International Journal of Enhanced Research in Medicines & Dental Care, ISSN: 2349-1590
Vol. 1 Issue 3, May-2014, pp: (1-8), Available online at: www.erpublications.com

Review of Equipments Pertaining to Prosthodontic Research

Dr. Shikha Gupta[1], Dr Vikas Setia[2], Dr. Sitaram Ramesh Waghle[3], Dr. Achla Bharti Yadav[4], Dr. Sumit Kumar Yadav[5], Dr. Shailesh Jain[6]

[1]Senior Lecturer, Department of Prosthodontics and Crown & Bridge, ITS Dental College & Hospital, Greater Noida, UP, India
[2]Assistant Professor, Department of Pedodontics & Preventive Dentistry, Adesh Institute of Dental Sciences and Research, Bathinda, Punjab, India
[3]Professor & Head, Department of Prosthodontics, Mithila Minority Dental College & Hospital, Darbhanga, Bihar, India
[4]Senior Lecturer, Department of Oral Pathology, Mithila Minority Dental College & Hospital, Darbhanga, Bihar, India
[5]Reader Department of Orthodontics & Dentofacial Orthopedics, Mithila Minority Dental College & Hospital, Darbhanga, Bihar, India
[6]Senior Lecturer, Department of Prosthodontics, Subharti Dental College, Meerut

Abstract: Studies conducted in the field of prosthodontics do need some special equipments or special apparatus for their successful completion. These equipments are used for testing mechanical properties of dental materials, detecting color, measuring distance between different reference lines or points, studying the surface properties of materials and visualizing oral microbes, studying stress distribution patterns at various interfaces, for measuring the bite forces, measuring the temperature changes, detecting the tongue palate contacts. This article provides a compilation of all these equipments.

Keywords: equipments, studies, prosthodontics.

INTRODUCTION

Prosthodontics, one of the dental specialities recognized by American Dental Association, pertains to the diagnosis, treatment planning, rehabilitation and maintenance of the oral function, comfort, appearance and health of patients with clinical conditions associated with missing or deficient teeth and/or oral and maxillofacial tissues using biocompatible substitutes. Various studies are being performed in the field of prosthodontics by the researchers across the world. These studies require some special apparatus, equipments or machines in order to produce the desired results. The aim of this article is to compile and explain most of these equipments used in prosthodontics studies. The different equipments can be categorized on the basis of their use as mentioned hereunder:

I. To measure the distance between two or more multiple reference points or reference lines

The distance between two or multiple reference points or reference lines is useful while comparing the accuracy, dimensional stability or surface reproducibility of different dental materials such as:

- Impression materials
- Bite registration materials
- Retraction materials: they can be compared based on the changes which they bring in sulcus depth and width.
- Duplicating materials used for making the refractory casts

For measuring this distance, various equipments are available which have different resolution powers. They can be used according to the requirements of the study. These equipments are:

1. PROFILE PROJECTOR (fig.1a)- This instrument enlarges and projects a workpiece onto the screen with accurate magnification and, the shape and dimensions of the workpiece can be observed and measured. Focusing is provided by moving the objective head up and down. There is an in-built digital counter that reads the measurements of the workpiece[1]. Resolution is 0.001mm.

2. COORDINATE MEASURING MACHINE (fig.1b) - It is a device for measuring the physical geometrical characteristics of an object. The CMM is composed of three axes, an X, Y and Z. These axes are orthogonal to each other in a typical three dimensional coordinate system. Each axis has a scale system that indicates the location of that axis. The machine reads the input from the touch probe, as directed by the operator. Then, it uses the X, Y and Z coordinates of each of these points to determine its size and position. Probes may be mechanical, optical, laser or white light. CMM can be used for dimensional measurement, depth mapping and digitizing[2]. Resolution is 0.001mm.

3. TRAVELLING MICROSCOPE (fig.1c) - This instrument is used for accurate measurement of diameters of different objects. It can travel horizontally 22cms and vertically 15cms with the help of slides. Two knobs are present for taking accurate readings. Resolution is 0.05 – 0.1mm.

4. VERNIER CALLIPER (fig.1d) - It is a precision instrument used for making external and internal linear measurements. It is named after its inventor, Pierre Vernier of France. It utilizes two graduated scales: a main scale similar to that on a ruler and an especially graduated auxiliary scale, the vernier that slides parallel to the main scale and enables readings to be made to a fraction of a division on the main scale. Accuracy is upto 0.01mm. Recently, digital Vernier Calipers are available in which the distances are read from an LCD display.

Figure- 1: Equipments to measure the distance between two or more multiple reference points or reference lines:
a. Profile Projector, b. Coordinate measuring machin, c. Travelling microscope, d. Vernier Calliper

Vernier calipers can be used:

- To compare the philtrum width with the width of maxillary cental incisors
- To compare the interalar width with intercanine width
- To measure the gap between adjacent teeth
- To measure the interocclusal distance
- To compare the occlusal vertical dimension of maxillary dentures after polymerization with that of wax trial dentures
- To measure very small distances on the casts

II. To study the surface properties of materials and visualize oral microbes

Various provisional fixed prosthodontic materials can be compared based on their surface roughness and susceptibility to adhere to streptococcus bacteria. Surfaces like implant – abutment interface, metal- acylic interface in cast restorations can be studied for marginal discrepancy and plaque accumulation and bacterial growth can be evaluated. Wear facets on the surface of gold, porcelain, resins and other materials can be analyzed. Surface analysis of prosthesis retaining screws can be done to find the causes of their failure. The instruments that can be used for this purpose are:

1. OPTICAL MICROSCOPE (fig.2a) - It uses visible light and a system of lens to magnify images of small samples. Magnification power = 10x multiplied by the power of objective lens used. At higher magnifications, optical microscopes are used to study thin specimens. Digital microscopes are now available, which use a CCD camera to examine a sample, and the image is shown on a computer screen[3]. Their magnification is upto 200x.

2. STEREOMICROSCOPE (fig.2b) - It uses two separate optical paths with two objectives and two eyepieces to provide slightly different viewing angles to the left and right eyes. So, it gives a 3-dimesional visualization of the sample. Magnification is upto 100x.

3. SCANNING ELECTRON MICROSCOPE (fig.2c) - It is a microscope that uses electrons instead of light to form an image. SEM has a larger depth of field and much higher resolution. So, a specimen and closely spaced specimens can be magnified at much higher levels. Wide range of magnification is possible, from about 10 times to more than 500,000 times. As this microscope works in a vacuum, all water must be removed from the specimen. All samples need to be made conductive by covering them with a thin layer of conductive material.

4. PROFILOMETER (fig.2d)- Profilometer is a measuring instrument used to measure a surface's profile, in order to quantify its roughness and finish. Vertical resolution is usually in the nanometre level (20 nm – 25 microns). There are 2 types of profilometers – Contact and Optical. Contact profilometers utilize a diamond stylus that moves vertically in contact with the sample. Profilometer measures small surface variations in vertical stylus displacement as a function of position. The vertical position of diamond stylus generates an analog signal which is converted to a digital signal, stored, analyzed and displayed. Optical profilometers do not contact the surface and hence are not damaged by surface wear.
Profilometers can be used to measure the surface roughness of porcelain [4] or other materials after ultrasonic scaling and periodontal curettage, and wear resistance of materials like composite resins.

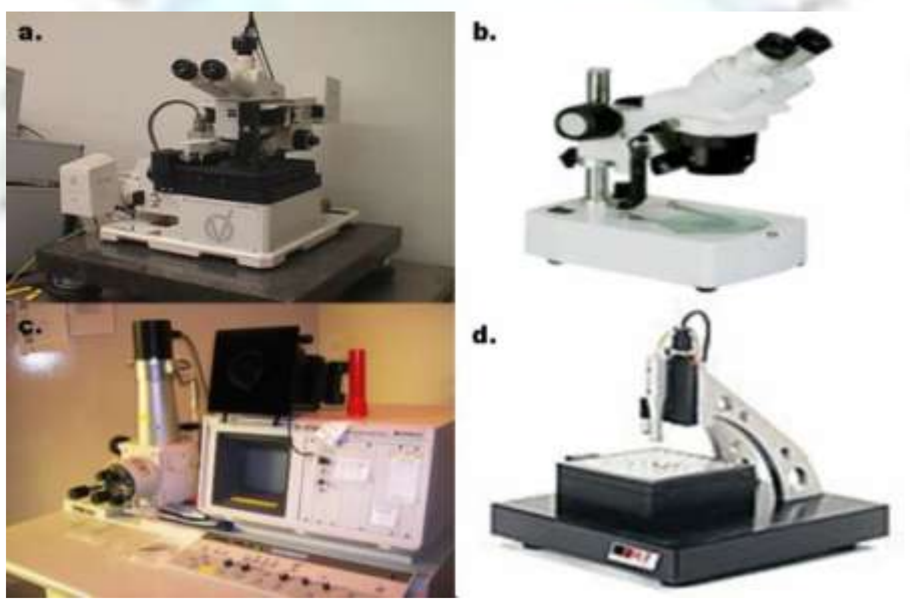

Figure- 2: Equipments to study the surface properties of materials and visualize oral microbes:
a. Optical microscope, b. Stereomicroscope, c. Scanning electron microscope, d. Profilometer

III. To study the mechanical properties of dental materials

Different dental materials are compared amongst each other for their inherent MECHANICAL PROPERTIES like compressive strength, tensile strength, fatigue strength, flexural strength, yield strength, impact strength, hardness etc. The different machines that may be used to study the various mechanical properties are:

1. UNIVERSAL TESTING MACHINE (UTM) (fig.3a) - It consists of 2 jaws mounted on two vertical spindles. The sample is held in jaws and the desired amount and type of load is applied gradually. The load is shown on a reading scale. The load varies from 20-20,000 KN. The equipment is connected to the computer which gives the values of required data. The machine is hydraulically operated. Least count of the machine is 0.005mm. It can be used for measuring the compressive strength, tensile strength, shear strength, flexural strength, yield strength, Poisson's ratio and Brinell's hardness test of various dental materials including impression materials, soft liners, post and core materials, bite registration materials etc.

2. TENSOMETER (fig.3b) - It is a smaller version of UTM. The sample is held horizontally and axial load is applied either manually or with an electric motor. The load reading is shown on a mercury scale. Samples can be tested at different temperatures and relative humidity. It evaluates various tensile properties like tensile strength, fatigue strength, Young's modulus, elastic limit and proportional limit.

3. IZOD PENDULUM (fig.3c) - It is an apparatus for measuring the impact strength of different materials like metals and plastics, denture base materials etc. It consists of a pendulum with a known weight at the end of its arm swinging down and striking the specimen as it stands clamped in the vertical position.

4. CHARPY PENDULUM (fig.3d) - It is an apparatus similar to Izod pendulum except for the vertical orientation of the specimen which is placed horizontally in the charpy pendulum. The pendulum axe swings at a notched sample of material. It can be used to measure the toughness, yield strength, ductility and impact strength of the material.

5. HARDNESS TESTERS - These are used for performing different hardness tests. These tests are based on the ability of a material to resist penetration by a diamond point or a steel ball under a specified load. The different types of hardness tests are:

Figure-3: Equipments to study the mechanical properties of dental materials:
a) Universal testing machine, b) Tensometer, c) Izod pendulum, d) Charpy pendulum, e) Rockwell Hardness tester

Brinell hardness Test: A hardened steel ball is pressed into the polished surface of a material under a specified load. The load divided by area of indentation gives the Brinell Hardness Number (BHN) of the material. This test is used for metals and metallic materials. It is unsuitable for plastic and brittle materials.

Rockwell Hardness Test (fig.3e): A steel ball or a conical diamond point is used. Instead of measuring the diameter of the impression, the depth is measured by a dial gauge on the instrument. It has a wider area of application than the Brinell hardness test.

Vickers Hardness Test: Instead of a steel ball, a diamond in the shape of a square pyramid is used. Load is divided by the area of indentation. The length of the diagonals of the indentation (sides of the diamond) are measured and averaged. This test is used for dental casting gold alloys. It is also suitable for brittle materials, hence used for measuring hardness of tooth structure.

Knoop Hardness Test: A diamond indenting tool is used. It can be used for testing the hardness of exceedingly hard and soft materials. It is independent of the ductility of material. The Brinell and Rockwell are classified as macrohardness tests. Knoop and Vickers are classified as microhardness tests.

Shore and Barcol Tests: A metal indenter that is spring loaded is used. Depth of penetration is read directly from a gauge. These are less sophisticated methods and can be used for rubbers and plastics [5]. There are separate testers available for different hardness tests. Also, a Universal hardness tester is available for performing all the hardness tests. Mobile hardness testers are available now which can be easily carried and used.

IV. To study the stress distribution patterns at various interfaces

FINITE ELEMENT ANALYSIS: It is mathematical software in which integral and partial differential equations are used. A 2-D or 3-D computer model of a required material or design is constructed. This model is stressed under specific conditions and analyzed. This helps the researcher to know how a particular structure will react to certain loading conditions. FES can be used in designing of a new product, and refinement of the existing product. It may be used to determine the design modifications to meet the new conditions.

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.

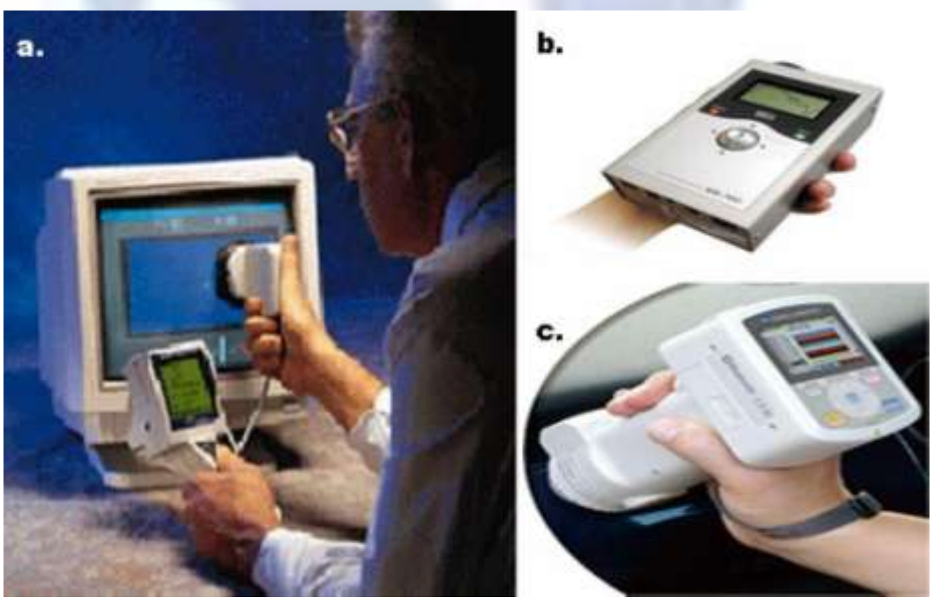

Figure-4: Equipments to study color:
a). Colorimeter, b). Spectrophotometer, c). Spectroradiometer

V. To study the temperature changes

THERMOCOUPLE - It is the most widely used electronic temperature sensor. It consists of two dissimilar metals joined together 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. It is a precise instrument for thermal testing. Accuracy is approximately = 0.05^0C. It can be used to measure the following:

- Temperature changes in the pulp camber during fabrication of direct restorations,
- Temperature change during rapid mixing of zinc phosphate cement [8].
- Temperature changes in the heat activated acrylic denture base resin during processing.

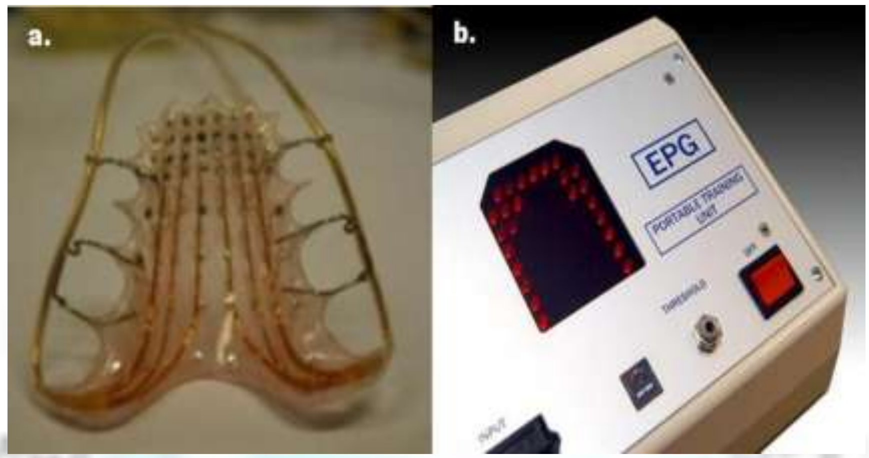

Figure-5: Equipments to study the temperature changes
a. EPG palate with embedded electrodes, b. Electropalatograph

VI. To study the color

COLOR - For color to be seen, light is reflected from an object and stimulates the neural sensors in the eye's retina to send a signal that is interpreted in the visual cortex of the brain. It has a very important role to play in prosthodontics because of the following reasons:

- To match the shade of the restoration with that of the natural teeth of the patient.
- To evaluate the optical influence of different metal alloys and porcelains on the final color of metal-ceramic complex
- To evaluate color stability of colorant – elastomer combinations on exposure to conditions like weathering
- To evaluate color changes in tooth colored veneering materials on consumption of beverages

Various shade taking devices are available to match the color.

1. COLORIMETER (fig.4a) - It consists of a color sensor and a handheld display unit. It expresses the color numerically according to international standards making it possible for anyone to understand which color is being expressed. Colorimeters have sensitivities corresponding to those of human eye, but because they always take measurements using same light source and illumination method, the measurement conditions will be same, whether its day or night; indoors or outdoors. This makes all accurate measurements simple.

2. SPECTROPHOTOMETER (fig.4b) - It is an instrument used to measure the amount of light a color sample reflects or transmits at each wavelength, producing a spectral data. It measures and quantifies color, thus ensuring color consistency. The object is usually illuminated with simulated daylight. Light reflected by the object is directed to a monochromator (spectral analyser). A diffraction grating in the monochromator separates the reflected light into individual wavelengths, typically from 360 to 700 nanometers (nm). The reflected light is measured with a photodiode array to determine the fraction of light reflected by the object (%R) at each wavelength. The computer software displays the reflectance values in 5 or 10 steps and/or graphs them as a spectral reflectance curve. Spectrophotometer calculates the values for any illuminant or observer while the colorimeter can only measure for one illuminant and one observer. In addition to the ability to supply values for quality control quite easily, the spectrophotometer is also able to determine the appearance of sample under different illuminants and calculates the metamerism.

3. SPECTRORADIOMETER (fig.4c) - Spectroradiometers are designed to measure the actual spectral power distribution of the light source. They operate almost like spectrophotometers in the visible region. The only difference is that spectrophotometers measure the reflected color of a given color sample.
All these digital shade matching devices are hand held products, each containing a color analyzer with its own light source that has accompanying software for downloading, evaluation and transmission of the relevant color data recorded. The program's interpretation of this shade record is downloaded on the prosthodontist's computer, can be used for selecting the shade of the provisional restoration fabricated chairside and is then transmitted via email to the laboratory where the definitive restoration is to be made.

Once received by the laboratory, 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].

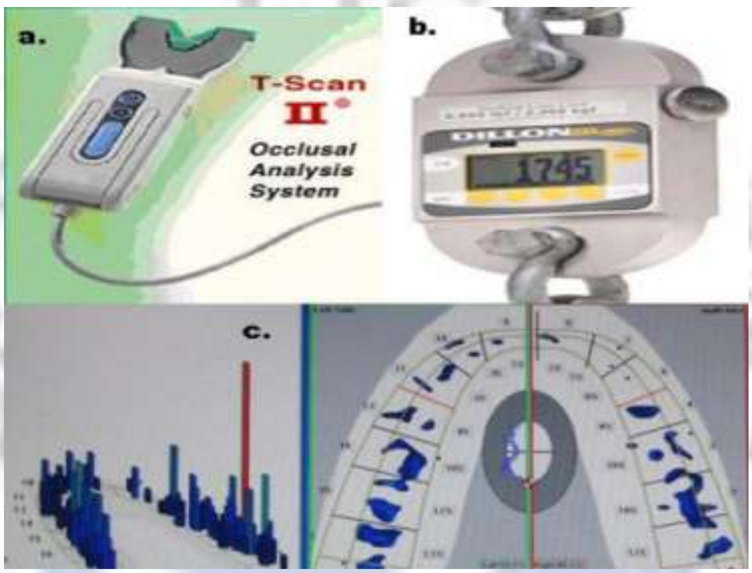

Figure-6: Equipments to measure bite forces
a). Dynamometer, b). T- scan II occlusal analysis system, c). T- scan

VII. To study the tongue – palate contacts

ELECTROPALATOGRAPH (EPG) (fig.5b) - Electropalatograph (also known as palatometer) is an instrument that records the timing and location of tongue contact with the roof of the mouth (hard palate) during speech. EPG requires the speaker to wear an artificial palate which is similar to an orthodontic brace and fits against the hard palate [10].The EPG palate (fig.5a) has 62 silver electrodes embedded in it. When the tongue touches these electrodes the pattern is recorded by a computer. By using specially designed software, these patterns can either be viewed straight away or analysed later. It is helpful to detect articulation difficulties in patients with cleft palate and Down Syndrome.

VIII. To measure the bite forces

1. DYNAMOMETER (fig.6a) - Dynamometer is used to measure force, torque or power. Earlier, hand dynamometers were used for routine screening of grip strength and initial and ongoing evaluation of patients with hand trauma and dysfunction. Recently, digital dynamometers are available to evaluate the physical status, performance and task demands.
Digital dynamometer is useful for prosthodontic studies in the following way:

- Used to compare the bite forces among dentate patients, denture wearers and patients with temporomandibular disorders [11].
- Useful in evaluating the fit in osseointegrated implant components [12].

2. T-SCAN (fig.6c) - The T-Scan is a grid-based sensor technology and occlusal analysis system (fig.6b) that allows for an easier, more accurate way to measure occlusal timing and force. Because the T-Scan can measure force over time, it is an indispensable tool for appraising the sequential relationships of a mandibular (lower jaw) movements. You can view, on screen, a patient sliding from MIP (where all of the teeth are in Maximum Intercuspal Position where all teeth bite together) or CR (Centric Relation position when the jaw closes on its backwards most arc of closure) into a lateral excursion (when you slide your teeth to the left or right side.) This is instrumental in locating occlusal interferences, determining the relative force on each interference, and evaluating 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

CONCLUSION

Thus, we see that there are so many equipments available which facilitate the researchers for performing successful studies in the field of prosthodontics. These equipments are updated regularly by incorporating new and more technologically advanced features so that they can be used by the researchers to get more precise results.

REFERENCES

[1]. Profile Projector. [Online]. [2007?] [cited 2010 January 26]; Available from: URL: http://www.profileprojector.com.
[2]. Coordinate measuring machine. [Online]. 2010 March 22 [cited 2010 March 25]; Available from: URL: http:// enwikipedia.org wiki/Coordinate-measuring_machine
[3]. Optical microscope. [Online]. 2008 October [cited 2010 March 25]; Available from: URL: http://enwikipedia .org/wiki /Optical_microscope
[4]. Goldstein GR. Profilometer, SEM, and visual assessment of porcelain polishing methods. Journal of Prosthetic Dentistry 1991;65(5): 6627-634 Manappallil J. Basic Dental Materials. New Delhi: Jaypee Brothers; 1998.
[5]. Zampelis A. Tilting of splinted implants for improved prosthodontic support: A two-dimensional finite element analysis. Journal of Prosthetic Dentistry 2007; 97(6): S35- S43.
[6]. Yuasa Y. Finite Element Analysis of the Relationship between Clasp Dimensions and Flexibility. Journal of Dental Research 1990; 69(10): 1664-1668.
[7]. Fakiha ZA. Rapid mixing of zinc phosphate cement for fixed prosthodontic procedures. Journal of Prosthetic Dentistry 1992; 67(1): 52-58.
[8]. Anand M, Shetty P. Shade matching in fixed prosthodontics using instrumental color measurements and computers. JIPS 2007; 7(4) : 179 – 183.
[9]. Speech in Down's syndrome: Electropalatography. [Online]; Available from: URL: http://www. qmu.ac.uk /ssrc /Down Syndrome /EPG. htm
[10]. Kogawa EM. Evaluation of maximal bite force in temporomandibular disorders patients. J Oral Rehabilitation 2006 Aug;33(8):559-65.
[11]. Wicks AR. An Evaluation of Fit in Osseointegrated Implant Components using Torque/Turn Analysis. Journal of Prosthodontics 2005;3(4):206-212.
[12]. Rosenberg SW. T- Scan II – The Occlusal Analysis Solution. [Online]. [2009?] [cited 2010 March 20]; Available from:
[13]. URL:http://www.drsimonrosenberg.com/T-Scan-Occlusal-Analysis.html.