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Digital Dentures Current Techniques In Cad/ Cam Denture Fabrication- A Review

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Abstract:
The advancement of digital denture technology has revolutionized the field of prosthodontics, offering significant improvements over traditional methods. Digital dentures integrate digital design and manufacturing processes, enhancing precision, comfort, and efficiency. The workflow begins with the clinician taking either traditional impressions or digital scans of the patient's oral cavity. These impressions are converted into digital formats to create a 3D model of the patient's anatomy. Using specialized software, dental professionals design the dentures, customizing fit, aesthetics, and functionality. Virtual try-ins allow for digital adjustments before finalizing the design. The finalized design is sent to a milling machine or 3D printer for fabrication, typically using materials such as acrylic or resin. The fabricated dentures undergo rigorous quality control to ensure accuracy, fit, and durability. Once manufactured, the dentures are tested in the patient's mouth, with any necessary adjustments made to ensure optimal fit and comfort. The process concludes with the delivery of the dentures, accompanied by instructions for care and maintenance, and follow-up appointments to monitor patient satisfaction. This digital approach provides superior outcomes, making dentures more precise and tailored to individual needs, ultimately improving patient satisfaction and oral health.

Keywords: *- CAD/CAM, Weiland digital denture system, Baltic digital denture system, BD Keys, Avadent digital denture system, Ceramil digital denture system,Dentca digital denture system.*

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I. Introduction

The Ancient Egyptians were the first to use dentures around 1500 BC, crafting them from human teeth threaded together with gold wire. By 700 BC, Italians began replacing their teeth with those of animals. Similarly, tribes in Mexico used wolf teeth for their dentures. In Japan, wooden dentures became common starting in the 16th century, a practice that continued until the 19th century. George Washington famously wore dentures made from hippopotamus tusks. Many others used ivory dentures crafted from walrus, hippopotamus, or elephant tusks. In the 1850s, the introduction of vulcanite, a type of hardened rubber, made dentures more affordable and accessible to a wider population.

Conventional Process

1st clinical step

During the initial clinical appointment, primary impressions were taken using reversible hydrocolloid impression material.

1st Laboratory step

After obtaining the impressions, a cast was poured using type 2 or type 3 gypsum material. A thin wax sheet, 1.5 mm thick, was then adapted, and a special tray was fabricated for border moulding.

2nd Clinical step

Border moulding was performed using low fusing impression material (type 1), followed by taking a second impression with zinc oxide eugenol paste.

2nd Laboratory step

The impression trays were beaded and boxed, and a master cast was fabricated. A denture base was createdon the master cast, and occlusal rims were constructedon this base.

3rd Clinical step
Jaw relations were recorded using the occlusal rims.3rd Laboratory step

The sealed occlusal rims were mounted on an articulator, and teeth arrangement was completed in the laboratory.

4th Clinical Step
A wax try-in was conducted.4th Laboratory Step

A clean wax-up was done, followed by de-waxing and packing with heat-cure acrylic resin. The dentures were then cured using either a short or long curing cycle. The processed dentures were remounted for selective grinding, and after grinding, the dentures were finished and polished.

5th Clinical Step

The dentures were inserted into the patient's oral cavity. The patient was recalled after 24 hours for a denture checkup.

To minimize the number of clinical appointments and reduce laboratory work, digital dentures have been introduced.

Introduction Of Digital Dentures

While traditional acrylic dentures have been a mainstay in prosthodontic treatment for decades, the future of denture materials is shifting towards innovative biocompatible resins. These advancements herald a new era in dentistry, one that emphasizes bothhealth and aesthetic improvements.

Weiland Digital Denture System

In 2016, the hospital dental unit acquired the WielandDigital Denture system, enabling the creation of fifteen bi-maxillary complete dentures. This system is specifically designed for completely edentulous patients and comprises a five-axis milling machine integrated with a laboratory scanner and design software, streamlining the denture fabrication process into four clinical sessions interspersed with three dental laboratory stages.

CLINICAL STEP – 1
The first clinical session of denture design includes three stages

PRIMARY IPRESSIONS - Conventional physio- chemical maxillary and mandibular primary impressions are taken, although optical impressions of the edentulous arch can be used, they remain time- consuming and offer limited advantages.

PRILIMINARY INTER ARCH SPACE

RECORDING - A specific device records the preliminary inter-arch relationship.

UTS CAD DEVICE - Used as a Fox plate to measuredeviations from reference planes, the UTS CAD device is attached to the Centric Tray. Digital deviation values are measured and transferred to a virtual articulator, positioning the virtual primary models in space.

LABORATORY STEP 1

Scanning impressions: Impressions bound around theCentric Tray are scanned. These scans, combined withthe UTS CAD values, create primary digital models ona virtual articulator.
Drawing trays edges: The edges of the individual traysare outlined according to conventional standards.

Designing occlusal rims: A software application designs the occlusal rims, which are intentionally reduced in height relative to the recorded verticalocclusion dimension.

Cut back integration: A cutback is integrated to leave space for the intra-oral center-point recording system,avoiding interference between the antagonist occlusalrims.
Milling project files: Finalized designs are sent to the milling machine

Milling machines: The system includes two five-axis milling machines: the Zenotec Select Ion, used for drydrilling of wax and PMMA resin, and the Zenotec Select Hybrid, used for both dry and irrigated milling of materials like glass-ceramics and zirconia. Both machines feature an 8-disc loader, operating autonomously during the milling process.

Clinical step 2

Functional impressions: Conventional functional impressions are made with manufacturing trays, as the mucosa's depressible nature cannot yet be captured byoptical impressions.

Recording inter arch relationship: This can be done during the same session using elastic impression material. The maxillary occlusal rim is checked with UTS CAD and its provided fork.

Modulating occlusal vertical dimension (OVD): Adjusted by a screwing/unscrewing pointer, a circular receiving plate with marker material registers differentmandibular movements.

Determining vertical dimension: are made via the central pointer, avoiding interference from occlusal rims and ensuring excellent retention of the impressiontrays.

Recording mandibular path: The cylindrical receivingplate is tinted to record mandibular paths, which converge at an equilibrium area used during inter-archrelationship recording.

Shaping lip support: Elastomer material shapes the lipsupport and locates the horizontal joint line of the lips.

Laboratory step – 2.

Scanning functional impressions: These are scanned to obtain virtual working models, placed on a virtual articulator with reference points identified for posterior teeth positioning.

Teeth setting proposal: Software proposes teeth settings, which can be modified except for tooth removal. Solutions for posterior teeth positioning facilitate a bilateral balanced occlusion concept.

Finishing virtual waxes: Finalizing virtual waxes avoids imperfections that could prevent milling.

Milling complete dentures: Project files are sent to themilling machine, producing a useful template on a white PMMA disc.

Clinical step 3

Functional validation: Patients use their manufacturedtemplates at home for functional validation

Modification and try outs - Patient feedback is collected, and necessary modifications are made. Significant changes may require new templates.

Laboratory step 3

Milling dentures: Four steps are needed to complete the denture milling on a pink resin disc with specific alveoli for the selected prosthetic teeth.

Bonding process: A positioning key ensures ideal teethsetting during bonding with PMMA resin.

Final milling: The denture intrados is milled, and the denture is removed from the disc, scraped, and polished.

Clinical step 4

Final session: Dentures are tried, and primary equilibration is performed. If all previous steps were followed correctly, the equilibration session is usuallyunnecessary or straightforward.

Avadent Denture Sysytem

The AvaDent Digital Denture System represents a breakthrough in dental technology, enabling the creation of highly customized dentures. By integrating digital design and manufacturing processes, AvaDent produces dentures that offer superior precision, comfort, and efficiency compared to traditionalmethods.

The process begins with an assessment of the patient's oral health and needs, using either traditional impressions or digital scans of the oral cavity. If digitaltechnology is used, intraoral scanners create a detailedscan of the patient's mouth.

The collected data is converted into a digital format toproduce a 3D model of the patient's oral anatomy.

Using specialized software, dental professionals design the dentures based on this digital model, customizing the fit, aesthetics, and functionality. A virtual try-in is performed to assess the design, allowing for digital adjustments if needed. Once finalized, the digital design is sent to a milling machine or 3D printer for fabrication, typically using materialssuch as acrylic or resin.

The fabricated dentures undergo stringent quality control checks to ensure they meet all specifications for accuracy, fit, and durability. After passing these checks, the dentures are tested in the patient's mouthfor fit and comfort, with any necessary adjustmentsmade.

Finally, the dentures are delivered to the patient, along with instructions on proper care and maintenance.Follow-up appointments are scheduled to monitor thepatient's comfort and address any concerns.

Advantages of AvaDent digital denture system

1. Digital technology allows for highly accurate measurements and customization, resulting in better-fitting dentures.
2. The streamlined digital workflow reduces the time required for design and manufacturing compared to

traditional methods.
3. Customized design ensures a comfortable fit,minimizing issues such as sore spots or discomfort[6].
4. AvaDent dentures are made from high- quality materials and undergo thorough quality control, ensuring longevity and reliability.

Disadvantages of AvaDent digital denture system.
1. Depending on the region, regulatory approval and compliance may be required for using digital denture systems in clinical practice. Adhering to these regulations adds another layer of complexity for dental professionals.
2. The materials used in digital denture
3. fabrication may have limitations in terms of aesthetics, durability, and biocompatibility compared to traditional denture materials. Some patients may not be suitable candidatesfor digital dentures due to material preferences or allergies[6].
4. The AvaDent system relies heavily on technology, including digital scanners, CAD software, and milling machines. Technical issues with any of these components can disrupt the workflow and delay the production of dentures.

Dentca Digital Denture System

Maxillary and mandibular two-piece impression trays of the desired size are used to create definitive impressions and record jaw relation records. These impressions are made using heavy- and light-body PVS material, ensuring adequate border extensions and detailed surface capture. Once the impressions are complete, the posterior portion of the tray, filled with impression material, is separated using a No. 15C surgical blade, following a predetermined line on each of the two-piece trays.

Advantages of Dentca digital denture system
1. Digital technology ensures a more accurate fit and better-functioning dentures compared to traditional methods.
2. The process is faster and often requires fewerappointments, reducing inconvenience for the patient.
3. Dentures can be tailored precisely to the patient's oral anatomy and aesthetic preferences.
4. Release less monomer content than the conventional dentures[8].
5. 3D printing allows for the use of high-qualitymaterials, resulting in durable dentures that can withstand daily wear and tear.

Overall, Dentca digital dentures offer a modern, efficient, and precise solution for patients in needof dentures, providing improved comfort,function, and aesthetics.

Baltic Denture System

The Baltic Denture System process opens up a new way of manufacturing full dentures in a digital workflow[9]. Combining the work steps in the dental practice and processes in the lab into a single workflowstands for quality and economy.
- Less manual work.
- Predictable results.
- High-quality materials and reproducibility.
- Reduced allergenic potential.

The Baltic denture system offers a great advantage ofreduced number of clinical appointments and reducedlaboratory work[10].

When compared to the conventional denture system Baltic system offers very a smaller number of appointments i.e., 2 clinical appointments with reduced laboratory work[10].

1st appointment:

Using the Baltic keys functional impression is made and bite registration is made using the bite registrationmaterial[10].

1st laboratory step:

Extra oral scanning is done for the impressions using an impression scanner. CAD designing is done for thescanned impressions and using a 5- axis milling machine the dentures are milled and
Finishing and polishing is done manually[10].

2nd appointment:

The second appointment is the final appointment for the Baltic denture system. The dentures are

inserted into the oral cavity. And recall of the patient within 24hrs of insertion is mandatory[11].

Advantages of Baltic denture system:

1. The biggest advantage of the Baltic DentureSystem is the reduced clinical visits, which is appealing to both the clinician (especially thosewith a higher throughput rate) and patients alike[12].
2. There is no concern of debonding of denture teethfrom the denture base, unlike other systems[12].
3. The denture delivery is ensured at the second visit in comparison with other CAD-CAM systems currently available.

Drawbacks of Baltic denture system:

1. The inability to digitally customize the dentures and accurately verify centric relation is one of the drawbacks[12].
2. This denture system is presently applicable only to patients with a favourable Class I maxillomandibular relationship, which isanother limitation when compared with conventional techniques.

Ceramil Digital Denture System

The digital workflow of the Ceramill Full DentureSystem begins in the laboratory, where the denture is designed by a laboratory technician. The process starts when the clinician sends the definitive maxillary and mandibular impressions to the laboratory. Using these impressions, the laboratory fabricates definitive casts and record bases. These bases are essential for registering the vertical dimension of occlusion (VDO), the midline, the smile line, the canine positions, and conducting a facebow transfer.

The laboratory technician uses the provided facebow and jaw relation records to mount the casts on a proprietary articulator. The mounted casts, along with the occlusal rims, are then attached to a transfer stand and placed in an optical three-dimensional scanner. This scanning procedure is crucial for transferring the accurate position of the casts to the design software.

Each cast is scanned separately to create a precisevirtual copy. For patients with high esthetic demands, an esthetic template can also bedigitized and taken into consideration during the digital design of the dentures. The virtual design process of the complete dentures begins with identifying precise anatomical landmarks on the virtual casts. These landmarks are critical for calculating the tooth arrangement lines and determining the position of the maxillary anterior teeth. Advanced calculation algorithms assist in detecting the midline of the alveolar ridges, ensuring accurate and natural tooth placement.

Based on the available space and patient-specific requirements, the design software suggests an appropriate set of artificial teeth from its extensive library, which includes data from several manufacturers. This automated suggestion is just the starting point; the dental technician can further customize the digitally proposed anterior toothsetup to meet the patient's esthetic preferences andrequirements.

The process of designing the dentures digitally allows for meticulous planning and adjustments, ensuring that the final product will be both functional and aesthetically pleasing. The digital workflow enhances precision and efficiency, reducing the margin for error that can occur with traditional methods.

Once the virtual design is finalized, it is sent to a milling machine or 3D printer for fabrication. The advanced technology used in the Ceramill Full Denture System ensures that the dentures produced are of high quality, with excellent fit anddurability.

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