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A Historical Review of Impression Materials & Techniques in Complete Denture Fabrication: Part 1

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ABSTRACT

Historically, impression techniques have been fundamental in successful denture fabrication, evolving from rudimentary materials like wax and plaster to sophisticated elastomeric materials that enhance the accuracy and comfort of dentures. Over the years, various impression techniques and materials for denture fabrication have been developed. Advances were based on a deep understanding of oral anatomy and the desire to preserve the integrity of soft tissues while ensuring a stable and retentive fit for the prostheses. The selection of the appropriate impression materials and technique directly influences the biomechanics of the final denture. It is fundamental to producing more detailed and accurate impressions that better serve patient needs. The field of removable prosthodontics is poised for further advancements as digital technology continues to evolve. However, the integration of these innovations must be supported by rigorous research and collaboration among clinicians, academics and the industry.

INTRODUCTION

Despite the increasing popularity of implant-supported prostheses, conventional complete dentures remain the most viable, conservative and cost-effective treatment option for patients who have lost all their natural teeth.[1] This is particularly true for patients with financial constraints, medical limitations, or lack of access to advanced surgical interventions. [2] Complete and removable partial dentures (RPDs) play essential roles in restorative dentistry to replace missing teeth and soft tissues in fully or partially edentulous patients, respectively. Both offer affordable and accessible dental care that addresses patients' aesthetic, masticatory, speech functions and for patients from diverse socio-economic conditions [3].

The first and most fundamental requirement for successful denture fabrication is the accuracy of the initial impression, as this directly influences the denture's support, retention, and stability.[4] These elements ensure dentures remain securely in place during everyday activities, enhancing patient comfort, oral function, and well-being.[5]

Over the years, impression materials and techniques have evolved, reflecting an ongoing effort to improve the precision of fit of dental prostheses.[6] The development of elastomeric impression materials in the 1950s marked a significant advancement in capturing the fine details necessary for high-quality dentures.[7] This paper provides a comprehensive overview of the development and current state of impression materials and techniques used for complete denture fabrication from early development until the latest digital advances. The latter will be reviewed in Part 2.

Historical Timeline of Impression Techniques

Recorded examples of denture fabrication date back to the 18th Century. Since then, the range and types of materials used have changed, as depicted in Table 1.

Biomechanics in Denture Construction

The construction of dentures requires a thorough understanding of biomechanics to ensure optimal support, retention, and stability, all of which directly affect the patient's comfort, function, and overall satisfaction.

Support refers to the denture's ability to resist vertical forces directed toward the alveolar ridges and mucosal tissues, particularly during chewing and swallowing. The primary support areas for maxillary dentures include the flat areas of the hard palate (the horizontal palate) and the posterior ridges, while the buccal shelf and retromolar pad provide primary support in the mandible.[12]

Retention refers to the denture's ability to resist forces that attempt to dislodge it during activities such as eating, speaking, and laughing. Factors contributing to retention include adhesion, cohesion, interfacial surface tension, mechanical locking into undercuts, and the peripheral seal created by the denture's fit against the mucosa.[12]

Stability refers to the denture's ability to resist dislodging forces that act laterally. It may be affected by occlusion, tooth arrangement, and the contour of the denture's polished surfaces. Stability depends on a balanced occlusion and teeth placed within the "neutral zone." Balance is achieved when the forces are evenly distributed across both sides of the arch. At the same time, the neutral zone is considered the area where the inward forces balance the outward forces exerted by the tongue forces from the cheeks.[5, 13]

Adhesion and cohesion refer to the physical forces between the denture base, the saliva film, and the oral mucosa that

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Table 1: A Historical Timeline of Impression Materials

Period	Technique/Material	Description
Pre-18th Century	Early Materials (Wood/Ivory Blocks)[8]	Artisanal approach using wooden or ivory blocks to approximate oral cavity contours. Poor fit led to consideration for more accurate impressions.
1736	Wax (Phillip Pfaff)[7, 8]	It was the first documented use of wax for sectional impressions, setting the 18th and 19th centuries standard.
1782	Wax and Plaster of Paris (William Rae)[8]	The early use of gypsum marks an advanced technique using wax pressed into gums, followed by casting in plaster of Paris.
1842-1848	Gutta-Percha[7, 8]	The discovery and application of gutta-percha improved the accuracy and quality of impressions.
19th Century	Wax and Plaster Wash (Franklin)[8]	A two-step process uses wax for initial impressions, followed by a plaster wash for more precise capturing of oral anatomy.
1907	Modelling Plastic Compounds (Greene Brothers)[8]	Introduction of plastic compounds used with a closed-mouth technique for controlled and consistent impressions.
1920s	Fluid Wax Compounds (Everett)[8]	Using fluid waxes to replicate fine oral tissue details lays the groundwork for more sophisticated materials.
1920s-1930s	Alginate and Agar[8]	Revolutionised impressions with satisfactory detail capture, though alginate required quick handling due to instability.
1930	Zinc Oxide-Eugenol (ZOE)[8]	It was developed for stable, highly detailed impressions, overcoming the limitations of earlier materials.
1950s	Polysulfide Rubber[8]	The first elastomeric material offers excellent flow properties and high accuracy, but drawbacks include unpleasant odour and long setting time.
1960s	Polyether[7]	It provides shorter setting times, better patient comfort, and rigidity, making it ideal for high-precision full-arch impressions.
1970s	Polyvinyl Siloxane (PVS)[9]	They combined high accuracy, good flow characteristics, and dimensional stability, becoming a widely used material in dental practices.
1980s-Present	CAD/CAM Systems[3, 10, 11]	Digital technology should be integrated into dental practices to create digital impressions, offer reduced treatment times, reduce appointments, and improve patient comfort.

help hold the denture in place. Interfacial surface tension and a well-formed peripheral seal contribute to retention by creating a suction/vacuum between the denture and the mucosa.[12]

Orofacial muscles: The oral and facial muscles can assist or hinder denture retention. Properly designed dentures need to consider the physiological movement of these muscles at rest and during function. Dentures must be fabricated to ensure that the muscle movements, particularly those in the lips, cheeks, and tongue, do not dislodge the denture during use. This can be achieved by ensuring special trays are moulded to the functional sulcus, and the impression captures the undistorted tissues in this state of activity.[5]

Occlusion must be carefully balanced to prevent interferences that can cause the denture to rock or shift during function. In complete dentures, this is achieved by having a bilateral balanced occlusion, with the forces evenly distributed across both sides of the denture and evenly over all the occlusal surfaces (with emphasis on posterior teeth).[5] It is also essential to have the teeth correctly positioned and arranged in the arch so that the forces of occlusion are directed along their long axes to enhance stability further.[5]

Impression Trays

Ideally, primary impressions for complete dentures are taken in stock trays, with close-fitting or spaced custom trays/special trays for secondary impressions. Stock trays are prefabricated trays of various sizes and shapes, typically made of metal or plastics, that can provide sufficient rigidity to support the impression material during setting. Early metal trays were made from Britannia metal, lead, copper, tin, silver, and pewter. While metal trays were appreciated for their strength, they also had drawbacks, such as the inability to be adjusted for individual patient needs.[8] Early non-metal stock trays were made from materials like gutta-percha or vulcanite. These trays were softer and more flexible, allowing a limited amount of customisation, and were generally used in conjunction with a final wash impression taken in plaster inside them.[8]

Custom trays are fabricated precisely for a patient's mouth based on the casts poured from the preliminary impressions. Their main advantage is their ability to replicate the entire denture-bearing area more accurately, ensuring an even thickness of secondary impression material and more detailed and precise replication of the oral structures.[14] Depending on the clinical needs, custom trays can be designed as close-fitting or spaced. The former closely matches the

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Table 2: The use, advantages, and disadvantages of the most commonly used impression materials in complete denture fabrication

Impression Material	Use	Advantages	Disadvantages
Impression Compounds [5]	They are used for border moulding and preliminary impressions.	- High viscosity - Supports itself - Compensates for under-extensions - Allows material additions	- Poor surface detail - Limited ability to capture undercuts
Irreversible Hydrocolloids [5]	They are commonly used for preliminary impressions, especially in denture fabrication and orthodontics.	- Captures fine details (e.g., alginate) - Easy manipulation - Reasonably accurate - Affordable	- Cannot absorb mucous secretions - Prone to moisture loss (requires immediate pouring) - Lack of self-supporting properties
Irreversible Hydrocolloids [15, 16]	Initially preferred by 94% of general dental practitioners [15], it was later reduced to 19% as preference shifted towards zinc oxide-eugenol and PVS [16].	- Easy to manipulate - Cost-effective	- Prone to shrinkage if not poured immediately
Elastomeric Materials [7-9]	Used for final impressions in fixed prosthodontics, removable prosthodontics, and implant dentistry.	- Excellent dimensional stability - High accuracy - Good flow characteristics	- Polysulfide: Extended setting time, unpleasant odour [8] - Polyether: Rigid (less suitable for patients with significant undercuts)
Zinc Oxide-Eugenol [5]	Primarily used for final impressions in edentulous patients.	- Creates detailed, stable impressions - Accurately captures soft tissues - Provides a firm base	- Rigid nature makes it less suitable for undercuts or the need for flexibility

final denture base, allowing clinicians to evaluate and adjust retention before taking the impression. This is beneficial in cases where retention is challenging, such as with severely resorbed mandibular ridges. However, close-fitting trays may require chairside adjustments to accommodate the impression material, making the procedure more complex.

Special trays are made by placing a 1 mm wax spacer on the cast before making the tray, creating room for the impression material. This design is easier to manage and helps ensure a uniform thickness of impression material.[5]

Impression Materials

Several impression materials can be used for primary and secondary impressions, each with properties suited to different clinical situations. Table 2 shows the most commonly used materials, their advantages, and disadvantages.

Impression Techniques

The choice of impression technique impacts the final denture's initial fit and possibly its biomechanical behaviour. For example, mucodisplasive techniques apply high pressure during impression-taking, resulting in very closely fitted dentures. In contrast, mucostatic techniques aim to capture the tissues in their passive form, minimising distortion and allowing for a more accurate representation of the ridge anatomy.[17] Regardless of the chosen technique, most clinicians agree that the trays should be adapted with judicious border moulding before making an impression. This step aims to capture the exact shape and contour of the denture borders. This process involves manipulating the peripheral muscles around the denture-bearing area to create a functional and stable impression of the borders. The goal is to record the denture margins accurately, providing a secure peripheral seal. This seal is not just technical but a key factor in enhancing retention and stability and preventing air and food particles from ingressing under the denture. It ensures the denture remains stable during speaking, chewing, and swallowing.

Some different impression methods are described below.

The Open Mouth Technique involves taking the impression with the patient's mouth open. This approach captures the tissues in a relaxed but slightly extended state. It is relatively easy to perform, making it the most commonly taught and used method in dental practice. However, because it does not capture the functional dynamics of the tissues, it may not fully represent how they function during activities like chewing and speaking. As a result, dentures made using this technique may be less stable during use.[18]

Closed mouth technique: The impression is taken with the patient's mouth closed in a biting position, attempting to capture the tissues in a functional state. It can be static or active; the latter tries to capture tissues while doing activities such as chewing and speaking. Although it is more complex and requires careful guidance of the patient's movements, it generally results in a better fit and stability of the dentures, especially in function. Despite its perceived benefits, the closed-mouth technique is less commonly taught, with only 9% of dental schools emphasising it as a standard method.[18]

Mucodisplasive, or high-pressure, impressions involve applying pressure to the oral tissues during impression-taking. The goal is to compress the soft tissues, theoretically providing a snug fit that resists displacement during function. Early advocates of the mucodisplasive techniques claimed that this method would ensure no food particles could find their way under the dentures, thereby improving

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denture comfort and stability.[6] However, there is no way of gauging how much pressure to apply, which could lead to complications. Subsequent research revealed that applying high pressure to the tissues could restrict blood flow, potentially leading to accelerated alveolar ridge resorption. This, in turn, would then compromise the long-term stability and comfort of the denture, making the techniques less favourable for complete denture fabrication.[19] Some still advocate the mucodisplasive technique in specific situations, such as the altered cast technique for free-end saddle partial dentures. In this situation, increased pressure is selectively applied to the distal edentulous ridge, which is believed to help achieve a more stable fit for the partial denture.[19]

The Mucostatic impression technique was introduced in 1937 and was designed to capture the tissues in their natural, undisturbed state without applying stress or causing displacement. It aims to record the tissues in their passive form, resulting in a denture that fits accurately without inducing pressure, distortion or accelerated resorption.[17] This approach relies on surface tension for retention, limiting the denture borders to stress-bearing mucosal areas and reducing tissue damage risk.[20] Other authors further highlighted the effectiveness of this technique in preserving the underlying tissues' health, as it minimises the forces applied during function.[21] The mucostatic technique is especially beneficial in severely resorbed ridges because it prevents tissue distortion, unlike the mucodisplasive technique.

The Selective pressure impression technique combines both the mucodisplasive and mucostatic approaches. It involves applying varying degrees of pressure across different impression areas to achieve a distribution of forces. The premise is that some areas of the maxilla and mandible are better suited to handling the forces exerted during chewing. It thus applies higher pressure to the primary stress-bearing regions, such as the posterior ridges and buccal shelves, while using less pressure on the secondary support regions, such as the anterior ridge and vestibular areas.[22] Patients with significant mandibular ridge resorption are believed to prefer dentures fabricated using this technique.[23]

Functional impressions are designed to capture the oral tissues during functions such as chewing and speaking. Lytle first described it in 1957, as he felt that traditional methods did not adequately reflect the actual condition of the tissues, leading to poor outcomes in denture fabrication.[24] Chase (1961) then introduced the concept of "dynamic adaptive stress," a two-step process that involves conditioning the tissues before taking the final impression.[25] This approach allowed for a more accurate representation of the tissues in their functional state, resulting in a better fit and greater comfort for the patient. Vig (1965) refined Chase's technique into what is now known as **functional impressions.**[26] This is also good for patients with compromised or injured tissues, where a tissue conditioner can be placed to restore health and capture a functional impression.

Modified Impression Techniques

Standard impression techniques may not be sufficient to address the many diverse intra-oral conditions. Various modifications have been developed to accommodate specific anatomical variations, compromised oral tissues, and other complexities that can affect the fit and function of dentures. One problem that is commonly experienced is the flabby anterior m*axillary ridge. This situation presents a unique challenge in denture fabrication*, as the mobile, fibrous tissue can compromise the denture's stability and retention. Several modified impression techniques have been developed and proposed to try to capture the flabby tissue in the most undistorted manner possible, thus ensuring the final denture fits well and remains stable during use.

The Flabby anterior maxillary ridge: Proposed techniques include:

- **Selective Pressure Technique:** This technique involves applying varying degrees of pressure across different areas of the maxillary ridge to capture the flabby tissue accurately while avoiding excessive compression. Custom trays allow the clinician to apply less pressure to the flabby areas and more pressure to the stable regions. One example is the Liddelow technique, which uses two different materials: the fast-setting plaster of Paris for the flabby ridge and zinc oxide-eugenol (ZOE) for the surrounding tissues. Watson modified this original concept and introduced **The "Window" Technique.** It involves creating a custom tray with a window over the flabby tissue. A mucocompressive impression is taken with ZOE, trimmed in the window area, and then re-seated in the mouth. A low-viscosity plaster of Paris mix is applied to the flabby tissue to capture it in a mucostatic manner, ensuring that the delicate tissue is not compressed.[27]
- Walter (1973) adapted the window technique by creating a composite impression using two trays. The first tray does not extend over the flabby ridge area, while the second tray fits over the first and includes perforations in the flabby region. This method involves making a selective impression with ZOE over the normal tissue, followed by a mucostatic impression of the flabby tissue with plaster of Paris.[28]
- Osborne suggested an alternative method involving using two separate trays to record the different tissues individually, thus capturing the flabby and stable tissues more precisely. The separate trays were then related intraorally after both individual impressions had been taken. He believed that this approach would optimise the denture's support and retention. It is not widely used due to its cumbersome nature and potential inaccuracies when the trays are joined.[27]
- Watt and McGregor proposed a method where an impression compound is applied to a modified custom tray to take a mucocompressive impression of the normal tissues, followed by a ZOE wash. This technique also aimed to capture the flabby tissue without compression, providing a stable base for the final denture.[27]

Fibrous Posterior Mandibular Ridge

The fibrous posterior mandibular ridge is characterised by thin, mobile, and often highly resorbable tissue. A selective pressure technique is recommended for accurately recording this ridge, ensuring that the impression captures the tissues in a way that will provide support and stability. McCord and Grant (2000) described first using a custom tray with a modelling compound to record the ridge. Once the impression is made (compound over the crestal tissues and tray material in the fibrous area), the tray is perforated in the fibrous tissue area. Light-bodied PVS is then injected onto the buccal and lingual shelves, and the tray is reintroduced to take a mucostatic impression, allowing excess material

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to extrude from the perforated tray.[29] This technique helps create a stable and comfortable denture by minimising the pressure on the delicate ridge tissues.

Neutral Zone Technique: The neutral zone technique, introduced by Beresin and Schiesser (1976), focuses on capturing not only the denture-bearing area but also the muscle function that shapes the external surface of the denture. This technique benefits patients with severely resorbed ridges or compromised muscle tone, where conventional impression techniques may not be sufficient to achieve a stable denture. In the neutral zone technique, a closed-mouth impression is taken in a specialised tray and modified by adding occlusal rims made from a modelling compound. The patient performs functional movements, such as speaking, swallowing, and sucking, during the impression-taking process to ensure that the dynamic forces of the surrounding musculature shape the denture fitting surface as well as the occlusal rims. [13] This approach allows teeth to then be placed in that area where the outwards forces of the tongue are balanced by the inwards forces exerted by the cheeks, thus resulting in a denture that is well adapted to the patient's unique oral environment and will potentially be more stable during function.

Microstomia or limited mouth opening presents many challenges when fabricating removable prostheses. This condition may arise from various causes, including radical surgery, cleft lips, maxillofacial trauma, radiotherapy, scleroderma, or facial burns. The complexity of creating dentures for patients with microstomia requires innovative approaches to impression-taking.

- Walter (1973) described a **split tray technique** for final impressions. The two tray segments are aligned by their handles. The first segment, which includes a perforated stalk, is inserted into the patient's mouth, and the second segment is then locked into place using a peg that slides through the perforation.[28]



- Cura *et al.* (2003) outlined using a **sectional foldable custom tray** with four stabilisation pins. This tray design allows it to be introduced and seated as a single piece, folded horizontally for the mandible, or as two separate pieces stabilised intraorally with an acrylic resin block for the maxilla.[30] Benetti et al. (2004) proposed fabricating a collapsible maxillary overdenture for patients with microstomia.[31] (Figure 1, above).

Technique for fabrication of Suction-Effective Mandibular Dentures:
To create a mandibular denture with effective suction, it is essential to understand the principles behind suction and how to implement them clinically. The most challenging aspect is achieving a posterior seal, particularly around the retromolar pad. This tissue is prone to deformation from pressure during impression-taking and tends to dislodge the dentures during regular mouth movements. Overcoming this requires precise techniques and tools. Kokubo and Abe described a multi-stepped technique that may be used to obtain a good peripheral seal in mandibular dentures. The process is complex, using precisely modified, well-fitting special trays and different materials during each stage. The fundamental premise is that this functional impression will help enhance suction by ensuring that there is sufficient thickness of material in the sublingual and buccal shelf areas for suction and thicker borders in the labial region for adequate lip support and stability, as well as correct recording and capturing of the buccal tongue contact (BTC) area, to ensure there is a peripheral seal. [32]

Digital Dentures

In recent years, digital technology has begun to reshape prosthodontics, mainly by integrating computer-aided design and computer-aided manufacturing (CAD/CAM) systems into the dental workflow. These systems enable clinicians to create digital impressions, which can be manipulated in a virtual environment before being used to fabricate physical dentures. Adopting CAD/CAM technology has reduced the number of clinical appointments required for denture fabrication, has the potential to minimise errors, and accelerates the production process while maintaining or possibly improving the quality of the final prosthesis.[33] The transition from traditional to digital impression and manufacturing techniques represents a significant shift in prosthodontics that aims to enhance precision, efficiency, and patient satisfaction. However, integrating digital technologies into routine clinical practice is still in its early stages, and long-term studies are needed to assess their impact on treatment outcomes.[10] This new fabrication process will be discussed in Paper 2.

Conclusion

Over the years, various impression techniques and materials for denture fabrication have been developed. Advances were based on a deep understanding of oral anatomy and the desire to preserve the integrity of soft tissues while ensuring a stable and retentive fit for the prostheses. The selection of the appropriate impression materials and technique directly influences the biomechanics of the final denture. It is fundamental to producing more detailed and accurate impressions that better serve patient needs.

The field of removable prosthodontics is poised for further advancements as digital technology continues to evolve. Integrating artificial intelligence, machine learning, and 3D printing can enhance the customisation and efficiency of denture fabrication, offering even greater precision and personalised care. As these technologies become more accessible and widely adopted, they will likely set new quality and patient satisfaction standards. The future of removable prosthodontics lies in the seamless integration of these innovations, supported by rigorous research and collaboration among dental professionals, leading to better clinical outcomes, higher patient satisfaction, and continued advancements in the art and science of denture fabrication. [2, 3, 10]

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