S. M. (1965) Maximal incisal opening – a diagnostic index? *J Dent Med*, **20**, 13–15.
- 39 Levin, B. (1981) Current concepts of lingual flange design. *J Prosthet Dent*, **45**, 242–252.
- 40 Neil, E. (1941) *The Upper and the Lower – A Simplified Full Denture Impression Procedure*. Chicago: Coe Laboratories, Inc., pp. 75–149.

- 41 Wright, C. R., Swartz, W. H., and Godwin, W. C. (1961) *Mandibular Denture Stability – A New Concept*. Ann Arbor: The Overbeck Co. Publishers, pp. 7–17.
- 42 Wright, C. R. (1966) Evaluation of the factors necessary to develop stability in mandibular dentures. *J Prosthet Dent*, **16**, 414–430.
- 43 Wright, C. R., Muyskens, J. H., Strong, L. H., *et al.* (1949) A study of the tongue and its relation to denture stability. *J Am Dent Assoc*, **39**, 269–275.
- 44 Kingery, R. H. (1936) Examination and diagnosis preliminary to full denture construction. *J Am Dent Assoc*, **23**, 1707–1713.
- 45 Kuebker, W. A. (1984) Denture problems: causes, diagnostic procedures, and clinical treatment. I. Retention problems. *Quintessence Int*, **10**, 1031–1044.
- 46 Fish, E. W. (1933) Using the muscles to stabilize the full lower denture. *J Am Dent Assoc*, **20**, 2163–2169.
- 47 Fish, E. W. (1964) *Principles of Full Denture Prosthesis*, 6th edn. Staples, London, pp. 36–37.
- 48 Schiesser, F. J. (1964) The neutral zone and polished surfaces in complete dentures. *J Prosthet Dent*, **14**, 854–865.
- 49 Ries, G. E. (1978) The neutral zone as applied to oral and facial deformities, in *Neutral Zone in Complete and Partial Dentures* (eds V. E. Beresin and F. J. Schiesser). 2nd edn. Mosby, St. Louis, MO, pp. 208–220.

