SPECIAL SECTION

Treatment of Edentulism: Optimizing Outcomes with Tissue Management and Impression Techniques

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Abstract

Significant numbers of patients throughout the world seek treatment for edentulism. The trend toward tissue-integrated prostheses has been a monumental step in restoring edentulous patients to function; however, this treatment can be out of reach for those who fail to qualify or those who do not have sufficient resources to afford it. In these cases, conventional dentures remain an important primary course of treatment. Attention to detail when diagnosing, treatment planning, and performing treatment for these patients is still a prime consideration for the best possible outcome. In particular, many experienced denture wearers are afflicted with chronically inflamed denture-bearing mucosa. Clinicians must recognize the need for tissue conditioning, choices of impression materials, and accepted fabrication techniques that can have favorable outcomes when matched with patients who are philosophical and realistic in their expectations. The purpose of this article is to review impression philosophies, associated materials, and methods of tissue conditioning. Retention and stability of the denture bases can be augmented by the routine use of denture adhesive, and indications for use of denture adhesive will be discussed.

Edentulous patients often seek treatment for replacement of their missing teeth for improvements in esthetics, function, and speech. According to recent studies, the incidence of edentulism worldwide has shown a decline, and the demand for treatment may be different than what it was several decades ago.[1-5] Despite this decline, however, there will be an increase in those adults in the United States who will need at least one or two complete dentures by the year 2020.[6] Further, there will be significant need for these patients to maintain their complete dentures due to residual ridge resorption phenomenon and material wear.

Successful outcomes of complete denture therapy have been associated with three variables: pretreatment expectations, satisfaction with the dental care received, and mental health.[7] Many patients who seek treatment for edentulism may fall into one of several personality classifications as described by House[8] and more recently by Gamer et al.[9] As a result of these classifications, patients and practitioners alike can be placed into one of several divisions based on their expectations from past treatment with complete dentures. Many patients who seek treatment for edentulism have realistic expectations in their ability to eat foods they desire, the esthetics they desire to achieve, and their overall psychologic improvement.[10] The ACP classification of edentulism is based primarily on anatomic factors and other modifiers to arrive at a diagnostic index.[11] With questionnaires and evaluations, it is important for clinicians to quantify the patient's level of satisfaction with his/her current prostheses as a predictor of the treatment outcome.[12] This can facilitate arriving at a diagnosis that aids in developing a prognosis when considering differential treatment. In fact, just the ability to masticate comfortably with newly fabricated dentures often leads to a more favorable result based on a patient's own perceptions.[13] From a predictive standpoint, this has been validated with a screening questionnaire that identifies which type of patient may benefit from such intervention;[14] however, some patients are maladaptive in their ability to tolerate conventional removable prosthodontic treatment and may require more advanced treatments.[15] The advent of osseointegration has vastly improved the outcome related to treating edentulous patients;[16] however, the treatment requirements involved with using an osseointegration protocol may preclude some patients from participating. Additionally, the resources needed to

provide even simplistic implant treatment may be out of reach financially for many patients. In some circumstances, osseointegrated implants in augmented jaws when compared to the results with newly fabricated conventional complete dentures do not always lead to a superior patient-perceived improvement over complete denture wear.[17] Therefore, the use of conventional denture treatment is the mainstay of treatment for many of these patients.

Human life expectancy has significantly increased over the last several decades,[18,19] resulting in many elderly patients medically managed with a myriad of pharmacologic regimens.[20,21] As such, many of these patients have drug interactions and drug side effects, which may predispose their oral environments to xerostomia. Dry mouth coupled with compromised denture-bearing tissues may render complete dentures intolerable. Even the most carefully selected patient and meticulous attention to technique may be insufficient to surpass the difficulties encountered with salivary dysfunction. Assuming proper adaptation of the denture base is obtained, the routine use of denture adhesives in xerostomic patients can help augment denture base contact with oral mucosa.[22]

Historical approach to denture fabrication-definitive impressions

Approaches to treating edentulous patients have been outlined over the last century and formed the foundation of philosophies for occlusion,[23,24] esthetics,[25-27] mandibular movement,[28] maxillofacial prosthodontics,[29,30] and other subdisciplines of prosthodontics.[31] These focus areas are all fundamental to complete denture fabrication, contributing their unique importance to the entire treatment. The impression technique has been a large area of focus due to its special consideration specific to each case.[32-34] It may be agreed upon that materials influenced impression techniques in the past, despite the criticism that this is an empiric approach.[35,36] Many impression materials have specific applications based on their unique properties. Conversely, as impression philosophy has changed and developed, concurrent development and application of newer materials have also taken place. The treatment of edentulous patients has historically undertaken a standard technique whereby the type of impression subscribes to one of several impression philosophies.[37]

The selective pressure technique has a long history of development, with impressions being made with vegetable or inorganic-based materials as far back as in the 1700s.[38] Frequently, a wash of wax, gutta-percha, or plaster was made inside a primary impression made with modeling plastic compound.[39,40] Some of these concepts were advocated by the Green Brothers in 1907 and were considered a significant advance in impression making.[41] Distinctions were made for maxillary and mandibular impressions, as it was recognized that there were significant differences between the two.[42,43] It was realized early on that excessive pressure applied to the edentulous maxilla could create significant tissue distortion. Therefore, a portion of the primary impression was removed to create space for secondary impression material that alleviated pressure created during the first phase of the impression. A variant of this technique was to create a vacuum on the tissue side using low-fusing material such as Adaptol (Kaye Research Laboratories, Ashaway, RI) to border-mold and create an effective seal (Figs 1, 2).[44] These techniques all used an open-mouth approach for creating a border seal with selectively directed pressure areas. More recent descriptions of border-molding techniques advocate the use of either polyether material or heavy body vinylpolysiloxane.[45,46] Border molding with heavy consistency polyether material has been suggested as an easier technique than impression modeling compound as its flow and temperature requirements are better achieved without overextending the base or potentially damaging tissue with superheated material. Additionally, polyether can be easily shaped or added to for modification after it has been formed. Other materials such as Iso Functional (GC Corporation, Tokyo, Japan) (Figs 3, 4) can provide this functional molding of the denture borders without trauma or undue tissue distortion. A properly extended custom tray is needed that is 2 to 4 mm short of full extension to accommodate space for border-molding materials. With the use of carefully constructed and border-molded custom trays, these steps are also achievable and result in a predictable outcome. Most of these techniques are applied in some fashion for obtaining impressions of edentulous arches today[47,48] (Figs 5, 6).

The mucostatic technique was discussed some years ago by Page[49] and was largely controversial due to its nonuniformity of application.[50] Mucostatic impressions were based on the use of recording materials that duplicated the tissues in a passive state. The borders of the dentures were also confined to only the stress-bearing mucosal areas, and were not refined to make a border seal.[44] The choices of impression material in these cases were thin zinc oxide eugenol pastes that accurately recorded the denture-bearing areas.

Although somewhat similar in principle to the mucostatic technique, the pressure-less or minimal pressure technique was different in tray design and choice of impression material. Light to heavy body elastomeric materials caused tissue displacement phenomena and could be anticipated to cause some distortion with their use.[37] The use of alternative materials such as thin mixes of alginate or zinc oxide eugenol pastes generated less pressure based on their flow properties.[51] Custom tray design has been suggested to include relief and escape holes to aid in reducing the pressures generated during the impression.[52] These combined features can reduce the pressures by almost half what is encountered without these features;[51] however, other studies do not support this finding and depict more of the choice of material used as a correlation of pressure generation.[53]

Functional impressions

Impressions can also be made with a closed-mouth technique, including a functional impression protocol that uses patients' musculature in stabilizing a record base or occlusion rim. This philosophy was introduced in the early 1900s[54] and often used wax,[55] modeling plastic compound, or more recently, tissue-conditioning material. As described later, many experienced denture wearers have some degree of alveolar resorption with

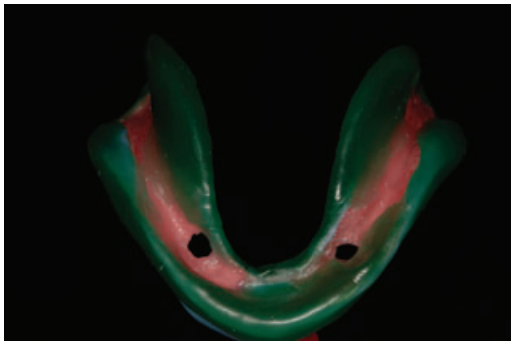

Figure 1 Border-molded custom tray with Adaptol® material to achieve peripheral seal.

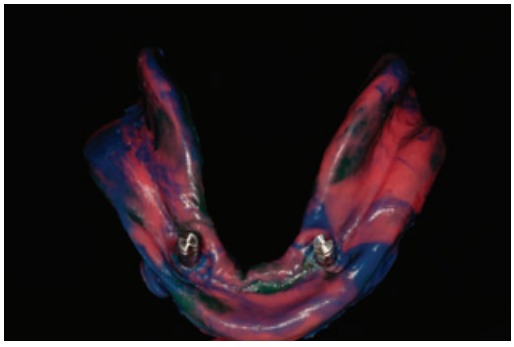

Figure 2 Secondary wash impression with polyether impression material. Implant analogs are in place.

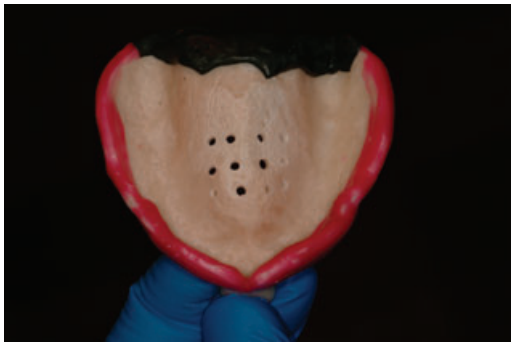

Figure 3 Border-molded custom tray using Iso Functional® material to capture peripheral tissues.

Figure 4 Secondary impression with vinylpolysiloxane material.

Figures 5 Border-molded impression tray with plastic modeling compound.

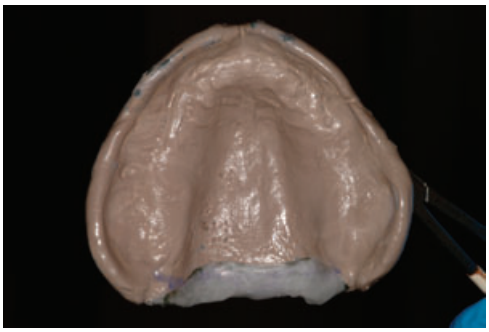

Figure 6 Rubber base secondary impression with functional use of mouth temperature wax to create a functional posterior palatal seal.

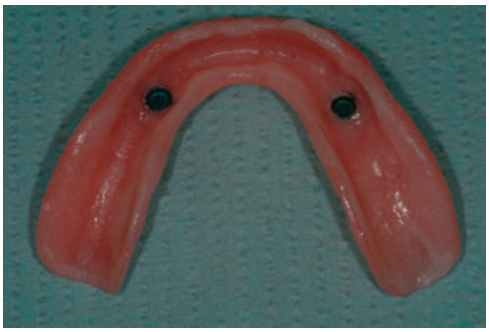

Figure 7 Tissue surface of functional impression/tissue conditioning with modified soft acrylic resin. Note matrix portion of stud attachment without intervening material.

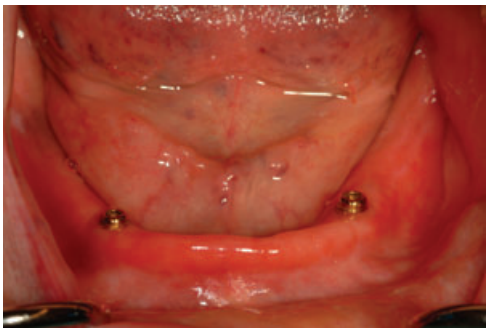

Figure 8 Patient treated for excessive pressure mucositis at day 1. Note erythema and edematous tissue surrounding and between the abutments.

some associated abused tissue. In these cases, the use of tissue conditioning material may compensate for these changes, occlusally stabilize the denture base, and obtain an impression simultaneously. This has been an adjunct in achieving healthy tissues, while obtaining a functionally accurate impression. To properly use the closed-mouth technique, well-fitting record bases, accurately occluding rims, and an acceptable vertical dimension is needed.[56] This technique may also be used for reline impressions of existing complete dentures and may be used with a linear or a branched denture construction technique. A linear technique is well understood and commences with recording of the tissues with impressions, recording centric position and eccentric pathways, trial tooth arrangements, and insertion procedures. A branched technique includes the use of a diagnostic prosthesis to accommodate for tongue thrusting habits, maxillomandibular discrepancies and other scenarios that create difficulties in obtaining comfort and function with complete dentures.[57] This diagnostic prosthesis aids in making the functional impression and gives indication if the patient can comfortably function. The functional impression is inclusive within the branched technique and is effective in achieving an accurate recording in relation to stable occlusal relationships.

The use of functional impression material, such as a tissue conditioner, in its flowable state, accurately records the tissues in a functional state. These soft acrylic resins do not set hard. They have properties that allow them to flow when forces are placed upon them, optimizing the shape and distribution of the material dependent upon the functional displacement of the tissue beneath the denture base. Some tissue conditioners have extended periods of flow, conforming to tissues during several hours of eating, speaking, and swallowing. After a suitable evaluation period of several days, the patient returns, the denture base is inspected for retention and stability, and, if satisfactory, it is invested and cast in newly polymerized acrylic resin[57,58] (Fig 7).

Other products have been introduced recently, including anatomically correct impression trays, which can be modified by the use of heat molding, adaptation, and refinement with elastomeric materials. With repeated practice, the use of these trays can allow for a definitive impression to be accomplished in a single visit.[59]

These impression philosophies may also be considered for edentulous patients treated with dental implants. Dependent upon the number of implants, these patients should be treated differently in that the majority of the load may be supported by dental implants. In implant-retained or -supported prostheses, high pressure areas can be adjusted, or the attachment mechanisms modified without significant loss of retention. This is not the case for conventional complete denture impressions where extended coverage and intimate base adaptation are essential to stability and retention. Complete but judicious extension of the impression into all possible supportive and retentive areas is the goal for conventional complete denture impression techniques.

Tissue conditioning

Understanding complete denture prostheses mandates an understanding of residual ridge resorption. It is also imperative that patients understand that residual ridge resorption is inevitable, and prostheses need to be modified appropriately to compensate for these changes on a timely, recurring basis. Residual ridge resorption has been reported and discussed by Tallgren,[60] Atwood,[61,62] and others.[63,64]

In light of changes inherent in edentulous jaws, continued use of complete dentures without prosthetic compensation (i.e., relining or rebase procedures) can result in significantly abused tissues. One of the key physical findings identifying abused tissues is the recognition of surface texture and color. Mobile tissues are especially susceptible to injury and are often found in anterior areas where combination syndrome has been identified.[65] Other commonly damaged areas are tissues in a chronic excessive state of positive or negative pressure (Figs 8–10). This diseased soft tissue state can be associated with overdentures where implants or natural teeth have been used as abutments. Some circumstances can precipitate formation of abused tissues in edentulous jaws:

(1) Tissues recorded with a nonactive impression protocol
(2) Denture wear has traumatized the supporting tissues
(3) Chronic infection
(4) Poor denture base adaptation.

To reverse inflamed tissues to a state of health, the tissues will often benefit from conditioning techniques. From the work of Lytle[66] and others,[67,68] it is important to understand that conditioning may favorably change the edentulous tissues in a way so that complete dentures may be successfully worn. Impressions of healthy tissues will be beneficial to maintaining health.

To accomplish tissue conditioning, it is preferable to use soft acrylic resin polymers, although zinc oxide eugenol pastes and silicone impression materials have also been suggested.[69,70] Uniform reduction of the intaglio denture surface (1 to 2 mm) should create sufficient space for the material. This can be done with a marking pen and depth cutting bur to insure uniformity. Modified acrylic resin materials are composed of conventional poly-methyl methacrylate (PMMA) beads and a liquid preparation of ester and ethyl alcohol. When mixed, these substances gel and become resilient. In time, the alcohol evaporates, and the material becomes progressively harder. To maintain the softness and conditioning effect of the material, it is important to change all the material every 3 to 4 days.[71,72] One way to minimize this hardening phenomenon is to preserve resiliency by sealing it with a surface coating agent such as J-305 monopoly syrup (Factor II, Inc., Lakeside AZ) or Microseal (Kay See dental, Kansas City, MO).[73] These materials are light cured after application to slow the evaporation of alcohols and keep the material resilient, thereby conditioning the underlying tissues longer. Although objectionable to many patients, a more expedient tissue response is seen when the dentures are completely removed from use. A slower response is seen when the soft tissue conditioning technique described above is used over 10 to 14 days.[74]

Improving fit to underlying tissues

Due to the polymerization shrinkage associated with PMMA resin, adaptation of the intaglio surface of complete dentures

Figure 9 This image demonstrates partial resolution of erythema after tissue conditioner was applied 48 hours previously.

Figure 10 This image shows progress at 5 days. Note decreased tissue height around the abutments.

Figure 11 Occlusal view of a clear denture base to be used as a definitive denture base. Note the finish line for secondary addition of acrylic resin.

Figure 12 Suggested application of denture adhesive to the intaglio surface of a maxillary denture that minimizes excessive use.

Figure 13 Clinical images of complete dentures in centric occlusion. These dentures have been fabricated with the traditional processing technique to produce color and surface texture.

may have uneven pressure distribution. To ensure uniform pressure distribution, using a processed acrylic resin denture base has been advocated.[75,76] Also, the use of this technique in incrementalizing contraction of acrylic resin leads to greater occlusal accuracy upon processing. Jacob and Yen[77] and others[78-80] have popularized this technique in conventional and maxillofacial prosthetic cases and have produced fewer occlusal processing errors and improved the level of fit. The use of clear acrylic resin bases allows a better assessment on the fit of these bases covering tissues or implant substructures. The use of light-cured urethane dimethacrylate bases has recently become available (Eclipse™, Dentsply, York, PA) and can expedite the processing time and result in more intimate adaptation between the denture base and the underlying supporting tissues.[81] Additionally, this material shows a higher transverse strength than conventional heat-processed acrylic resins[82] (Fig 11).

Processing techniques are another consideration for improvement of fit and material quality of complete dentures. The biggest discrepancy in denture construction appears to be that of the acrylic resin processing. The classic use of compression molding acrylic resin has been well accepted for the last 70 years.[83,84] In recent years, it has been shown that injection molding techniques can improve the level of fit and adaptation

Figure 14 Maxillary complete denture fabricated with a characterized tinted denture to simulate soft tissues. (Courtesy Robert E. Kreyer, CDT).

of processed acrylic resin to the underlying stone cast.[85] Such injection molding techniques allow less dimensional change upon processing, thereby improving adaptation of the denture base to the underlying tissues. Craig has cited that linear dimensional change of acrylic resin approximates 6%.[86] Comparisons of the accuracy of compression and injection molding have been disputed over the years;[87,88] however, the most recent data indicate that injection molding is better than compression molding.[89–91] Although residual monomer content in injection molding is said to be similar to that of compression molding techniques, this may be more related to the length of processing rather than the technique itself.[92] Injection molding techniques, however, do not lend themselves to use in reline procedures, which are best accomplished by compression molding.

Improving patient acceptance

The use of denture adhesives has been met with mixed reception from practitioners, but most agree that denture adhesives can be used as a helpful adjunct to conventional complete denture treatment.[93] Assuming proper denture construction and optimal fit to healthy tissues, denture adhesives have several indications.

Denture adhesives:

(1) can be used for stabilization of trial denture bases and immediate dentures
(2) may assist xerostomic patients with complete denture wear[94]
(3) may help mentally handicapped or elderly patients with adapting to and using new complete dentures
(4) can stabilize dentures against newly rehabilitated jaws with osseointegrated implants, and tissue-supported removable partial dentures.[22,95,96]

Contraindications for using denture adhesives are primarily ill-fitting prostheses.[22] Concern for masking underlying pathology may be an important contraindication for using denture adhesives as changes in denture base adaptation to the edentulous tissues should be suspect. As with other modes of therapy, regular care and discretionary follow-up are suggested.

The appropriate application of denture adhesive has been suggested to be in small pea-sized increments distributed throughout the denture base, as needed based on retention or lack thereof (Fig 12). This helps establish guidelines that may prevent overuse and excessive intake of material.[97] Zinc additions to denture adhesives were introduced in the 1980s to increase adhesive properties.[22] The effect of zinc copper depletion has been potentially implicated with neurological disease, where significant overuse and ingestion of the material is suspected.[98] Patients treated for this problem benefited from copper supplementation and cessation of denture adhesive use.

The use of patient-based outcomes can be further enhanced with custom tinting acrylic resin denture bases. Custom-tinted denture bases tend to yield a more realistic representation of soft tissue color and potentially better acceptance of the dentures. Incremental additions of tinted acrylic resin with the use of custom characterization kits (Candulor, USA, Inc., Los Angeles, CA) and the present-day selection of esthetic denture teeth have transcended the traditional denture acrylic resin red fiber appearance and provides patients with more natural esthetics (Figs 13, 14).[99]

Conclusions

Treatment of edentulous patients with specific impression techniques is often a topic of discussion when considering complete dentures for treating edentulous patients. To increase the prognosis for favorable outcomes, it is important that the appropriate patient personality be identified to understand realistic outcomes and limitations of treatment. Second, it is also critical to assess tissue health and determine if a conventional linear sequence of denture construction will be appropriate. Impression techniques can be selected based on the present state of basal tissue support; for instance, firm tissues may be well recorded with a spaced custom tray using elastomeric material. The use of processed denture bases where there is compromised support, significant maxillomandibular discrepancy, and neuromuscular deficits may enhance the recording of centric relation and minimize occlusal processing errors. Contemporary materials and processing techniques also optimize the chances of providing patients with well-constructed, well-fitting prostheses. Additionally, attention to esthetics with custom base tinting and realistic tooth selection can help optimize patient acceptance of treatment. The routine use of denture adhesives with specific indications has also been advocated to have an augmentative role in optimizing retention and stability of the complete denture prostheses.

TIPS FOR THE PRACTICING DENTIST

1. For patients who are wearing complete dentures requiring refabrication, ensure soft tissue health by serially relining with a 10- to 14-day period of conditioning with soft acrylic resin every 3 to 4 days. Alternatively, patients should leave their dentures out of the mouth for 48 hours prior to impressioning.
2. Use border-molded custom trays with relief for nonload-bearing tissues to record tissues in a state of displacement for selective pressure distribution. The choice of an elastomeric material should be based on flow properties and relative surface area to be recorded. For example, high flow materials should be used for the edentulous maxilla, and higher viscosity materials should be used for the mandible.
3. Where sufficient interarch distance exists, it is suggested to use injection-molded processed bases to aid in obtaining accurate interocclusal registration, decreased occlusal errors, and improved base adaptation. Insertion steps for complete dentures should follow laboratory and clinical remount verification procedures to minimize clinical impact of processing errors along with standard adaptation assessment with pressure indicating mediums.

References

1. Osterberg T, Carlsson GE, Sundh V, et al: Number of teeth–a predictor of mortality in 70-year-old subjects. Community Dent Oral Epidemiol 2008;36:258-268
2. Dye BA, Tan S, Smith V, et al: Trends in oral health status: United States, 1988–1994 and 1999–2004. Vital Health Stat 2007;248:1-92
3. Chattopadhyay A, Arevalo O, Cecil JC, 3rd: Kentucky's oral health indicators and progress towards healthy people 2010 objectives. J Ky Med Assoc 2008;106:165-174
4. Armour BS, Swanson M, Waldman HB, et al: A profile of state-level differences in the oral health of people with and without disabilities, in the U.S., in 2004. Public Health Rep 2008;123:67-75
5. Zitzmann NU, Hagmann E, Weiger R: What is the prevalence of various types of prosthetic dental restorations in Europe? Clin Oral Implants Res 2007;18(Suppl 3):20-33
6. Douglass CW, Shih A, Ostry L: Will there be a need for complete dentures in the United States in 2020? J Prosthet Dent 2002;87:5-8
7. Diehl RL, Foerster U, Sposetti VJ, et al: Factors associated with successful denture therapy. J Prosthodont 1996;5:84-90
8. House M: Full denture technique. In Conley FJ, Dunn AL, Quesnell AJ, et al (eds): Classic Prosthodontic Articles: A Collector's Item. Chicago, IL, American College of Prosthodontists, 1978
9. Gamer S, Tuch R, Garcia LT: M. M. House mental classification revisited: intersection of particular patient types and particular dentist's needs. J Prosthet Dent 2003;89:297-302
10. Lechner SK, Roessler D: Strategies for complete denture success: beyond technical excellence. Compend Contin Educ Dent 2001;22:553-559; quiz 60
11. McGarry TJ, Nimmo A, Skiba JF, et al: Classification system for complete edentulism. J Prosthodont 1999;8:27-39
12. Awad MA, Shapiro SH, Lund JP, et al: Determinants of patients' treatment preferences in a clinical trial. Community Dent Oral Epidemiol 2000;28:119-125
13. Garrett NR, Kapur KK, Perez P: Effects of improvements of poorly fitting dentures and new dentures on patient satisfaction. J Prosthet Dent 1996;76:403-413
14. Allen PF, McMillan AS, Walshaw D: A patient-based assessment of implant-stabilized and conventional complete dentures. J Prosthet Dent 2001;85:141-147
15. Zarb GA, Schmitt A: The longitudinal clinical effectiveness of osseointegrated dental implants: the Toronto Study. Part II: the prosthetic results. J Prosthet Dent 1990;64:53-61
16. Adell R, Lekholm U, Rockler B, et al: A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg 1981;10:387-416
17. Kimoto K, Garrett NR: Effect of mandibular ridge height on patients' perceptions with mandibular conventional and implant-assisted overdentures. Int J Oral Maxillofac Implants 2005;20:762-768
18. Minino AM, Heron MP, Smith BL: Deaths: preliminary data for 2004. Natl Vital Stat Rep 2006;54:1-49
19. Hoyert DL, Heron MP, Murphy SL, et al: Deaths: final data for 2003. Natl Vital Stat Rep 2006;54:1-120
20. Carter LM, McHenry ID, Godlington FL, et al: Prescribed medication taken by patients attending general dental practice: changes over 20 years. Br Dent J 2007;203:E8; discussion 200-201
21. Jainkittivong A, Aneksuk V, Langlais RP: Medical health and medication use in elderly dental patients. J Contemp Dent Pract 2004;5:31-41
22. Grasso JE: Denture adhesives. Dent Clin North Am 2004;48:721-733
23. Monson GS: Applied mechanics to the theory of mandibular movements. Dental Cosmos 1932;74:1039-1053
24. Payne SH: A comparative study of posterior occlusion. J Prosthet Dent 1952;2:661-666
25. Vig RG, Brundo GC: The kinetics of anterior tooth display. J Prosthet Dent 1978;39:502-504
26. Frush JP: The dynesthetic interpretation on the dentogenic concept. J Prosthet Dent 1958;8:558-551
27. Frush JP: Introduction to dentinogenic restorations. J Prosthet Dent 1955;5:586-595
28. Gysi A: Simplifying the correct articulation of artificial teeth. Dent Digest 1913;19:1-8
29. Curtis TA, Griffith MR, Firtell DN: Complete denture prosthodontics for the radiation patient. J Prosthet Dent 1976;36:66-76
30. Kelly EK: Retentive dentures for patients with mutilated jaws. J Am Dent Assoc 1965;71:1419-1425
31. Pound E: Utilizing speech to simplify a personalized denture service. J Prosthet Dent 1970;24:586-600
32. Zinner I, Sherman H: An analysis of the development of complete denture impression techniques. J Prosthet Dent 1981;46:242-249
33. Drago CJ: A retrospective comparison of two definitive impression techniques and their associated postinsertion adjustments in complete denture prosthodontics. J Prosthodont 2003;12:192-197
34. Devan M: Basic principles of impression making. J Prosthet Dent 1952;2:26
35. Petrie CS, Walker MP, Williams K: A survey of U.S. prosthodontists and dental schools on the current materials and methods for final impressions for complete denture prosthodontics. J Prosthodont 2005;14:253-262
36. Firtell DN, Koumjian JH: Mandibular complete denture impressions with fluid wax or polysulfide rubber: a comparative study. J Prosthet Dent 1992;67:801-804
37. Koran A: Impression materials for denture bearing mucosa. Dent Clin North Am 1980;24:97-111
38. Lindsay L: A Short History of Dentistry. London, John Bale and Sons and Danielsson, 1933
39. Turner C, Anthony L: American Textbook of Prosthetic Dentistry (ed 1). Philadelphia, PA, Lea and Febiger, 1928
40. Tench R: Impressions for dentures. J Am Dent Assoc 1934;21:1005-1018
41. Greene J: "Greene Brothers" Clinical Course in Dental Prostheses, Revised Edition. Detroit, MI, Detroit Dental Manufacturing Company, 1913
42. Neil E: The Master Impression: An Important Feature of Standardized Full Denture Practice (ed 4). Nashville, TN, Marshall Bruce Co., 1932
43. Schlosser R: Complete Denture Prosthesis. Philadelphia, PA, Saunders, 1939
44. Heartwell CM: Syllabus of Complete Dentures (ed 2). Philadelphia, PA, Lea and Febiger, 1974
45. Smith DE, Toolson LB, Bolender CL, et al: One-step border molding of complete denture impressions using a polyether impression material. J Prosthet Dent 1979;41:347-351
46. Chaffee NR, Cooper LF, Felton DA: A technique for border molding edentulous impressions using vinyl polysiloxane material. J Prosthodont 1999;8:129-134
47. Massad JJ, Cagna DR: Immediate complete denture impressions: case report and modern clinical technique. Dent Today 2008;27:58,60,62-65

48. Cagna DR, Massad JJ: Vinyl polysiloxane impression material in removable prosthodontics. Part 2: immediate denture and reline impressions. Compend Contin Educ Dent 2007;28:519-526; quiz 27-28
49. Page H: Mucostatics-A Principle Not A Technique. Chiacgo, IL, published by author, 1946
50. Tuckfeld W: Review of impression techniques in full denture prosthesis. Int Dent J 1950;1:112-130
51. Frank RP: Analysis of pressures produced during maxillary edentulous impression procedures. J Prosthet Dent 1969;22:400-413
52. Campbell D: Full Denture Prosthesis. St. Louis, MO, Mosby, 1924
53. Masri R, Driscoll CF, Burkhardt J, et al: Pressure generated on a simulated oral analog by impression materials in custom trays of different designs. J Prosthodont 2002;11:155-160
54. Lieberthal R: Advanced Impression Taking. New York, NY, Professional Publishing Company, 1919
55. Schlosser R, Gehl D: Complete Denture Prosthesis (ed 3). Philadelphia, PA, Saunders, 1953
56. Winkler S: Essentials of Complete Denture Prosthodontics. Philadelphia, PA, Saunders, 1979
57. Pound E: Personalized Denture Procedures Dentist's Manual. Anaheim, CA, Denar Corporation, 1973
58. Grant A HJ, McCord JF: Complete Prosthodontics (ed 1). London: Mosby-Wolfe, 1994
59. Massad JJ, Cagna DR: Vinyl polysiloxane impression material in removable prosthodontics part 3: implant and external impressions. Compend Contin Educ Dent 2007;28:554-560; quiz 61
60. Tallgren A: The continuing reduction of the residual alveolar ridges in complete denture wearers: a mixed-longitudinal study covering 25 years. J Prosthet Dent 1972;27:120-132
61. Atwood DA: Reduction of residual ridges: a major oral disease entity. J Prosthet Dent 1971;26:266-279
62. Atwood DA: Bone loss of edentulous alveolar ridges. J Periodontol 1979;50:11-21
63. Lkeman PR, Watt DM: Morphological changes in the maxillary denture bearing area. A follow up 14 to 17 years after tooth extraction. Br Dent J 1974;136:500-503
64. Wical KE, Swoope CC: Studies of residual ridge resorption. I. Use of panoramic radiographs for evaluation and classification of mandibular resorption. J Prosthet Dent 1974;32:7-12
65. Kelly E: Changes caused by a mandibular removable partial denture opposing a maxillary complete denture. J Prosthet Dent 1972;27:140-150
66. Lytle R: Management of abused tissues in complete denture construction. J Prosthet Dent 1957;7:27-42
67. Chase W: Tissue conditioning utilizing Dynamic Adaptive Stress. J Prosthet Dent 1961;11:804-15
68. Dukes BS: An evaluation of soft tissue responses following removal of ill-fitting dentures. J Prosthet Dent 1980;43:251-253
69. Pound E. Preparatory dentures: A protective philosophy. J Prosthet Dent 1965;15:5-18
70. Lytle R: Compolete denture construction based on a study of the deformation of the underlying soft tissues. J Prosthet Dent 1959;9:539-551
71. Murata H, Iwanaga H, Shigeto N, et al: Initial flow of tissue conditioners–influence of composition and structure on gelation. J Oral Rehabil 1993;20:177-187
72. Graham BS, Jones DW, Sutow EJ: Clinical implications of resilient denture lining material research. Part II: Gelation and flow properties of tissue conditioners. J Prosthet Dent 1991;65:413-418
73. Malmstrom HS, Mehta N, Sanchez R, et al: The effect of two different coatings on the surface integrity and softness of a tissue conditioner. J Prosthet Dent 2002;87:153-157
74. Laney WR: Diagnosis and Treatment in Prosthodontics. Philadelphia, PA, Lea and Febiger, 1983
75. Brewer AA: Prosthodontic research in progress at the School of Aerospace Medicine. J Prosthet Dent 1963;13:49-69
76. Langer A: The validity of maxillomandibular records made with trial and processed acxrylic resin bases. J Prosthet Dent 1981;45:253-258
77. Jacob RF, Yen TW: Processed record bases for the edentulous maxillofacial patient. J Prosthet Dent 1991;65:680-685
78. Crane K: Processed bases for complete dentures. Trends Tech Contemp Dent Lab 1992;9:21-24
79. Thomas-Weintraub A, Weintraub GS: Processed permanent record bases in complete denture therapy: rationale and technique. Compend Contin Educ Dent 1985;6:660-665, 668
80. Jackson AD, Lang BR, Wang RF: The influence of teeth on denture base processing accuracy. Int J Prosthodont 1993;6:333-340
81. Gunji K: A basic study on newly developed light-curing resins–Fitness, flexural properties and bond strength to self-curing resins. Kokubyo Gakkai Zasshi 2005;72:7-12
82. Machado C, Sanchez E, Azer SS, et al: Comparative study of the transverse strength of three denture base materials. J Dent 2007;35:930-933
83. Souder W, Paffenbarger G: Physical properties of dental materials. In Office GP (ed): Circular C433 of the National Bureau of Standards. Washington, DC, National Bureau of Standards, 1942
84. Academy of DP: Final report of the workshop on clinical requirements of ideal denture base materials. J Prosthet Dent 1968;20:101-105
85. Ganzarolli SM, de Mello JA, Shinkai RS, et al: Internal adaptation and some physical properties of methacrylate-based denture base resins polymerized by different techniques. J Biomed Mater Res B Appl Biomater 2007;82:169-173
86. Craig R: Craig's Restorative Dental Materials (ed 12). St. Louis, MO, Elsevier, 2006
87. Jackson AD, Grisius RJ, Fenster RK, et al: Dimensional accuracy of two denture base processing methods. Int J Prosthodont 1989;2:421-428
88. Haug SP, Duke P, Dixon SE, et al: A pilot clinical evaluation of a new injection denture base system. Compend Contin Educ Dent 2001;22:847-852, 54; quiz 56
89. Campos MS, Cavalcanti BN, Cunha VP: Occlusal changes in complete dentures processed by pack-and-press and injection-pressing techniques. Eur J Prosthodont Restor Dent 2005;13:78-80
90. Keenan PL, Radford DR, Clark RK: Dimensional change in complete dentures fabricated by injection molding and microwave processing. J Prosthet Dent 2003;89:37-44
91. Nogueira SS, Ogle RE, Davis EL: Comparison of accuracy between compression- and injection-molded complete dentures. J Prosthet Dent 1999;82:291-300
92. Lung CY, Darvell BW: Minimization of the inevitable residual monomer in denture base acrylic. Dent Mater 2005;21:1119-1128
93. Slaughter A, Katz RV, Grasso JE: Professional attitudes toward denture adhesives: A Delphi technique survey of academic prosthodontists. J Prosthet Dent 1999;82:80-89
94. Stafford GD: Denture adhesives–a review of their uses and compositions. Dent Pract Dent Rec 1970;21:17-19

95. Adisman IK: The use of denture adhesives as an aid to denture treatment. J Prosthet Dent 1989;62:711-715
96. Folse GJ: Denture adhesives: when, why, and how. Dent Today 2004;23:70-71
97. Grasso JE: Denture adhesives: changing attitudes. J Am Dent Assoc 1996;127:90-96
98. Nations SP, Boyer PJ, Love LA, et al: Denture cream. An unusual source of excess zinc, leading to hypocupremia and neurologic disease. Neurology 2008;71:639-643
99. Donovan TE, Derbabian K, Kaneko L, et al: Esthetic considerations in removable prosthodontics. J Esthet Restor Dent 2001;13:241-253