Tools used in Prosthodontic Research studies- A Review Article

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Abstract: In order to successfully complete studies in the field of prosthodontics, some specialized tools or apparatus are required. These tools are used to measure the distance between various reference lines or points, evaluate the mechanical qualities of dental materials, detect color, and examine the surface characteristics of materials, imaging oral microorganisms, analyzing patterns of stress distribution at different interfaces, measuring temperature changes, detecting tongue-palate interactions, and measuring bite forces. All of these equipment used for various prosthodontic research studies are compiled in this article.

Keywords: tools,prosthodontics,studies

INTRODUCTION:

Prosthodontics is the branch of dentistry concerned with the design, fabrication, and placement of artificial replacements for missing teeth or other oral structures. Prosthodontic research studies aim to improve the materials, techniques, and procedures used in prosthodontic treatment. A variety of equipment is used in these studies.Researchers from all around the world are doing a variety of studies in the subject of prosthodontics. For these studies to yield the intended results, some specialized tools, machinery, or equipment are needed. This article's goal is to list and describe the majority of the tools used in prosthodontic research. These equipments can be grouped according to their purposes, as explained below:

1. To research on dental materials mechanical characteristics:

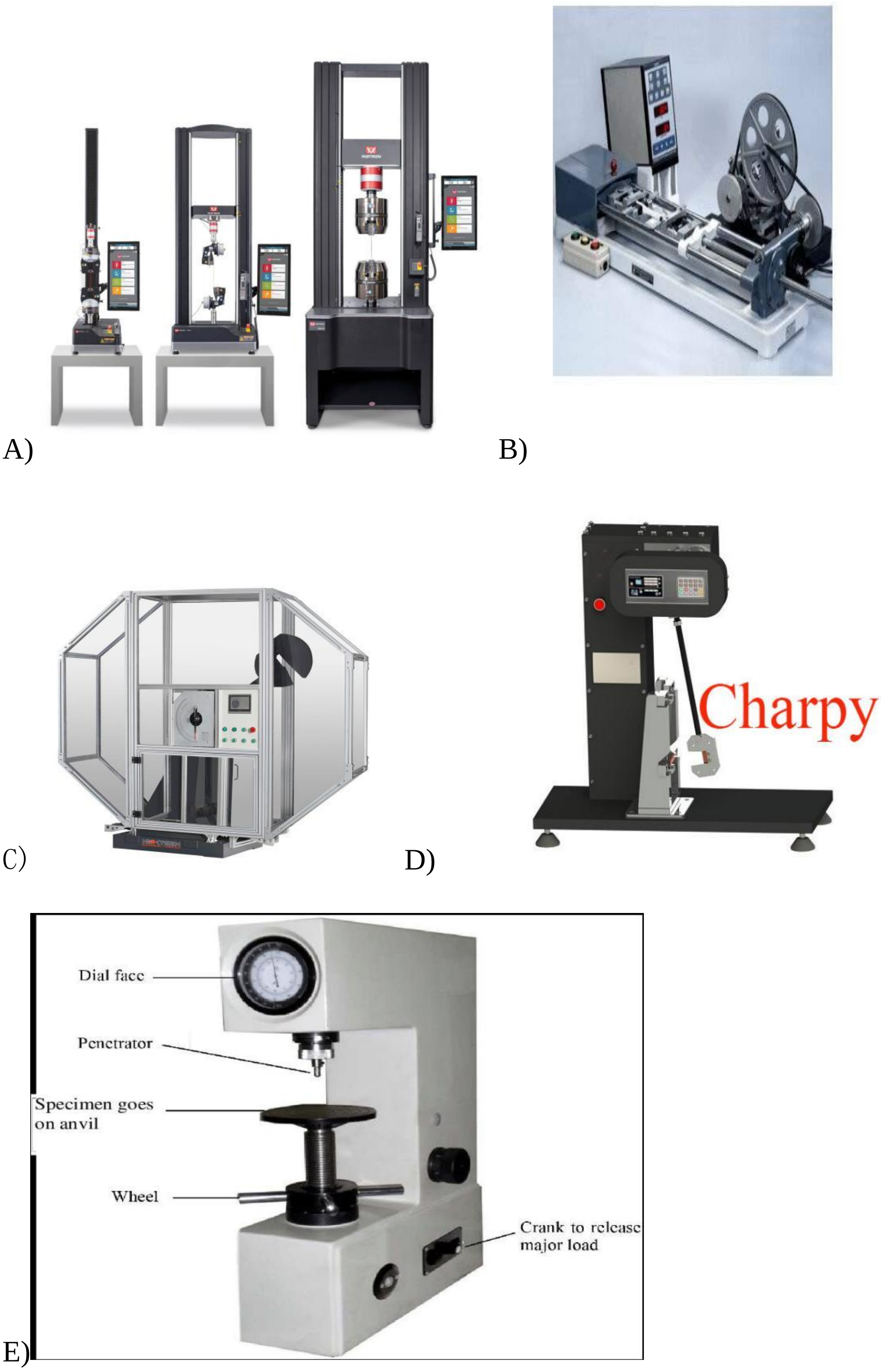
The intrinsic MECHANICAL PROPERTIES of various dental materials, such as their compressive, tensile, fatigue, flexural, yield, impact, and hardness strengths, are compared with one another.The following are some examples of machines that can be used to research different mechanical properties:

1.UNIVERSAL TESTING MACHINE (UTM)(Fig.1a): Two jaws set atop two vertical spindles make up this device. The sample is kept in jaws while the load of the appropriate kind and quantity is introduced gradually. A reading scale is used to display the load. The load ranges between 20 and 20,000 KN. The device is linked to the computer, which provides the necessary data values. The device is powered by hydraulics. The machine's least count is 0.005mm.It is useful for quantifying the Brinell's hardness test, Poisson's ratio, tensile strength, shear strength, flexural strength, yield strength, and compressive strength of different dental materials, such as bite registration materials, soft liners, impression materials, post and core materials, etc.

2. TENSOMETER: A scaled-down version of UTM (fig. 1b). Axial load is applied either manually or with the aid of an electric motor while the sample is held horizontally. A mercury scale is used to display the load reading. It is possible to test samples at various relative humidity levels and temperatures. Young's modulus, elastic limit, proportional limit, tensile strength, and fatigue strength are among the tensile characteristics that are assessed.

3. The IZOD PENDULUM (fig. 1c) is a device that measures the impact strength of various materials, including metals, polymers, denture base materials, etc. It is made up of a pendulum that swings down and strikes the specimen while it is clamped in the vertical position. The pendulum has a known weight at the end of its arm.

4. CHARPY PENDULUM (fig. 1d): This device is comparable to an Izod pendulum, with the exception that the specimen is positioned horizontally inside the charpy pendulum and is vertical. A sample of material with a notch causes the pendulum axe to swing. It can be used to gauge a material's impact strength, ductility, toughness, and yield strength.



(FIG:1)Equipments to research on dental materials mechanical characteristics : A) Universal testing machine, B) Tensometer, C) Izod pendulum, D) Charpy pendulum, E) Rockwell Hardness tester

5. HARDNESS TESTERS: These are employed to conduct various testing of hardness. These tests are predicated on a material's capacity to withstand penetration by a steel ball or diamond point under a given stress. The various kinds of hardness

tests include:

The Brinell hardness Test: It involves applying a predetermined load while pressing a hardened steel ball onto a material's polished surface. The material's Brinell Hardness Number (BHN) is calculated by dividing the load by the indentation area. Metals and metallic materials are subjected to this test. It is not appropriate for fragile or plastic materials.

Vickers Hardness Test: A diamond shaped like a square pyramid is used in place of a steel ball. The region of the indentation divides the load. The indentation's diagonals, or the diamond's sides, are measured and averaged in length. Dental casting Gold alloys are evaluted by this test. It is used to measure the hardness of tooth structure because it works well with brittle materials.

The Rockwell Hardness Test:(fig. 1e) uses a conical diamond point or a steel ball. A dial gauge on the device measures the depth rather than the diameter of the impression. Compared to the Brinell hardness test, it has a broader range of applications.

Knoop Hardness Test: An indenting instrument made of diamond is employed. Both soft and extremely hard materials can have their hardness tested using it. It is unaffected by the material's ductility. The Brinell and Rockwell tests are categorized as tests of macrohardness. Microhardness tests include Vickers and Knoop.

Shore and Barcol Tests: A spring-loaded metal indenter is employed. A gauge provides a direct reading of the depth of penetration.Rubbers and plastics can be treated with these less complex techniques(5). For various hardness testing, multiple testers are available. Additionally, all of the hardness tests can be completed with a universal hardness tester.Mobile hardness testers are now portable testers that are simple to use.

2. To observe oral bacteria and investigate the surface characteristics of materials:

The surface roughness and ability to adhere to streptococcus germs on different provisional fixed prosthodontic materials can be compared. Surfaces such as the metal-acylic interface in cast restorations and the implant-abutment interface might be examined for slight variations, and the development of germs and plaque can be assessed. It is possible to study wear facets on the surface of materials such as resins, porcelain, and gold. To determine the reasons behind the failure of prosthesis holding screws, surface analysis might be performed. The following tools are available for usage in this context:

1. OPTICAL MICROSCOPE (fig. 2a): This device magnifies images of tiny samples using visible light and a lens system. Magnification power is equal to 10x times the power of the objective lens being employed. Optical microscopes are used to examine thin specimens at higher magnifications. There are now digital microscopes that examine samples using a CCD camera and a computer screen displays the image(3). They can magnify up to 200 times.

2.STEREOMICROSCOPE(fig. 2b):It gives the left and right eyes slightly different viewing angles by using two distinct optical channels with two objectives and two eyepieces. Thus, it provides a 3-D representation of the sample. It may magnify up to 100 times.

3.ELECTRON MICROSCOPE SCANNING (fig. 2c) It's a microscope that creates images using electrons rather than light. SEM offers significantly greater resolution and a wider depth of field. Therefore, it is possible to magnify a specimen and closely spaced specimens at considerably higher levels. Magnification can range widely, from roughly 10 times to over 500,000 times. Since this microscope operates in a vacuum, the specimen needs to be completely dry. A small coating of conductive material must be applied to all samples in order to make them conductive.

4.PROFILOMETER (fig. 2d): A profilometer is a tool for measuring the profile of a surface to determine how rough and finished it is. Typically, vertical resolution falls between 20 and 25 microns.Profilometers come in two varieties: optical and contact. A diamond stylus that moves vertically in contact with the sample is used in contact profilometers. Small surface differences in vertical stylus displacement as a function of position are measured by a profilometer.The diamond stylus's vertical orientation produces an analog signal that is transformed into a digital signal, saved, examined, and shown. Since optical profilometers are not in contact with the surface, surface wear cannot harm them.After ultrasonic scaling and periodontal curettage, the surface roughness of porcelain(4) or other materials, as well as the wear resistance of materials like composite resins, can be measured using profilometers.

A)


B)

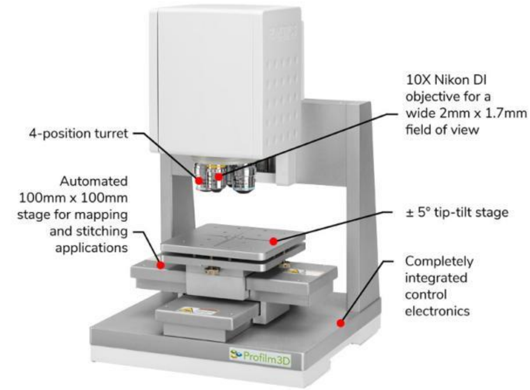

C)  D) 

Figure- 2: Equipments to observe oral bacteria and investigate the surface characteristics of materials: A. Optical microscope, B. Stereomicroscope, C. Scanning electron microscope, D. Profilometer

3. To calculate the separation between two or more reference lines or points:

When evaluating the accuracy of two or more reference points or reference lines, the distance between them is helpful.The surface repeatability or dimensional stability of several dental materials, including:
-Materials for impressions
-Materials for Bite registration
-Retraction materials can be compared according to the changes they make to the width and depth of the sulcus.
-Reusing the materials that were utilized to make the refractory casts

There are several equipments with varying resolution powers available for measuring this distance. They can be applied in accordance with the study's specifications. These tools are:

1. PROFILE PROJECTOR (fig. 3a): This device accurately magnifies and projects a

workpiece onto the screen, allowing measurements and observation of the workpiece's dimensions and shape. Moving the objective head up and down helps with focus. The workpiece's measurements are read using an integrated digital counter(1). There is a 0.001mm resolution.

2.COORDINATE MEASURING MACHINE (fig. 3b). It is a tool for determining an object's physical geometric properties. The X, Y, and Z are the three axes that make up the CMM. In a standard three-dimensional coordinate system, these axes are orthogonal to one another. Every axis has a scale system that shows where it is located. The

As instructed by the operator, the machine reads the input from the touch probe. It then calculates its size and location using the X, Y, and Z coordinates of each of these points. White light, laser, optical, and mechanical probes are all possible. Digitization, depth mapping, and dimensional measurement are all possible with CMM(2). There is a 0.001mm resolution.

3. TRAVELLING MICROSCOPE (fig. 3c): This tool is used to measure various objects' diameters precisely. It has slides that allow it to move 22 cm horizontally and 15 cm vertically. There are two knobs for taking precise measurements. There has a 0.05–0.1mm resolution.

4. Fig. 3d: VERNIER CALLIPER It is a precise tool for taking linear measurements both internally and outside. It bears the name of Pierre Vernier, a French inventor. The vernier, which slides parallel to the main scale and allows readings to be made to a fraction of a division on the main scale, is an exceptionally graduated auxiliary scale. The main scale is identical to that on a ruler. There is a 0.01mm accuracy limit. Digital Vernier Calipers have recently been accessible, in which the distances are read from an LCD display.

Use vernier calipers:

-To compare the width of the maxillary cental incisors with the philtrum
-To contrast the intercanine and interalar widths
-To determine the interocclusal distance, or the space between neighboring teeth
-To contrast the wax trial dentures' occlusal vertical dimension with that of maxillary dentures following polymerization
-Using the castings to measure extremely tiny distances

A)  B) 

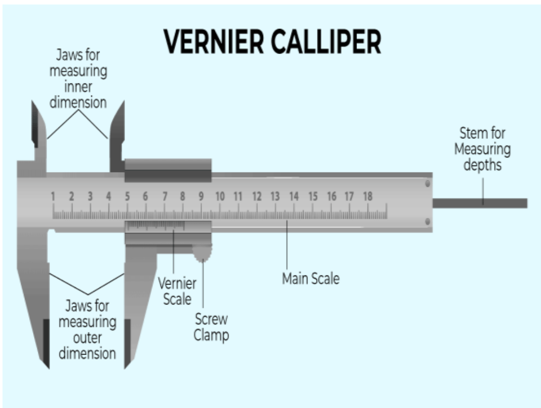
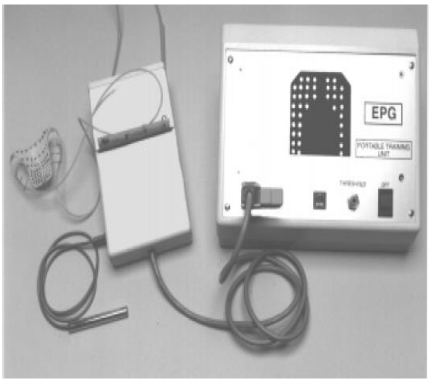
C)  D) 

FIGURE:3To calculate the separation between two or more reference lines or points: A). Profile Projector, B). Coordinate measuring machin, C). Travelling microscope, D). Vernier Calliper

4. **To examine variations in temperature:**

THERMOCOUPLE: The most popular electronic temperature sensor is THERMOCOUPLE. It is made up of two different metals that are connected at one end.When the junction of the two metals is heated or cooled, a voltage is produced that can be corelated back to the temperature. For thermal testing, it is an accurate tool. The accuracy is roughly equal to 0.050C. The following can be measured with it:
Temperature variations in the heat-activated acrylic denture base resin during processing, temperature variations in the pulp camber during direct restoration fabrication, and temperature variations during the quick mixing of zinc phosphate cement[8].

A)



B)

FIGURE:4To examine variations in temperature A)EPG palate with embedded electrodes,B). Electropalatograph

5. To investigate the patterns of stress distribution at different interfaces:

FINITE ELEMENT ANALYSIS: It is mathematical software that uses partial differential equations and integral equations. A computer model of a necessary material or design is created in two or three dimensions. This model is emphasized in some circumstances and examined. This aids the researcher in understanding how a specific structure will respond to specific loading scenarios. FEA can be applied to both new product design and product improvement. It could be used to figure out how to change the design to fit the new requirements.

In prosthetic dentistry, it may be used for analyzing the stress distribution patterns at various interfaces. For example:

□

- Stress distribution at bone-implant interface after placing tilted and non tilted implants or placing implants of different designs(6). □

- Relationship between clasp dimensions and flexibility(7). □

- Stress distribution and flexion among different designs of bar attachments for implant overdentures. □

- Comparing stress distribution among different post and core systems like light transmitting post and custom cast post, comparing glass fibre post and titanium post.

- Stress induced phase transformation of nickel titanium alloys. □

- Stress distribution within connector of a cantilever FPD. □

- Studying the effect of curvature of retentive arm of a CPD on the retention.

6. To examine the contacts between the tongue and palate:

ELECTROPALATOGRAPH (EPG) (fig.6b): An electropalatograph, sometimes referred to as a palatometer, is a device that tracks when and where the tongue makes contact with the hard palate, or roof of the mouth, during speech. EPG requires the speaker to wear an artificial palate that fits against the hard palate and resembles an orthodontic brace(10) .There are 62 silver electrodes placed in the EPG palate (fig. 6a). A computer records the pattern when the tongue comes into contact with these electrodes. These patterns can be viewed immediately or examined at a later time using software that has been particularly created. In patients with Down syndrome and cleft palate, it is useful to identify articulation issues.

7. In order to quantify the bite forces:

1. DYNAMOMETER (fig. 7a): is a device that measures power, torque, or force. Previously, hand dynamometers were used to assess patients with hand trauma and dysfunction both initially and continuously, as well as to routinely test for grip strength. Digital dynamometers are now available to assess task demands, performance, and physical condition. For prosthodontic research, a digital dynamometer is helpful in the following ways: It is useful for assessing the fit of osseointegrated implant components(12) and for comparing biting forces across individuals with temporomandibular disorders, dentate patients, and denture users(11).

2. T-SCAN.(fig. 7c): An easier and more precise method of measuring occlusal time and force is made possible by the T-Scan, a grid-based sensor technology and occlusal analysis system (fig. 7b). The T-Scan is a vital tool for evaluating the sequential relationships of a mandibular (lower jaw) movement since it can measure force over time. You may watch, on screen, a patient transitioning from CR (Centric Relation position, when the jaw closes on its backwards most arc of closure) or MIP (Maximum Intercuspal Position, where all teeth bite together) into a lateral excursion (when you slide your teeth to the left or right side). This is crucial for identifying occlusal interferences, figuring out how much force each interference is subject to, and assessing the potential for trauma caused by the occlusal interferences(13). The T-Scan II helps reduce the risk of:

-implant failure

-traumatized teeth

-unstable dentures

-ineffective splints

-porcelain fractures

A)

B)

FIGURE:7 Equipments to measure bite forces a). Dynamometer, b). T- scan II occlusal analysis system, c). T- scan

To examine the colour:

COLOR: In order to perceive color, light must be reflected from an object. This signals are perceived by the retinal neural sensors, which then interpret the signal in the brain's visual cortex. It plays an extremely significant function in prosthodontics because of the following reasons:

- To ensure that the restoration's shade matches the patient's natural teeth.
-To assess how various metal alloys and porcelains affect the metal-ceramic complex's ultimate color optically
-To assess the color stability of colorant-elastomer combinations when they are exposed to weathering and other factors
-To assess how drinking beverages affects the color of tooth-colored veneering materials.

Various shade taking devices are available to match the color.

1. COLORIMETER (fig. 8a): It is made up of a handheld display unit and a color sensor. Anyone can comprehend which color is being conveyed because it uses international standards to quantitatively express the color. The sensitivity of colorimeters is similar to that of the human eye, however because they always measure utilizing the measuring conditions will be the same whether it is day or night, indoors or outdoors, using the same light source and lighting technique. This simplifies all precise measurements.

2. SPECTROPHOTOMETER (fig. 8b): This device generates spectral data by measuring the amount of light that a color sample transmits or reflects at each wavelength. It ensures color uniformity by measuring and quantifying color.

Usually, artificial daylight is used to illuminate the object.The object's reflected light is sent to a monochromator, also known as a spectral analyzer. The monochromator's diffraction grating divides the reflected light into distinct wavelengths, usually ranging from 360 to 700 nanometers (nm). A photodiode array is used to measure the reflected light in order to ascertain the percentage of light at each wavelength that the object reflects (%R). The computer program graphs the reflectance data as a spectral reflectance curve or shows them in five or ten steps. The readings for any illuminant or observer are calculated by a spectrophotometer , but the colorimeter is limited to measuring for a single observer and illuminant. The spectrophotometer can readily provide values for quality control, as well as determine how a sample appears under various lighting conditions and calculates the metamerism.

2. SPECTRORADIOMETER (fig. 8c): Spectroradiometers are instruments that measure the light source's true spectral power distribution. In the visible spectrum, they function similarly to spectrophotometers. The sole distinction is that spectrophotometers measure a color sample's reflected color. Each of these portable digital shade matching devices has a color analyzer with a separate light source and software for downloading, analyzing, and sending the pertinent color data that has been captured. The prosthodontist downloads the program's interpretation of this shade record to their computer, uses it to choose the shade of the chairside-fabricated temporary restoration, and emails the results to the lab where the final replacement will be created. After being delivered to the lab, the shade file is processed by the reciprocal software, which defines the specific porcelain blends needed to realize the desired shade in the ultimate restoration[9].

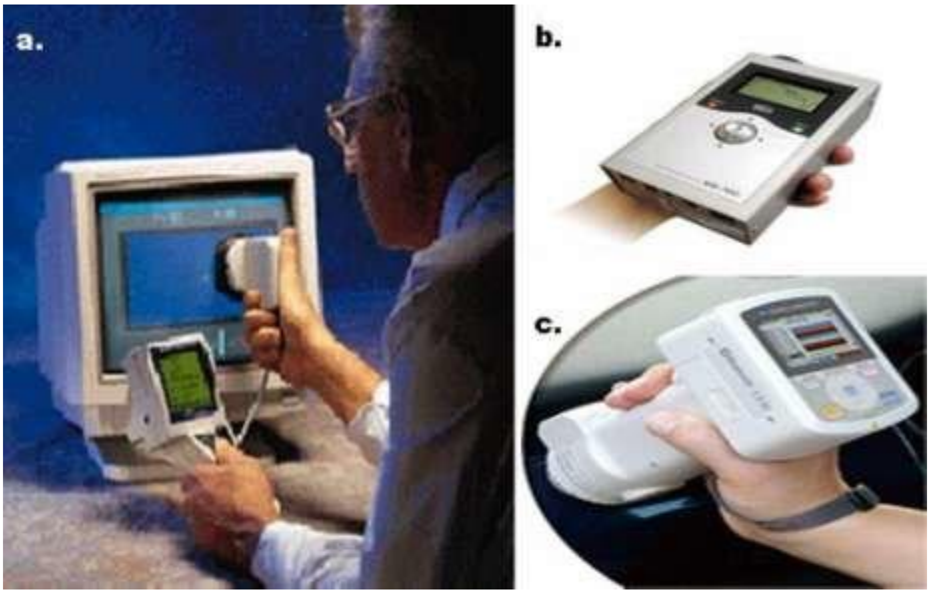


FIGURE:8 Equipments to examine color: a). Colorimeter, b). Spectrophotometer, c). Spectroradiometer

CONCLUSION:

The equipment used in prosthodontic research studies is essential for advancing the field of prosthodontics. By using these equipments/tools, researchers can develop new and improved prosthodontic treatments that can benefit patients with missing teeth or other oral structures.

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