COURSE GUIDE

DNT 404
METALLIC PROSTHODONTICS 1

Course Team

Raji A. Kazeem (Course Developer/Writer) - General Hospital, Oyo
Prof.AfolabiAdebanjo (Programme Leader) - NOUN
Dr.Shehu Ibrahim Omoniyi (Course Coordinator)- NOUN

NATIONAL OPEN UNIVERSITY OF NIGERIA

National Open University of Nigeria
Headquarters
14/16 Ahmadu Bello Way
Victoria Island, Lagos

Abuja Office
5 Dar es Salaam Street
Off Aminu Kano Crescent
Wuse II, Abuja

e-mail: centralinfo@nou.edu.ng
URL: www.nou.edu.ng

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INTRODUCTION

DNT 404: Metallic Prosthodontics 1 is a basic course which is designed for students with no previous knowledge of metallic appliances in Dental Technology. It is a three- credit unit course which is broken down into five modules and twenty-one study units.

Metallic prosthodontics deals with the use of metallic artificial devices to replace lost or missing teeth and associated jaw or intra oral structures. This is the introductory stage of your study in metallic prosthodontics. Therefore, this course tells you what type of metals or alloys can be used in the mouth, the properties of such alloys, the design and construction of metallic appliances as well as the principles of supporting units for partial dentures.

This course guide therefore, help you to know what the course DNT 404 is all about, the type of materials to be used, what you are expected to know in each unit and how to work through the course material. It suggests the general guidelines and also emphasis the need for self-assessment and tutor marked assignment. There are also tutorial classes that are linked to this course and students are encouraged to attend.

WHAT YOU ARE TO LEARN IN THIS COURSE

The course content consist of a unit of the course guide which tell you briefly what the course is about, what course materials you need and how to work with such materials. It also gives you some guideline for the time you are expected to spend on each unit in order to complete it successfully.

It guides you concerning your tutor-marked assignment which will be placed in the assignment file. Regular tutorial classes related to the course will be conducted and it is advisable for you to attend these sessions. It is expected that the course will prepare you for challenges you are likely to meet in the field of Dental Technology.

COURSE AIM

This course aims to introduce you to metallic prosthodontics in general. The general overview and other knowledge in this course will equip you with the necessary skill to excel in your examination and practical work.

COURSE OBJECTIVES

Note that each unit has specific objectives. You should read them carefully before going through the unit. You may want to refer to them during your study to check on your progress. You should also look at the unit objectives after completing a unit.

However, below are the overall objectives of this course. At the end of this course, you should be able to:

- Identify the metals and alloys suitable for the construction of metallic prostheses.
- State the chemical, thermal and mechanical properties of metallic materials
- Know how to design and fabricate different metallic prosthodontics appliances.
- Explain the principles of supporting units such as Onlays,Rests,Clasps and bars.
- Discuss methods of investing, heating and casting metallic prostheses.
- Undertake rough finishing, fine finishing and polishing processes
- Describe the procedure for fitting the appliance on patient.

WORKING THROUGH THIS COURSE

To complete this course you are expected to read each study unit, read the textbooks and other materials which may be provided by the National Open University of Nigeria. Each unit contains self-assessment exercises. In the course you would be required to submit assignment for assessment. At the end of the course there is final examination. The course should take about 15 weeks to complete.

Listed below are the components of the course, what you have to do and how to allocate your time to each unit, in order to complete the course successfully and timely.

The course demands that you should spend good time to read and my advice for you is that you should endeavour to attend tutorial session where you will have the opportunity of comparing knowledge with colleagues.

COURSE MATERIALS

The main components of the course are:

1. The course guide
2. Study units
3. References / Further readings
4. Assignments
5. Presentation schedule

STUDY UNITS

This course consists of twenty-one units in five modules as follows:

Module 1 Materials for the Construction of Metallic Appliances

Unit 1 Brief Description of the Structure of Metals and Alloys
Unit 2 Gold Alloys
Unit 3 Cobalt-Chromium Alloys
Unit 4 Swaged Stainless Steel

Module 2 Properties of Metallic Materials for Prosthodontics Appliances

Unit 1 Corrosion Resistance and Tarnishing
Unit 2 Thermal Conductivity, Malleability and Ductility
Unit 3 Impact Strength and Fatigue Strength
Unit 4 Heat Treatment, Work Hardening and Stress Anneal

Module 3 Design and Construction of Metallic Prosthodontics Appliance

Unit 1 Duplication of Model Using Refractory Material
Unit 2 Design of Skeletal Plates
Unit 3 Types and Design of Clasps
Unit 4 Metallic Mainframes (Plates)
Unit 5 Combination of Metallic and non-Metallic Denture Base Materials

Module 4 Principles of Supporting Units for Partial Denture

Unit 1 Onlays
Unit 2 Rests and Hooks
Unit 3 Continuous Clasp and Bars

Module 5 General Pattern of Investment Procedures

Unit 1 Investing, Wax-Elimination and Heat-soaking
Unit 2 Casting in various Types of casting Machines
Unit 3 Finishing
Unit 4 Soft(Resilient) Lining Practice
Unit 5 Fitting the Appliance on Patient

RECOMMENDED TEXTS

These texts will be of immense benefit to this course

Combe, E.C. (1981). Notes on Dental Materials. (4th ed.). Churchill Livingstone.

Kamal, A. *et al.* (1981).Restorative Dental Materials. Michigan: University of Michigan Press.

Richard, W. *et al.* (1980).*Dental Technology Theory and Practice*. St Louis: C. V. Mosby Co.

Shaw, F.G. & Scott, D.C. (1968). *Practical Exercises in Dental Mechanics*. (3rd ed.). London:Dental Technician Ltd.

ASSIGNMENT FILE

The assignment file will be given to you in due course. In this file, you will find all the details of the work you must submit to your tutor for marking. The marks you obtain for these assignments will count towards the final mark for the course. Altogether, there are 21 Tutor- Marked Assignments (TMAs) for this course.

PRESENTATION SCHEDULE

Your course materials have important dates for the early and timely completion and submission of your TMAs and attending tutorials. You are expected to submit all your assignments by the stipulated time and date and guard against falling behind in your work.

ASSESSMENT

There are three parts to the course assessment and these include self-assessment exercises, Tutor marked Assessments and the written examination or end of course examination. It is advisable that you do all the exercises. In tackling the assignments, you are expected to use the information, knowledge and techniques gathered during the course. The assignments must be submitted to your facilitator for formal assessment in line with the deadlines stated in the presentation schedule and assignment file. The work you submit to your tutor for assessment will count for 30% of your total course work. At the end of the course you will need to sit for a final end of course examination of about three hours duration. This examination will count for 70% of your total course mark.

TUTOR- MARKED ASSIGNMENT (TMA)

The TMAs is a continuous component of your course. It account for 30% of the total score. You will be given four (4) TMAs to answer. Three of these must be answered before you are allowed to sit for the end of course examination. The TMAs would be given to you by your facilitator and returned after you have done the assignment. Assignment questions for the units in this course are contained in the assignment file. You will be able to complete your assignment from the information and material contained in your reading, references and study units. However, it is desirable in all degree level of education to demonstrate that you have read and researched more into your reference, which will give you a wider view point of the subject.

Make sure that each assignment reaches your facilitator on or before the deadline given in the presentation schedule and assignment file. If for any reason you cannot complete your work on time, contact your facilitator before the assignment is due to discuss the possibility of an extension. Extension will not be granted after the due date unless there are exceptional circumstances.

FINAL EXAMINATION AND GRADING

The end of course examination for Metallic Prosthodontics 1 will be for about 3 hours and it has a value of 70% of the total course work. The examination will consist of questions, which will reflect the type of self-testing, practice exercise and tutor-marked assignment problems you have previously encountered. All area of the course will be assessed.

Use the time between finishing the last unit and sitting for the examination to revise the whole course. You might find it useful to review your self-test, TMAs and comments on them before the examination. The end of course examination covers information from all parts of the course.

COURSE MARKING SCHEME

The following table includes the course marking scheme.

Table 1 Course Marking Scheme

Assessment	**Marks**
TMAs	30%
Final Examination	70%
Total	100%

Four assignments, out of which the best three marks of 10% each will be selected

End of course examination is 70% of overall course marks and Total is 100% of course materials.

COURSE OVERVIEW

This table indicates the units, the number of weeks required to complete them and the assignments.

Table 2:Course Organizer

Unit	**Title of Work**	**Weeks Activity**	**Assessment (End of Unit)**
	Course Guide	Week 1	
Module 1	**Materials for the construction of metallic appliances**		
Unit 1	Brief Description of the structure of metals and alloys	Week 1	Assignment 1
Unit 2	Gold Alloys	Week 2	Assignment 2
Unit 3	Cobalt-Chromium Alloys	Week 2	Assignment 3
Unit 4	Swaged Stainless Steel	Week 3	Assignment 4
Module 2	**Properties of Metallic Materials for Prosthodontics Appliances**		
Unit 1	Corrosion Resistance and Tarnishing	Week 3	Assignment 5
Unit 2	Thermal conductivity, malleability and Ductility	Week 4	Assignment 6
Unit 3	Impact Strength and Fatigue Strength	Week 4	Assignment 7
Unit 4	Heat Treatment, Work hardening and Stress Anneal	Week 5	Assignment 8
Module 3	**Design and Construction of Metallic Prosthodontics Appliance**		
Unit 9	Duplication of Model Using Refractory Material	Week 5	Assignment 9
Unit2	Design of Skeletal Plates	Week 6	Assignment 10

Unit 3	Types and Design of Clasps	Week 7	Assignment 11
Unit 4	Metallic Mainframes (Plates)	Week 8	Assignment 12
Unit 5	Combination of Metallic and non-Metallic Denture Base Materials	week 8	Assignment 13
MODULE 4	**Principles of Supporting Units for Partial Denture**		
Unit 1	Onlays	Week 9	Assignment 14
Unit 2	Rests and Hooks	Week 9	Assignment 15
Unit3	Continuous Clasp and Bars	Week 10	Assignment 16
Module 5	**General Pattern of Investment Procedures**		
Unit 1	Investing, Wax-Elimination and Heat-soaking	Week 10	Assignment 17
Unit 2	Casting in Various Types of casting Machines	Week 11	Assignment 18
Unit 3	Finishing	Week 11	Assignment 19
Unit 4	Soft (Resilient) Lining Practice	Week 12	Assignment 20
Unit 5	Fitting the Appliance on Patient	Week 12	Assignment 21

FACILITATORS/TUTORS AND TUTORIALS

There are 15 hours of tutorials provided in support of this course. You will be notified of the dates, times and location of the tutorials as well as the name and the phone number of your facilitator, as soon as you are allocated a tutorial group.

Your facilitator will mark and comment on your assignments, keep a close watch on your progress and any difficulties you might face and provide assistance to you during the course. You are expected to mail your Tutor marked Assignment to your facilitator before the schedule date (at least two working days are required). They will be marked by your tutor and returned to you as soon as possible.

Do not delay to contact your facilitator by telephone or e-mail if you need assistance.

The following might be circumstances in which you would find assistance necessary, hence you would have to contact your facilitator if:

- You do not understand any part of the study or the assigned readings.
- You have difficulty with self-tests.
- You have a question or problem with an assignment or with the grading of an assignment.

You should endeavour to attend the tutorials. This is the chance to have face to face contact with your course facilitator and to ask question which are answered instantly. You can raise any problem encountered in the course of your study.

To gain more benefit from course tutorials prepare a question list before attending them. You will learn a lot from participating actively in discussions.

SUMMARY

Metallic Prosthodontics 1 is designed to give you the general overview of metals and alloys used in the construction of metallic dentures. It will also equip you with the skills required in the design and fabrication of metallic frame as well as combining it with acrylic material to form a complete prosthesis.

Basically, this course material provides you with both the theoretical background and practical procedures needed for the fabrication of metallic partial dentures. To gain most from this course you are advised to consult relevant books to widen your knowledge on the topic.

I wish you success in the course. It is my hope that you will find it both illuminating and useful.

MAIN COURSE

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MODULE 1 MATERIALS FOR THE CONSTRUCTION OF PROSTHODONTIC APPLIANCES

UNIT 1 BRIEF DESCRIPTION OF STRUCTURE OF METALS AND ALLOYS

CONTENTS

1.0 INTRODUCTION

In this unit, you will learn the basic knowledge of metals and alloys used for metallic prostheses. Metallic Prosthodontics deals with the replacement of teeth and related mouth or jaw structures by metallic artificial devices. Therefore, it is important to understand the structure and behavior of metals either in pure state or when used in combination with other metals. Suffice to say that the blending of two or more metals is known as an alloy.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- define metals and differentiate it from an alloys
- identify the different stages in the cooling curve of pure metal
- explain the structure of metals and space lattices
- enumerate the purposes of alloying.

3.0 MAIN CONTENT

3.1 Definition of Metals

A metal is any chemical element which ionizes positively in solution. In more than 100 elements in the Periodic Table, 68 are metals, such as iron, zinc, tin etc, 8 are metalloids (similar to metals in some respects) e.g. Silicon, Arsenic and Boron while the remaining elements are non-metals.

Metals may be crystalline or amorphous in nature. You will learn more about this in space lattice later in this unit.

3.1.1 Classification of Metals

Metals may be classified into three groups as follows:

- Noble metals – these are metals that occur freely in nature and have good resistance to tarnishing and corrosion. Examples of such metals include Gold, Silver, and Platinum etc.
- Base metals or non-precious metals – these metals seldom occur alone but occur in combination with other elements or impurities and lack tarnish and corrosion resistance. We have chromium, zinc, copper etc.
- Metalloids – Though these elements ionize negatively in solution, they behave as metals and sometimes combine with metals to form an alloy. They are non- crystalline in nature. Examples of metalloids are Boron, Silicon, Carbon, Phosphorous etc.

3.1.2 Properties of Metals

A pure metal is a substance possessing chemical and physical properties which enable it to be easily distinguished from other non-metals:

- Metals are electropositive, that is they give positive ions in solution
- They are good conductors of heat and electricity due to the nature of metallic bond
- Metals are usually hard, lustrous and dense

- It possesses relatively high strength, density, elasticity and toughness
- It exhibits high ductility and malleability.

3.1.3 Cooling of Molten Metal

A pure metal in liquid state when cooling gradually losses heat and decrease in temperature is reached which remain constant over a period of time. After all the metals have solidify, the temperature then falls as you can see in the cooling curve shown below.

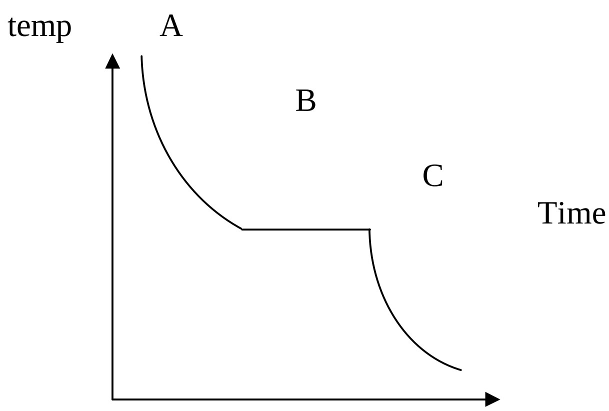

Fig 1.1: Temperature-time Curve for Cooling of a Molten Metal

The above graph shows three portions
A – Cooling of the molten liquid metal
B – A plateau or horizontal portion when the metal is solidifying and there is evolution of latent heat of fusion.
C – Cooling of the completely solidified metal.

3.1.4 Structure of Metal on Solidification

The solidification of pure metal starts at the Centre of crystallisation called nuclei. Growth of the crystals from nuclei occurs in the form of dendrites or branched structures. The growth of crystal continues until it makes contact with adjacent growing crystal and solidification is complete when the pools of liquid between the dendrite arms have crystallised.

Each crystal of a metal is called a grain. Within each grain, the orientation of the crystal lattice and crystal plane is uniform. However, the adjacent grain has different orientation because the initial nuclei acted independently from each other. Therefore, at the grain boundary, the atoms take up position intermediate between those of the atoms in the adjacent space lattices.

3.1.5 Space-Lattice Structure

In this section, you will better understanding about space-lattices introduced in the previous section. A space-lattice is a regular three dimensional atomic arrangement in crystalline material. This consists of basic atomic pattern or unit cell repeated in three-dimension. This is the structure of most metals in pure state.

Most metals used in dentistry conform to cubic space lattice systems which are of three types as follows:

- Body -Centred Cubic Space-Lattice

It has an atom at each of its eight corners and one at its centre of gravity e.g. Chromium, Molybdenum, Tungsten, Iron. This structure is more difficult to deform.

- Face-Centred Cubic Space-Lattice

It has an atom at each of its eight corners and one at the centre of its six sides but non at the centre of the cube. Examples of such metals include Gold, Silver, Platinum and Copper. They are easily deformed.

- Close- packed hexagonal structure

The basic unit of the crystals is repeated in all the three directions to produce a space lattice. Examples of metals with this structure are Zinc and Magnesium.

3.2 Alloys

In metallic Prosthodontics and dentistry in general, metals are seldom used alone except such metals as Tin, Copper, Zinc, Gold foil, Platinum with dental Porcelain. The properties of pure metals may be improved by alloying.

Definition: An alloy may be defined as a material formed by the intimate blending of two or more metals, sometimes a metalloid or non-metal may be added provided the mixture of elements display metallic properties.

3.2.1 Reasons for Alloying

To:

- increase hardness and strength
- lower the melting point and increase fluidity
- modify the structure or colour
- increase resistance to tarnishing and corrosion
- provide special electrical or magnetic properties
- facilitate sound and workable casting.

3.2.2 Classification of Alloys

There are two parameters for classifying alloys, viz:

1 Constituents
2 Solubility

3.2.2.1 Classification Based on Constituents

Alloys may be classified with regards to constituting elements; thus, the greater the number of constituents, the more complex the structure of the alloy.

- Binary alloys have two constituents
- Ternary alloys have three constituents
- Quaternary alloys have four constituents

3.2.2.2 Classification Based on Solubility

A more comprehensive classification is based upon the solubility after solidification of the constituents. A solution is formed when two molten metals are mixed. Solution is defined as perfectly homogeneous mixture. The cooling of such solution of molten metals gives rise to three classifications:

- Solid solution: this is made up of metals which are soluble in each other in the solid state. You can define solid solution as a solid structure in which the invading atoms are distributed throughout the crystal grains without causing fundamental change in the shape of parent space-lattice. Also, the structures are homogeneous and they resemble pure metal when observed through a microscope. Dental gold alloys are of the solid solution type. Examples include Au +Ag. Au +Ni, Au +Cu, Au+Pd, etc.

- Intermediate or inter-metallic compound: This occurs if the constituting metals are partially soluble in each in the liquid and solid states. Metals in these compounds have chemical affinity for each other e.g. Ag+Sn, Ag+Cu, Pb+Sn etc.
- Eutectic alloys: here, you see a case of complete solid insolubility. The metals are completely insoluble in each other in the solid state. This system is characterized by the fact that the melting limit of the alloy is less than the melting point of its components. In dentistry, these alloys are used as soft solders, dies and counter-dies for crown and bridge work because of their low melting point. E.g. fusible alloys.

4.0 CONCLUSION

In this unit, the relevance of metals and alloys to Prosthodontics technology was stressed. Metal is any substance which ionizes positively in solution and examples of such elements were given as Zn, Ag, Au, etc. All metals have solid structure with the exception of mercury which is in liquid state. Since metals are crystalline materials, the geometric arrangement of atoms within metallic structures was discussed.

However, pure metal is seldom used in dentistry; therefore alloys are equally important in metallic Prosthodontics. An alloy is a mixture of two or more metallic elements. Alloys were classified using two criteria – constituents and solubility of metals.

5.0 SUMMARY

This unit equips you with foundation knowledge that is needed for better understanding of the course in general. In this unit, you learnt that metals are:

- Chemical elements that are electropositive in nature e.g. gold, tin, silver platinum etc.
- Metals are classified as noble or precious metals, base metals or non-precious metals and metalloids.
- Metalloids are non-metallic substances such as Carbon, Silicon, Boron, Phosphorous etc. which behave as metals.
- A pure metal in liquid state when cooling gradually losses heat until a definite temperature is reached which remain constant for a period of time. After all the metals have solidify, the temperature again falls as shown in fig. 1.1
- The grain structure of metal shows that each crystal grows from the nucleus located at the centre of crystallisation.

- The space lattice structure of most metals in pure state conform to the cubic space lattices system which are of three types, namely; Body- centred, faced- centred and hexagonal close- packed.
- Alloy is a mixture of two or more metallic elements. Some of the reasons for alloying are to improve tarnishing and corrosion resistance as well as aid special electrical and magnetic properties of alloying metals.
- Alloys are classified based on the number of elements it contains hence, Binary alloy has two metals, Ternary alloy has three elements; Quaternary has four and so on.
- Three categories of alloys were identified based on solubility of its constituents i.e. solid solubility, partial solubility and insolubility of the combining alloys in each other.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is the difference between metals and metalloids?
2. Identify the three categories of alloys based on solubility of metals in solid state.
3. Graphically describe the stages in the solidification of pure molten metal.
4. Describe the space lattice structure of pure metal.

7.0 REFERENCES/FURTHER READING

Asgar, K. *et al.* (1981). *Restorative Dental Materials*. Michigan: University of Michigan Press.

Combe, E.C. (1981). *Notes on Dental material*. (4th ed.).

Churchill, Livinstone (1999). *The Glossary of Prosthetics Terms.* (7th ed.). *Prosthetic Dentistry*.

UNIT 2 GOLD ALLOYS

CONTENTS

1.0 INTRODUCTION

The previous unit serves as general introduction to the entire study of metallic prosthetics. That is why you learnt the properties, nature and structures of pure metals. However, pure metals are rarely used in dentistry hence the need to modify the properties of these pure metals through the formation of alloys.

This unit is the first in the series that deal with various alloys used for the construction of metallic appliances for dental purposes.

Gold is used extensively in wrought and cast dental operations, therefore, you will study the characteristics, composition and heat treatment of Dental Gold alloys is this unit.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- enumerate the properties of gold
- determine the quantity or proportion of pure gold in the alloy
- state the composition of various types of gold alloys
- evaluate the effects of other constituents in the alloy
- describe the heat treatment procedure on dental gold alloy.

3.0 MAIN CONTENT

3.1 Pure Gold

Pure gold is a mobile metal because of its ability to resist corrosion in the mouth. It is soft and ductile; therefore, it is not used for cast dental restorations and appliances but only in the form of foil for cold-swaging internal cavities. Pure gold is mainly used as chief constituent of gold alloys for cast or wrought appliances.

3.1.1 Properties of Pure Gold

- Pure gold is yellow in colour and has a brilliant lustre.
- It has ability to resist corrosion in the oral environment
- It is the most malleable and ductile of all metals used in the mouth.
- It has a Brinell hardness of 27
- Its specific gravity is 19.3
- It has a melting point of 1063^{o}C
- Pure gold is not responsive to heat treatment except when alloyed.
- It is easily cold-worked.

3.1.2 Gold Rating

A good dental technologist or metallic prosthetist must know how to determine the quality of a gold alloy. The rating of gold alloy is an estimate of the economic value and tarnish resistance of an alloy. Gold alloy is rated by the amount of pure gold present in the alloy. The proportion of gold in an alloy may be rated in two ways:

- The carat rating expresses the number of 24th parts of gold in the alloy e.g. 24 carat gold is pure gold while 18 carat gold contains 18/24th or 75% gold.
- The finess rating is the parts per thousand of gold e.g. 24 carat gold is 1000 fine and 12 carat gold is 500 fine.

Conversion Technique

The carat rating can be determined from finess rating and vice versa by a simple direct proportion. E.g. convert 12 carat gold to fines rating;

$$\frac{\text{Carat}}{24} = \frac{finess}{1000}$$
$$\frac{12}{24} = \frac{finess}{1000}$$
Answer = 500 fine

3.2 Yellow Gold

Basically, yellow gold alloy consist of gold, copper and silver, sometimes Platinum may be present in small quantity. Palladium and Zinc are also added.

3.2.1 Composition of Yellow Gold Alloy

Gold	64%
Silver	18%
Platinum	4%
Palladium	2%
Copper	1%

3.2.2 General Effects of Constituents

Gold alloys are complex and many comprise six or more metallic constituents. Each of these alloying elements has special properties it imparts on the alloy.

3.2.2.1 Gold (Melt at 1063^{o}C)

It is the principal constituent of gold alloy as it imparts colour and corrosion resistance. Gold contribute malleability and ductility to the alloy. It increases the specific gravity and combines with copper content to facilitate heat treatment of gold alloy.

3.2.2.2 Silver

Silver is a white metal which take a high polish and exceedingly malleable and ductile. It is seldom used in pure state except for ligature wire for splinting broken jaws. Silver forms a solid solution with gold in all proportion.

As a constituent of gold alloy, silver increases the strength and hardness of gold. It tends to whiten the alloy and overcome the reddening effect of copper. Molten silver occlude gases such as oxygen leading to porosity though this can be reduced by effective fluxing. Silver allow tarnishing.

3.2.2.3 Copper

Copper is a heavy red metal, very malleable and ductile with Brinell hardness of 42 and melting point of 1083^0C. Its inclusion in gold alloy normally imparts red colour, increase the hardness and strength as well as reducing the density of the alloy.

However, only a small amount of Cu can be used (about 4%) because corrosion can result.

3.2.2.4 Platinum

Platinum is a grey-white metal with exceptional malleability and ductility. It has a Brinell hardness of 42 and melting point of 1773^0C. Gold forms a solid solution with Pt but the wide melting range of up to 300^0C result in cored structure which can be removed by homogenizing at 700^0C-750^0C for at least ten minutes.

Platinum is also used in small quantity along with Cu to increase tensile strength, elasticity and hardness of gold alloy. Its presence also tends to whiten the alloy and raise the melting point. It also increases the corrosion resistance of the alloy.

3.2.2.5 Palladium

It is a very white metal, malleable and ductile. Its Brinell hardness is 46 and melts at 1553^0C. It replaces platinum to a limited extent because of its similarity in function and its comparative cheapness.

3.2.2.6 Zinc (Zn)

Zinc is bluish-white in colour with a Brinell hardness of 54 and melting point of 419^0C. The melting point of zinc is comparatively low; thus, the alloy should not be over heated as zinc content will evaporate above 900^0C. Au form eutectic mixture with Zn thereby lowering the melting point.

Zinc is included as a scavenger as it removes oxides more readily than all the other constituents of a gold alloy.

3.2.2.8 Tin (Sn)

Form Eutectic solution with Au but its less effective scavenger than Zn.

3.2.2.9 Iridium, Indium, Osmium and Ruthenium

This group of metals, even when present in small quantity refine the grain structure. This section of dental casting may contain a few grains if the structures are coarse and this could be very weak. Refinement of the grain is therefore very important in the strength of casting.

3.2.3 Types of Yellow Gold Alloys

This is the classification of gold alloys based on strength and purpose for use. Four categories are recognised as follows:

3.2.3.1 Type 1 Gold Alloy (soft)

They are essentially alloy of Au, Ag, and Cu and they seldom contain platinum or Palladium. They have low proportional limit and cannot be age hardened. Type 1 alloys are used in situation where they are not subjected to great stress as in class III and V cavities. The composition of a typical Type 1 gold alloy is Au-90%, Cu -4%, Ag -6%, Pt -0%, Pd-0% Zn -0%. They have high melting range 950-1050^{0}C.

3.2.3.2 Type II (Medium)

This type may contain some Pd and Pt while the Cu content is higher than that of the previous type. It may be described as medium. Their fusion temperature is higher than type 1 that is 927-971^{0}C. They are widely used for most types of inlay. A typical type II gold alloy contain: Au-76.5%, Cu -8%, Ag -12%, Pt -1%, Pd- 12% Zn -0.5%.

3.2.3.3 Type III (Hard)

They contain more Pd and Pt content which make them lighter yellow than the previous types. They are amenable to age hardening with a marked decrease in ductility. This type of alloy is used for crown and in situation that involves great stresses. Composition of a typical type III goes thus: Au-73%, Cu -9%, Ag -11%, Pt -2%, Pd- 4% Zn- 1%.

3.2.3.4 Type IV (extra hard)

This is the type of gold alloy suitable for casting large appliances such as saddles, one pieces partial denture, clasps and lingual bars. They have great strength and resistance. The fusion temperature is 871-982^{0}C, also falls within dental casting operation. This lower fusion temperature was facilitated by the addition of more Cu at the expense of Au. Composition: Au-65%, Cu -14%, Ag -12%, Pt -4%, Pd- 3.5%, Zn-1.5%.

3.3 White Gold Alloy

White gold alloys have high silver Palladium content and these are responsible for the white or silver colour. Nickel can also be added but in very small quantity because of its tendency to embrittle the alloy and lower its tarnish resistance.

White gold alloys have higher melting range than yellow gold and possesses greater strength. They generally have low ductility in comparison to the gold coloured alloys with low tarnish resistance. White gold alloys also shrinks more than yellow gold alloys on freezing and cooling.

There are two types of white gold alloy; the more expensive type is truly the gold alloy with substantial quantities of Palladium and Platinum. Palladium is more effective in whiting Au alloy than Pt. for instance; about 10% of Pd makes Au grey-white 25% of Pt is required for the same effect.

The low cost white gold contains little gold and its called silver-Palladium alloy. Composition: Au-15%, Cu -15%, Ag -45%, Pd- 24% Zn-1%.

3.4 Heat Treatment of Gold Alloy

At this point, you need to know how heat can be used to re-order the structure of gold alloys. Generally speaking, heat treatment is a means whereby the structure of an alloy may be altered and this affects mechanical properties such as strength, elasticity, ductility and so on. Type I and type II gold alloy do not harden or harden to a lesser degree than type III and type IV. Also, white gold alloys should not be heat hardened unless otherwise instructed by the manufacturer.

3.4.1 Hardening Heat Treatment

The hardening heat treatment or age-hardening of gold alloy can be achieved in any of the following three ways:

- The alloy can be cooled slowly from red-hot 700^{o}C. Such treatment allows time for the proper solid state reaction to take place.
- You can also furnace-cool the alloy from 450^{0}C to 250 over a period of 30minutes and then quench in water. This is called oven –cooling. A school of thought advocates that this method is too drastic for white gold alloy because it tends to embrittle the alloy.

- The most practical method is by soaking or ageing the alloy at specific temperature for definite time before it is quenched in water. Although, the ageing temperature ranges between 200 - 400^0C between 15-30 minutes, the proper temperature and time are usually specified by the manufacturer.

3.0 CONCLUSION

The importance of pure gold and its alloys in dentistry was emphasized. Pure gold is yellow in colour, so the commonest type of gold alloys is yellow though white gold alloy also exists. Gold alloy may contain silver, copper, palladium, Platinum, zinc, nickel, iridium, tin, indium Osmium and Ruthenium with each constituent playing a special role in the compound. You also see how the mechanical properties of dental gold alloy can be improved through heat treatment.

4.0 SUMMARY

In this unit, you learnt that gold is a noble or precious metal suitable for use in the mouth because of its corrosion and tarnish resistance. The physical, thermal and mechanical properties of gold are improved by alloying with other metals.

Silver increases the strength, hardness and tend to whiten the alloy. Copper though used in small quantity, impart red cololur and reduces the density of the alloy. Platinum also whiten the alloy and raise its melting point. Palladium play similar role as platinum thus it is often used as substitute because of its cheapness. Zinc and tin are used as scavenger. Others like nickel, iridium, indium, osmium and ruthenium refine the grain structure.

There are four general types of yellow gold alloys used for different purposes;

Type 1 (soft) are used mainly as inlay for classes III and IV cavities
Type II (medium) can be used where III type and IV are indicated.
Type III (Hard) for crowns and on-lays.
Type IV (Extra hard) for, appliances like skeletal plates, clasps, lingual or palatal bars.

White gold alloy usually is a ternary alloy of gold, silver and Palladium. They have higher melting range and greater strength than yellow gold alloys. Thus, they have lower tarnish resistance and more casting shrinkage.

You also study the re-ordering of the grain structure of gold alloys by heat treatment. Casting gold alloy is amenable to both softening heat treatment and age hardening.

6.0 TUTOR-MARKED ASSIGNMENT

1. What do you understand by the term "heat treatment"?
2. Highlight the composition of a typical type IV gold alloy.
3. State five properties of gold.
4. How would you determine the quality of gold?
5. Compare and contrast white and yellow gold alloys.

7.0 REFERENCES/FURTHER READING

Combe, E.C. (1981). *Note on Dental materials*. (4th ed.). Churchill, Livingstone.

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UNIT 3 COBALT- CHROMIUM ALLOY

CONTENTS

1.0 INTRODUCTION

In the last unit, you learnt about gold alloys which are widely used in dentistry. The knowledge of its properties and composition help you as a dental technologist to manipulate the alloy during casting operation.

However, this unit shall introduce you to another commonly used alloy called Cobalt-Chromium. These alloys are hard, rigid and corrosion resistant. Besides their application for cast partial dentures, they are used for surgical implants.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe cobalt-chromium alloys
- highlight the composition of cobalt-chromium alloys
- manipulate the alloy through the techniques of melting, casting and finishing
- identify the method of heat-treatment of Cobalt-Chromium alloys.

3.0 MAIN CONTENT

3.1 Description of Cobalt-Chromium Alloys

In the engineering world, these alloys are referred to as Stellite. They originated from an investigation by Elwood Haynes who was seeking an alloy for use in the manufacture of car sparking plugs. It was discovered that Cobalt-Chromium alloys maintain its resistance to corrosion at high temperature. This led to its use in the manufacture of turbine blades for jet engine as well as making cutting tools.

Cobalt-Chromium alloy is silvery in colour, its specific gravity is as low as 8.0. Its hardness is 300 BHN; its elongation is 6.2% while the main constituents are cobalt, chromium, nickel and molybdenum. Also present in small quantities are Manganese, silicon, aluminum, tungsten, iron and carbon.

However, latest research shows Cobalt alloy containing Titanium exhibits superior properties as it is more ductile than other types. Similarly, some alloys contain Beryllium which refines the grains and lower the melting point but renders the alloy cytotoxic. Therefore, such alloys cannot be used for implants.

3.2 Composition of Cobalt-Chromium Alloys

You should note that cobalt is the chief constituent hence the name Cobalt-Chromium alloy. Other names such as chrome-cobalt, chromium-cobalt and Chrome alloy are used in error.

Cobalt and Chromium form a solid solution. Other metals are added with the aim of modifying its properties by reducing the very high modulus of elasticity, melting point as well as the overall strength of the alloy.

Composition of a typical Cobalt-Chromium alloy is as follows:

Cobalt	36-60%
Chromium	25-30%
Nickel	0-30%
Molybdenum 5-6%	
Carbon	0.2-0.4%
Tungsten	0-5%
Manganese	Small
Quantity	
Silicon	‘’ ‘’
Iron	‘’ ‘’

3.2.1 Roles of the constituents Cobalt-Chromium Alloys

- Cobalt – melt at 1480^0C. It is a silvery-white metal which impart strength and hardness to the alloy. It is the principal constituent.
- Chromium –it forms a solid solution with cobalt and renders the alloy corrosion resistant due to the passivating effect. But only a minimum proportion is used due to its high melting point (1800^0C)
- Nickel – It usually replace the cobalt content because of its slightly lower melting point (1455^0C)
- Molybdenum –Reduces the grain size of the alloy
- Carbon – It increases the strength and hardness. But combines with other metals to form carbides grains. It reduces the ductility and causes brittleness
- Tungsten, manganese, silicon and iron - harden and strengthen the alloy. They also act as scavenger.

3.3 Manipulation of Cobalt –Chromium Alloy

The casting technique of these alloys is similar to that of gold alloys but with some differences on manipulation as follows:

3.3.1 Melting the Alloy

Co-Cr alloys melt between $1250\text{-}1500^0$C hence gypsum bonded investment is inadequate. Therefore, silicon bonded or phosphate bonded materials are indicated.

It is important for you to know that the high melting range make it impossible to use the gas/air blow torch to melt it. The alternative methods of melting the alloys are:

- Oxy-acetylene flame: it requires some degree of skill to achieve consistent result. Too much of acetylene will result in carbon pick-up which causes brittleness of the alloy. While too much of oxygen will result in oxidation of the alloy. The correct ratio of 2 or 3 of oxygen to 1 acetylene must be used.
- High frequency induction: expensive electrical equipment is required but the operation is simple. Though care must be taken to avoid overheating.

3.3.2 Casting Co-Cr Alloys

Cobalt-Chromium alloys do not melt freely as gold alloys and they are comparatively viscous in molten state whether melted by oxy-acetylene or induction machine. Centrifugal force is necessary in the casting operation. The melting operation should be performed as quickly as possible and cooling should be slow preferably in furnace as it cools down.

Defect in cast Co-Cr may occur as a result of:

- The inclusion of dirt or particle of investment
- Gaseous or contraction voids which may be avoided by the use of correct melting techniques and adequate sprues. The re-use of old button is possible but you must clean it thoroughly by sand-blasting and add some new ingots.

A careful melting technique will avoid an under buildup of carbon which may result in the loss of chromium content.

3.3.3 Finishing the alloy

The finishing of Co-Cr alloys is very difficult due to high abrasion resistance. The investment material cling unto the rough casting and an oxide layer forms on the surface especially when phosphate bonded investment is used. Therefore, special techniques include:

- Sand blasting – this is used to remove adherent investment material and smoothen the surface of the rough cast. It is also necessary to use high speed grinding and polishing apparatus.
- Electrolytic polishing: the principle is the same as for electroplating except that the appliance is made anode of an electrolytic cell. When current is applied, the surface layer is dissolved.

3.4 Heat Treatment of Cobalt-Chromium Alloys

These alloys cannot be heat treated like the gold alloys. Hence, they cannot be softened for adjustment. The modified heat treatment is performed by either allowing them to bench cool or replacing the cast in hot furnace immediately after casting where it is allowed to cool according to manufacturer’s instruction.

The procedure depend on the composition of the alloys as follows
Alloy 1: The casting ring is put back into the furnace and left to cool.
Alloy 2: The casting ring is bench cooled for not less than one hour; it may then be sprinkled with water.
Alloy 3: The casting ring is bench cooled for 20 minutes before being plunged into cold water.

3.5 Comparisons between Co-Cr and Gold Alloys

- The Co-Cr alloys have a modulus of elasticity that is about twice that of Au i.e. they are stiffer. This makes it more desirable as connector while Au alloys clasps are better because of flexibility.
- Co-Cr alloys have higher melting range and greater hardness than Au alloys.
- The casting procedure of Co-Cr alloys is more cumbersome than that of Au alloys.
- The proportional limit of Co-Cr alloys is less than that of hardened gold alloys.
- Co-Cr casts are not amenable to heat treatment unlike gold alloys.
- Co-Cr alloys are cheaper and less expensive than Au alloys.

4.0 CONCLUSION

Cobalt-chromium alloys are silvery in colour because of silvery-white colour of cobalt which is the principal constituent. The alloy has a high melting range with superior strength and hardness when compared to gold alloys. The casting procedure is more tedious because of special techniques of melting, sand blasting and electro-polishing. However, it is suitable for cast partial denture plates and connectors as it can be used in thin sections hence, a lighter appliance.

5.0 SUMMARY

You will recall that Co-Cr alloy is otherwise known as Stellite. Other constituents of the alloy include nickel, molybdenum, carbon, tungsten, manganese, silicon and iron. These alloys have greater strength and hardness but could be very brittle. The melting range is between 1250-1500^{0}C, therefore, melting the alloy could only be achieved with the use of oxy-acetylene flame or induction machine.

Casting alloy is achieved by the use of centrifugal casting machine because of the viscosity of the alloy in molten state. We also discussed that finishing the cast Co-Cr job require special skill of sand blasting and sometimes electrolytic polishing.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are the advantages of Co-Cr alloys over gold alloys?
2. Discuss the roles of each of the component of Co-Cr alloys.
3. Describe the possible methods of heat treatment of Co-Cr alloys.
4. How would you obtain a good finished cast from Co-Cr alloys?

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UNIT 4 SWAGED STAINLESS STEEL

CONTENTS

1.0 INTRODUCTION

In the last unit, our focus was on the strongest and the hardest alloy used in metallic Prosthodontics. Co-Cr alloys require special skill and cumbersome casting procedure to achieve the best result. However, this unit deal with stainless steel alloys which is used extensively for the construction of clasps, bars, orthodontic appliances as well as inter maxillary fixation. But it can also be manipulated to fabricate denture base through swaging technique.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- state the properties of stainless steel alloys
- identify the types of stainless steel alloys
- perform swaging operation on stainless steel sheet.
- highlight the steps involved in heat treatment of stainless steel.

3.0 MAIN CONTENT

3.1 Steel and Stainless Steel Alloys

Steel is an alloy of iron and carbon and are used in the construction of burs and dental instruments. Steel bars are made of hyper-eutectoid alloy which usually contain manganese and molybdenum. This type of steel is also used in the production of cutting instrument and amalgam condensers. However, hypo-eutectoid steels are used for dental forceps.
Stainless steel has in addition to the steel content (iron and carbon), chromium and nickel. They are used in the dental laboratory for the construction of various applications including swaged denture base.

3.1.1 Properties of Swaged Stainless Steel

- Stainless steel denture base has good resistance to corrosion.
- Stainless steel plate has good thermal conductivity hence the wearer can have a feel of the hotness or coldness of the food.
- It can be used in thin sections, as low as 0.11mm compared to acrylic denture of about 1.52mm.
- Stainless steel has great malleability and ductility, therefore, greater resistance to fracture.
- It takes and retains high polish.

3.2 Composition and Types of Stainless Steel Alloys

The composition and types of stainless steel are highlighted as follows:

3.2.1 The composition of a typical 18/8 stainless steel:

Iron – 73% principal constituent. For strength and hardness
Chromium – 18% improve the tarnish and corrosion resistance
Nickel – 8% also help the corrosion resistance and strength of the alloy
Carbon and Tungsten-0.12% used in small quantity to improve strength and hardness.

3.2.2 Types of Stainless Steel Alloy

There are basically two types of stainless steel alloys you can use in dental laboratory:

- Austenitic Stainless Steel: This is usually called 18/8 stainless steel. You should note that 18/8 represents the ration of chromium 18% to Nickel 8%. These two constituents form austenitic structure which is a solid solution that remains even on cooling. This material is not suitable for cutting instruments but is excellent for the construction of denture base and orthodontic wires.

- Martensitic stainless steel: It contains 12-13% chromium and a small amount of carbon. These alloys can be hardened by heat treatment as opposed to Austenitic type which is hardened by cold-working.

3.3 Swaging

Swaging is the forging process in which the shape of the stainless steel sheet is altered using dies and counter-dies under pressure. Swaging is usually a cold-working process but sometimes done as a hot-working process e.g. softening heat-treatment of gold alloy which enables the clasp arm to be adjusted.

3.3.1 Methods of Swaging

Though there are several methods used in engineering field but, only three are of dental interest. These are:

3.3.1.1 Conventional Method

The stainless steel sheet is pressed between die and a counter-die in a hydraulic press. Dies and counter-dies are made of low-fusing alloys. However, the problems associated with this technique include:

- Difficulty in ensuring a uniform thickness of finished plate
- Dies and counter-dies can be damaged under hydraulic pressure. It is necessary to use more than one die and counter-die.
- Loss of fine detail, since many stages are involved between recording the original impression and obtaining the final product.

3.4 Hydraulic Forming

The procedure for this technique is as follows:

- Place a die in a metal cone and locate it within the pressure vessel
- Select a stainless steel sheet of desired thickness and place over the die.
- Carefully place a rubber diaphragm over the sheet and insert the cover plate held in position by high tensile bolts.
- Raise the pressure in the chamber to 70 MN/m^2 to remove the work-piece for cleaning.
- The denture base is cut to size and weld the retentive tags onto it.

- If necessary reform the plate on the die to eliminate distortion and polish the denture.
- Stainless steel can be annealed

3.4.1 Explosion Forming

This method involves the use of a die made from Epoxy resin. A sheet of stainless steel is placed over the die before overlaying with a layer of plasticine. A pressure wave produced by a small charge of high explosives is transmitted to the steel forcing it into requisite shape. Finish in the usual way as described above (last three bullets in 3.4.2).

3.5 Heat Treatment of Stainless Steel Alloys

The Austenitic stainless steel used for plates, bars and clasps do not respond to hardening heat treatment but are hardened by cold-working i.e. beating, pressing and bending. The BHN of stainless steel in softened state is 163 which increase to 375 when work-hardened.

You should remember that earlier in this unit, we let you know that Martensitic alloy can be hardened by heat-treatment. Although plates may be annealed during swaging process by heating in a furnace to 1100^oC for three minutes, the best result is achieved by pre-heating to dull red before placing in a hot oven. Note also, that frequent annealing of stainless steel tend to reduce its corrosion resistance.

4.0 CONCLUSION

The difference between steel and stainless steel was highlighted in this unit. Stainless steel (alloy of iron and carbon) fortified with chromium and nickel to impart tarnish and corrosion resistance. This makes it possible for use as denture base in form of swaged stainless steel plate.

5.0 SUMMARY

In this unit, you studied stainless steel as an alloy of iron, carbon, chromium, nickel and tungsten. The two types of the alloy are Austenitic and Martensitic stainless steel. The former is suitable for swaged denture base, bars, clasps and orthodontic wires. Three methods of swaging stainless steel were discussed namely, conventional method, hydraulic and explosion forming. Austenitic stainless steel is not hardened by heat unlike the Martensitic type. However, annealing can be performed during swaging by heating the alloy to 1100^0C for three minutes.

7.0 TUTOR- MARKED ASSIGNMENT

1. What do you understand by the term “18/8” as regard stainless steel?
2. Describe in detail a method of using wrought steel sheet for partial denture.
3. State the composition of Austenitic stainless steel.
4. Steel is a compound of ………….and ………
5. Swaging involves the use of ……and ……under pressure.

7.0 REFERENCES/FURTHER READING

Alexander, W. & Street A (1979), *Metals in Service of Man*. (7th ed.). Harmondsworth, Middlesex: Penguin.

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MODULE 2 PROPERTIES OF METALLIC MATERIALS FOR PROSTHODONTIC APPLIANCES

UNIT 1 CORROSION RESISTANCE AND TARNISHING

CONTENTS

1.0 INTRODUCTION

In this unit, two important properties of metallic dental materials are discussed. One basic requirement of dental appliance is aesthetics, that is, pleasing appearance. To fulfill this requirement, metallic materials should not corrode or tarnish in the oral environment. Corrosion is an electrolytic process that may lead to rusting or weakness of the appliance while tarnishing is a surface discolouration.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- define corrosion and tarnishing

- explain how electrolytic circuit is set up both in the mouth and laboratory
- outline the steps taken to ensure resistance to corrosion and tarnishing.

3.0 MAIN CONTENT

3.1 Definition and Types of Corrosion

Corrosion can be defined as the chemical reaction between a metal and its environment to form metal compound. It is the actual deterioration of metal through the action of moisture, atmosphere, acid or alkaline solution influenced by temperature fluctuation.

Types of Corrosion – There are two types:

* Aqueous Corrosion: - It mainly occurs in the mouth with metallic appliance due to the presence of saliva with changing PH caused by diet, decomposition of foodstuffs and temperature fluctuation.
* Non-aqueous corrosion: - In this case, metals react to form compounds like Oxides and Sulphides. You can observe this very clearly on metal surface which has been soldered. This same theory explains the discolouration seen on the surface of castings caused by oxidation.

3.2 Galvanic Cell

In your study of elementary physics, you remember how two electrodes of different metals like copper and zinc are immersed in an electrolyte of Sulphuric acid. Current will flow in this circuit when contact is made between the two electrodes. This arrangement is called Galvanic or corrosion cell.

If zinc is made the anode and copper the cathode, during the process, zinc atoms are being converted to zinc ions by oxidation reaction. Therefore, zinc gradually dissolve and pass into solution leading to corrosion of the zinc metal.

The chemistry of reaction goes thus:

At the anode: $Zn \longrightarrow Zn^{2+} + 2e^-$
At the cathode: $2H^+ + 2e^- \; H_{2(g)} \longrightarrow$

3.3 Causes of Electrolytic Corrosion

There are three broad categories of causes of corrosion which can be seen below.

3.3.1 Causes Due to Composition of Material

- Difference in the composition of solder and the alloy may cause metallic appliance to corrode.
- When two dissimilar metallic restorations are use in the mouth e.g. Gold inlay and Amalgam filling. The latter can form the anode of electrical cell in the presence of saliva and then corrode.
- Eutectic alloys actually have low corrosion resistance as a result of different grain having different composition.
- Cored structure have non-uniform grain structure hence part of the grain can form the anode while the other form the cathode.

3.3.2 Causes Due to Composition of Electrolyte

- Good homogeneous metal or alloy may also corrode if placed in an electrolyte with concentration gradient.
- An unpolished metallic restoration has concavities and pitting which harbours food debris and lead to difference in concentration of Oxygen in the saliva.
- A semi-buried implant will certainly dwell in an environment with difference in composition of electrolyte. This creates a favourable condition for corrosion.

3.3.3 Stress Condition

During cold working, metals are stressed differently; therefore, the parts with maximum stress form the anode in the presence of saliva and thus corrode. This is called stress corrosion.

3.4 Galvanic Shock

The effect of corrosion is not limited to the attack on metals alone; it can also cause intermittent pain or shock on the patient. For instance, a patient with gold foil or inlay may experience sharp, sudden pain when the tine of a fork touches the restoration with the tongue in-between. The electric circuit is set up which generate current that causes painful stimulation of the tooth pulp.

3.5 Protection against Corrosion

For a metal or alloy to be used in the mouth, effort must be made to improve its corrosion resistance. You can achieve this through the following ways:

- Use of noble metals such as Gold, Platinum, Palladium etc. The alloy must contain at least 70-75% noble metal.
- Surface irregularities like pits, scratches or concavities should be avoided by giving the restoration high polish.
- Electroplating – Metals such as iron in steel which are prone to corrosion should be electroplated with chromium as in stainless steel.
- Passive alloys are widely used for dental prostheses to prevent corrosion e.g. Cobalt-Chromium, Stainless Steel and Nickel-Chromium.

3.6 Tarnishing

Definition: Tarnishing can be defined as surface discolouration of the surface finish or luster of a metal. Tarnishing often occur in the oral cavity because of the formation of soft and hard deposits on the surface of the restoration. Plaque and calculus are the principal deposits and their colour varies from light yellow to brown.

You will notice the effect of tarnishing on used denture from patients with poor oral hygiene, a chain smoker or drug addict. This may be prevented or minimized by supplying denture with high polish or surface finish. Instruct patients or denture wearer to maintain good oral hygiene and wash the denture regularly with dentifrices.

4.0 CONCLUSION

This unit dealt with two major properties of metallic prostheses. Corrosion is the actual deterioration of metals while tarnishing is a mere surface discolouration of the appliance. Corrosion may also induce a sharp, sudden pain on the wearer of metallic prostheses. This phenomenon is called *galvanic shock*. Therefore, it is important for oral appliances to have corrosion and tarnish resistance.

5.0 SUMMARY

The study in this unit covered corrosion and tarnish properties of metallic materials. Corrosion occurs mainly if electrical circuit is set-up in the oral environment. This may occur if two dissimilar metallic appliances are used in the mouth where saliva acts as an electrolyte. Two types of corrosion, the aqueous and non-aqueous were also discussed. To make an appliance corrosion resistant in the mouth, you must use 70-75% of noble metal or passive alloys such as Gold, Platinum, Cobalt and Chromium. Tarnishing resistance can also be achieved by giving the appliance good finishing or high luster and maintaining good oral hygiene.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain how you will set-up a galvanic cell in the laboratory.
2. What type of corrosion occurs in the mouth?
3. How do you achieve corrosion and tarnish resistance in dental alloys?

7.0 REFERENCES/FURTHER READING

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UNIT 2 THERMAL CONDUCTIVITY, MALLEABILITY AND DUCTILITY

CONTENTS

1.0 INTRODUCTION

In this unit, you will learn more about the properties of metallic prostheses. These are mechanical properties such as thermal conductivity, malleability and ductility. Thermal conductivity is important so that the user of the appliance can experience the sensation associated with different temperatures produced by hot or cold food and beverages.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the phenomenon of thermal conductivity
- discuss the concept of thermal expansion
- state the importance of malleability and ductility to metallic prostheses.

3.0 MAIN CONTENT

3.1 Thermal Conductivity

This is the transfer of heat energy from one part of the material to another. The conditions that favour effective conduction of heat include ability of the particles (atoms) to move and possession of regular lattice structure. In this case, metals or alloys are good conductors while acrylic and ceramic are examples of thermal insulators. It is desirable for denture base material to transmit some thermal energy to underlining tissues so that patient can experience hot and cold sensation of the food.

Thermal conductivity is measured in W/mK thus enamel has 6.88W/mK.

3.1.1 Thermal Expansion

This property is closely related to conductivity property. However, the linear coefficient of thermal expansion of a material is the change in length per unit length when its temperature changes by 1^0C.

Your will notice that when a material get hotter, its size increase or expand while the same material contract upon cooling. Suffice to say that the increase in size is proportional to temperature rise while the rate of expansion is defined by coefficient of expansion.

On the average, metals have higher value of coefficient of expansion than polymers. This is an important consideration in metallic appliances because the expansion and contraction of materials could be a source of dimensional error if not well compensated or regulated.

3.2 Malleability

This is the ability of a material to withstand permanent deformation without rupture under compression as in hammering or rolling into sheet. It occurs after the material has been stretched beyond its elastic limit before fracture. Therefore, malleability depends on plasticity. Malleability also increases with increase in temperature. Gold is said to be the most malleable metal, followed by silver. This property can be measured by the method of reduction in area of cross section. The greater the malleability, the bigger is the reduction in cross-sectional area.

3.3 Ductility

Ductility is the ability of a material to withstand permanent deformation under a tensile load without fracture. It is dependent on plasticity and tensile strength. A metal which can be stretched to form wire is said to be ductile. Gold is therefore the most ductile metal. This property can be measure by the method of percentage elongation. When a metal specimen of known length is fractured under tensile load, the broken fragments are pieced together and the new length measure. A high percentage increase in length indicates a very ductile material.

4.0 CONCLUSION

The properties discussed in this unit are important consideration when choosing metallic material to be used in the mouth. Thermal conductivity enables the denture wearer to feel the degree of hotness or coldness of food. A good dental material should be dimensionally stable hence thermal expansion property. Ductility and malleability of metal mean that the material should withstand deformation under tensile and compressive stress.

5.0 SUMMARY

In this unit, you studied thermal and mechanical properties of metals. Thermal conduction is the transfer of heat from one part to another while thermal expansion relates to the change in the dimension of metal under the influence of heat. Ductility and malleability occur when metallic material can be stretched to form wire or beaten into sheet without fracture. Metallic material should have great ductility and malleability to avoid fracture during processing in the laboratory or while in use by the patient.

6.0 TUTOR-MARKED ASSIGNMENT

1. How do you measure the ductility and malleability of metals?
2. Define thermal conductivity and state its unit of measurement.
3. Two factors that affect malleability are ……and ………
4. Explain the importance of thermal expansion to metal casting operation.

7.0 REFERENCES/FURTHER READING

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UNIT 3 IMPACT STRENGTH AND FAFTIGUE STRENGTH

CONTENTS

1.0 INTRODUCTION

In the previous unit, we considered thermal properties and some mechanical properties notably malleability and ductility of metals.
In this unit, we shall shed more light on the behavior of metallic materials under the influence of forces that tend to break it. Our focus shall be on impact and fatigue strength of metals and alloys used in dentistry.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- define the impact strength of metallic materials
- enumerate the techniques of testing for impact strength.
- explain the effects of fatigue stress on dental materials.

3.0 MAIN CONTENT

3.1 Impact Strength

This is defined as the energy required to fracture a material under an impact or sudden force. This is an important consideration because sudden blow or stress may be induced on the prostheses at different stages of production or use. For instance, when you divest your job or make effort to remove investment material from the cast. Accidental dropping of prosthesis either by the prosthetist or during use by patient may produce sudden blow. Trauma or sudden blows are common occurrences during domestic accident or RTA. Therefore, alloys used for metallic prostheses should have high impact strength to resist fracture under impact stress.

You can test a material for impact strength in two ways.

3.1.1 Charpy-type Impact Tester

In this method, a material of known dimension is clamped firmly in position. A pendulum is released which swings down to fracture the specimen. This lost energy by the pendulum during fracture and displacement can be determined by measuring the reduction in amplitude of the pendulum. The unit of measurement of this energy is usually in Joules, foot-pounds or inch-pounds

3.1.2 Izod Tester

In this technique, specimen is clamped vertically at one end; the blow is delivered at a certain distance above the clamped end instead of at the centre.

3.2 Fatigue Strength – It is the energy required to fracture a material under a small repetitive application of force. Dental appliances and restorations are prone to this type of stress as a result of constant masticatory force applied while chewing and grinding food particles.
To test the fatigue strength of a material, you hold the material firmly at one end and bend or twist it many times along its right angle until fracture occurs. Then, you count the number of cycles (N) a material can withstand at a known stress (S).

Consequently, a graph of S on the ordinate axis versus N on the horizontal is plotted as in figure 3.2.1 below.

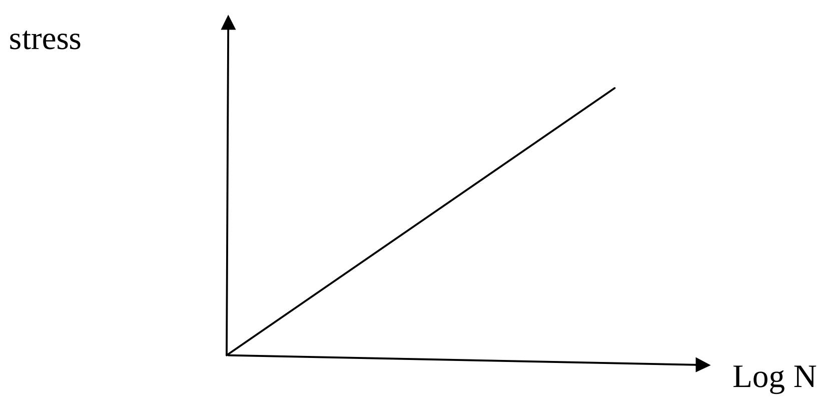

Fig. 3.2.1: Graph of Stress versus Log N

The above Figure 3.2.1 is S-N curve for ferrous alloys where S is the stress and N is the number of cycles. X is the endurance limit. From the graph, the endurance limit can be found. Fatigue fracture will not occur below this stress limit.

4.0 CONCLUSION

This units mark the end of our discussion on mechanical properties of metallic denture base materials. We have seen how metallic materials can absorb various types of forces before fracture. It is important for dental prostheses to have high impact and fatigue strength.

5.0 SUMMARY

In this unit, there is further discussion on mechanical properties of metallic materials. Impact strength is defined as the maximum energy a material can absorb before fracture when subjected to sudden blow or assault. Two types of impact tester equipment were described namely, the Charpy tester and Izod tester.

Similarly, fatigue strength is a measure of endurance limit of a material under small repetitive force. The simple laboratory testing for fatigue strength was described.

6.0 TUTOR-MARKED ASSIGNMENT

1. Graphically described the test for fatigue strength of stainless steel material.
2. State three likely sources of impact stress on metallic prostheses.
3. How do you test a material for impact strength?
4. What is stress?

7.0 REFERENCES/FURTHER READING

Combe, E.C & Grant, A.A. (1973). “The Selection and Properties of Materials for Dental Practice”. *British Dental Journal*.

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UNIT 4 HEAT TREATMENT, WORK HARDENING AND STRESS ANNEAL

CONTENTS

1.0 INTRODUCTION

Before you study this unit, it is better you understand the structure of metals with regard to grain structures and space lattices (refer to unit 1, subsections 3.1.4 and 3.1.5). Although heat treatment procedures have been discussed individually for alloys commonly used for metallic prosthetics, it is a general principle that alloys that have been stressed during construction/processing need to be relieved for greater strength and hardness.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the meaning of heat treatment
- know the effects of work-hardening on dental alloys
- differentiate between softening and hardening heat treatment.

3.0 MAIN CONTENT

3.1 Heat Treatment

Heat treatment is the controlled heating and cooling of metals to alter their physical and mechanical properties without changing the product shape. It is often associated with increasing strength of material but it can also be used to achieve other objectives such as improve formability, and restore ductility after a cold working operation. Steel is an example of alloy that responds to heat treatment. In summary, the main reasons for heat treatment are for softening, hardening and material modification. Alloys that can be hardened can also be softened.

3.1.1 Softening Heat Treatment

Softening is done to reduce strength or hardness, remove residual stress, improve toughness, restore ductility, refine grain size or change the electromagnetic properties of metals.

Procedure

Softening heat treatment is achieved by placing the alloy in an electric furnace for ten minutes at a temperature of 700^0C and then quenched in water.

During this period, all intermediate faces are presumably changed to disordered solid solution and the rapid quenching prevents their ordering while cooling. The tensile strength, proportional limit and hardness are reduced but ductility is increased.

3.1.2 Hardening Heat Treatment

Hardening heat treatment is done to increase the strength and wear properties. This process depends on time, temperature and composition of the alloy. The increase strength, proportional limit, hardness and reduction in ductility are controlled by the amount of solid-solid transformation allowed.

A school of thought advocates that any hardening or age treatment must be preceded by softening heat treatment to relieve all strain hardening if present.

The procedure for hardening treatment depends on the type of metal or alloy and it’s done according to manufacturer’s instruction. You should refresh your memory with methods in unit 2, section 3.4.1.

3.1.3 Material Modification

Heat treatment is used to modify properties of materials in addition to hardening or softening. These processes modify the behaviour of alloys in a beneficial manner to maximize service life e.g. stress relieving, cryogenic treatment and other desirable properties such as spring ageing.

3.2 Stress Anneal

Anneal in metallurgy and material science is a heat treatment that alters material properties to increase its ductility and make it more workable. It is a low temperature heat treatment which has little effect on the fibrous grain structure.

Anneal can induce ductility, soften the material, relieve internal stress, refine the structure by making it homogeneous and improve working properties.

Procedure

For metals like copper, steel, silver and brass, this process is performed by heating the material for a while and then letting it cool to room temperature in still air.

Unlike ferrous metals which must be cooled slowly to anneal, copper, steel, silver and brass can be cooled slowly in air or quickly by quenching in water. This softens the metal and prepare for further work such as shaping, stamping and forming.

3.3 Work Hardening

Work hardening is the increase in hardness of a metal induced deliberately or accidentally by hammering, rolling and drawing or other physical processes. It is also called strain hardening or cold working. The consequences of strain hardening are:

- Increase in hardness of the metal
- Greater yield strength and ultimate tensile strength
- Lesser ductility.

4.0 CONCLUSION

Various methods of improving the properties of dental alloys have been discussed in this unit. Depending on the purpose, heat treatment can be done to soften or harden the alloy as well as modifying other properties such stress-relieving and spring ageing.

5.0 SUMMARY

In this unit, you have studied the phenomenon of heat treatment which is the controlled heating and cooling of metals or alloys to alter its properties. Stress can be induced in metal during casting or cold process. These stresses tend to weaken or strengthen the material hence the need for heat treatment to impart desirable physical and mechanical properties on the final product or prostheses. While softening heat treatment is done to reduce the strength and hardness, hardening process tend to increase the strength and wear properties.

Stress anneal is a low temperature heat treatment which tend to reduce internal stress. Heat treatment is a function of time and temperature which varies from one alloy to the other. Thus, it is important to adhere to manufacturer's instructions during the operation.

6.0 TUTOR-MARKED ASSIGNMENT

1. State the effects of strain-hardening?
2. Mention other purposes of heat treatment apart from hardening and softening of the material.
3. Discuss the procedure for softening heat treatment.
4. What are the reasons for annealing?

7.0 REFERENCES/FURTHER READING

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MODULE 3 DESIGN AND CONSTRUCTION OF METALLIC PROSTHODONTIC APPLIANCES

UNIT 1 DUPLICATION OF MODEL USING REFRACTORY MATERIALS

CONTENTS

1.0 INTRODUCTION

In the past units, we examined various types of materials used for the fabrication of metallic appliances. Similarly, we discussed the properties of these materials which enable the prosthetist to manipulate them for functional appliances. However, this unit shall expose you to the practical aspect of the course. You are expected to use your manual dexterity while following the procedure for duplication of master cast using refractory materials.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the preliminary steps leading to the duplication of master cast
- describe how to produce a duplicate cast in refractory material.

3.0 MAIN CONTENT

3.1 Apparatus

- Master cast
- Refractory material
- Blue wax
- Model surveyor
- HP Pencil
- Duplicating flask
- Plasticine
- Duplicating material
- Model vibrator
- Mixing bowl and spatula
- Bees wax
- Dental furnace

3.2 Procedure

This can be done in three stages:

3.2.1 Preliminary Steps on Master Cast

This starts with the removal of pimples and surface roughness on the master cast. Then you have to survey the model using a suitable model surveyor with its accessories. Block out all unwanted undercuts with blue wax. Relieve the rugae, and prominent incisive papilla. Cut the posterior dam in case of upper model. Finally, design the plate and clasp outline.

A school of thought advocates that small ledges may be built up with wax below the outline of clasps and bars to show their correct position on the duplicated cast.

3.2.2 Duplicating the Master Cast

The master cast is best duplicated using the duplicating flask and Agar-Agar duplicating material. But first, you have to seal the master cast to the base of duplicating flask using plasticine.

Agar-Agar should be poured at the temperature of about 52^0C after soaking the model in warm water of about 40^0C leaving it for about 20 minutes. Allow the Agar-Agar to cool for 20 minutes and then transfer to water bath one inch deep under cold running water for another 20 minutes.

After this, you will carefully remove the master cast and be ready to pour the refractory material into the mould. If phosphate bonded investment is used, the water-powder ratio is usually 12mls: 100g and spatulated between 30-60 seconds; although it is better to adhere to manufacturer's instruction.

Pouring is done carefully over a vibrator from the heels of impression until it completely fills the mould. A vacuum investor may be used if available. When the material is hard, strip the duplicating material around the duplicated cast instead of withdrawing it.

3.2.3 Hardening the cast

At this stage, you have to remove any surface roughness or pimples and trim down the base to the minimum level. Dry it in the oven at 100^0C for two hours. Further treatment is done by either spraying with aerosol or dip the cast in molten stearine or bees wax for about two seconds. When the wax is completely absorbed and dried, the cast is withdrawn from the oven ready for use

The importance of this treatment is to impart a hard surface which prevents the investment from being rubbed away during use. It also assists the wax pattern to adhere to the cast.

4.0 CONCLUSION

You have been guided through the entire process and stages involved in the duplication of master cast. The essence is to produce a duplicate cast in refractory material hard enough to withstand the heat at casting temperature.

5.0 SUMMARY

In this unit, you learnt how to produce a duplicate cast from a master cast using refractory material. The process was broken into three stages for better understanding. However, in practice, duplication of model is done without any noticeable division.

The preliminary action on master cast may involve cleaning, surveying and relieve of prominent tissues. Duplication is done using Agar-Agar material with duplicating flask. The refractory material used depends on the alloy intended to be used for casting. Phosphate bonded investment was used in this section. The set cast is removed and hardened by soaking in beeswax and dried in the oven for strength and surface hardness.

6.0 TUTOR-MARKED ASSIGNMENT

1. List ten apparatus you need to duplicate a master cast.
2. Describe how to harden a duplicate cast.
3. What is the water/powder ratio of investment?
4. What is the use of vacuum investor?

7.0 REFERENCES/FURTHER READING

Robert, P. R. & Alexander, S. (1980). *Dental Technology: Theory and Practice.* St Louis: C V Mosby.

Shaw, F.G. & Scott, D.C. (1968). *Practical Exercises in Dental Mechanics.* (3rd ed.) London Dental Technician Ltd.

UNIT 2 CONSTRUCTIONAL DESIGN OF SKELETAL PLATES

CONTENTS

1.0 INTRODUCTION

In the previous unit, you studied technique of duplicating the master cast in order to produce a working model in refractory material. The next step after duplication is to trace the outline of the skeletal plate using HP pencil on the duplicate cast.

Therefore, this unit will teach you the basic things you look out for while making your pattern. In other words, you will learn the component parts of partial denture, their functions and how they are linked together to form metallic frame-work.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the concept of saddle
- define rests and state the types available
- discuss briefly the two types of connectors
- identify retainers as important component of partial denture.

3.0 MAIN CONTENT

3.1 Component Parts of Skeletal Plate

A skeletal plate is a metallic Prosthodontics framework constructed for a patient to replace lost teeth but with some standing teeth in the mouth (not fully edentulous). The components of skeletal plate are saddles, rests, retainers and connectors.

3.1.1 Saddle

This is the part of dentures that replace the lost alveolar tissues and bear the artificial teeth. The two types are the bonded and free-end saddles. The former have standing tooth at both ends while the latter have only a standing tooth anterior to the saddle. On insertion, the saddle fit accurately into the saddle area.

3.1.2 Rests

These are metallic extensions located on the teeth to prevent vertical displacement of the denture towards the soft tissue. Rests are usually placed in conjunction with clasps. Sometimes, a natural tooth is prepared to receive the rest. This small preparation is called seat. Types of rests include:

- Cingulum rest – Its placed on the cingulum of canines or other anteriors.
- Internal rest – This is strictly type of precision attachment which is intra-coronal.
- Incisal rest – It is usually on the incisal edge of upper canine.
- Occlusal rest – It is located on the occlusal portion of posterior tooth or teeth.
- Continuous clasp – It may act as multiple rests.
- Onlay – when occlusal rest cover the whole occlusal surface of posterior tooth.

3.1.3 Retainers

Retainers are mechanical security which resist dislodgement or change in position of the denture. There are two types of retainers namely direct and indirect retainers

* Direct retainer – In partial dentures, direct retainers are clasps and precision attachment. In bridge work, direct retainers are the crowns or inlays which are cemented on preparations on natural teeth.
* Indirect retainer – This is a device that provide resistance to the occlusally displacing forces acting on the saddle by the creation of resistance passively placed on the opposite side of the fulcrum to that on which the displacing force is applied. It is more applicable to lower Kennedy claps I where lingual bar is used as

major connector. They do not engage undercuts. Such retainers are:

- Continuous clasps
- Cummer rests
- Anterior or posterior palatal bars
- Anterior or posterior plate sections
- Onlays.

3.1.4 Connectors

These are the means by which the various parts of partial denture or metal plate are linked or connected together. They are mainly bars or plates. Connectors are of two types, viz major and minor connectors.

- Major connectors – it connect or join one saddle to another or to an anchorage point or stabilizer and should be rigid except for stress breaker design. Examples are lingual, palatal and buccal bars, full plates or lingual plates etc.
- Minor connectors – join one component part of the denture to another. They may be tags, occlusal rest extension, continuous clasp or extended clasp arm.

3.2 Constructional Design of Skeletal Plate.

In designing skeletal plate, a pencil outline of the design is made and a post –dam marking the border of the design should be made. A post dam is a shallow trough of about 1 mm deep running across the junction of hard and soft palate of the upper arch. The connection between the bar and the saddle must be smooth and gently curve while the bar itself should be undulating with constrictions. There should be no extra point in the middle. Also, the edges of the bar should be smooth and not serrated. In case the bar goes over a prominent tissue like Torus Palatinus, the bar should also take that shape.

There should be beading created at the border between the saddle and the connector. This beading elevate slightly above the thickness of the palatal bar. The design should also show clearly the clasps, rests and other notable component parts of partial denture.

4.0 CONCLUSION

I hope you have a clear understanding of this unit about the design of skeletal plate. Before you attempt to draw the pattern on the cast, you must have a mental picture of the appliance you want to produce. After considering the clinical factors, you will outline the component parts i.e. the saddle, rests, retainers and link them together with connectors.

5.0 SUMMARY

This unit has taught you in brief, the component parts of partial denture. This includes the saddle which carry the lost or missing teeth and form the flange, rests are sometimes part of clasp which prevent sinking of the plate into soft tissue due to vertical displacing force. Retainers provide mechanical retention while connectors link together all the other parts. The design of skeletal plate enumerated in this unit is the combination of these component parts and other constructional guides.

6.0 TUTOR-MARKED ASSIGNMENT

1. Differentiate between major and minor connectors.
2. What do you understand by the terms “post dam” and “seat”?
3. Mention five types of rests you know.
4. What are the factors you consider in the design of skeletal plate?
5. What is retainer?

7.0 REFERENCES/FURTHER READING

Craddock, F.W. (1967). *Prosthetic Dentistry*. (3rd ed.). London: Henry Kimpton.

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UNIT 3 TYPES AND DESIGN OF DENTAL CLASPS

CONTENTS

1.0 INTRODUCTION

The central theme of the last unit is the component parts and design of metallic skeletal plate. An important component of the plate is the retainer which is also subdivided into direct and indirect retainers. The two major categories of direct retainers are the clasps and precision attachment.

Hence the focus of this unit is clasps which is a metallic device that give retention, bracing and support to denture. You will learn about the survey lines which dictate the types and design of clasps.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- define clasps and state its functions
- classify survey lines according to blatterfein criteria
- describe the two types of clasps available
- design clasps that will satisfy oral requirement.

3.0 MAIN CONTENT

3.1 Definition of Clasps

You can define clasps as metallic appliances made in gold, stainless steel or Cobalt-Chromiun alloy incorporated into partial denture to provide mechanical retention, bracing and stability to denture. For a clasp to be an effective retainer, its terminal end must rest on an undercut area of a tooth. It may be wrought from plate, round or half round wire or cast.

3.2 Functions of Clasps

There are three general functions of clasps:

- **Retention –** The only way clasps provide retention is to place the flexible portion of clasp arm in an undercut area. Thus, there is sufficient retention to resist dislodgement of the denture during mandibular movements.
- **Bracing –** This is obtained by the shoulder or rigid portion of the clasp embracing the tooth closely thereby preventing any lateral or horizontal movement of the denture. This provides stability to the denture.
- **Support –** This is achieved by well-filling occlusal rest which prevents the movement of denture into the tissue under the force of mastication.

Fig. 11.1: Plan View of Clasp

The above figure represents an occlussally approaching clasp showing retentive and bracing portion. The attached occlusal rest and clasp shoulders give support.

3.3 Position of Clasps

The position of clasp on a tooth depends on certain clinical and laboratory factors. The clinical consideration includes the condition of the supporting structure, the root size and form of tooth. These will determine the amount of lateral load the tooth can bear. However, from the laboratory viewpoint, the chief indication for the position of clasp is the survey lines.

3.3.1 Types of Survey Lines

The function of survey lines is to indicate the undercut and non-undercut areas of a tooth or tissue as well as to suggest the appropriate type of clasp. Although, there is another classification but the Blatterfein classification of survey lines will be discussed in this course.

Blatterfein classified survey lines into four types:

- High survey line- the survey line is high on both sides of the tooth and result from the fact that the tooth is tilted. It is better to employ occlusally approaching clasps.
- Diagonal survey line: The survey line slant or diagonal on the tooth. These lines are commonest on premolar and canines and usually result in undercut area lying near the saddle. The commonest clasp is the gingivally approaching clasps.
- Medium survey line: The survey line is neither high nor low. This survey line normally indicates the occulusally approaching clasp arm.
- Low survey line – The survey line is positioned low on the tooth. This occurs when the tooth is tilted and there is high survey line on the opposite side. A De Van Clasp which has a gingivally approaching clasp arm may be indicated.

3.4 Types of Clasps

There are basically two types of clasps but each type has a wide range of modifications required to perform specific function(s). These are:

3.4.1 Occlusally Approaching Clasp

It is also called C-clasp as it approaches the undercut from occlusal direction. Other modifications of this type are:

Circumferential Clasp

It is normally called three arm or encircling clasp. You could make it in wrought wire using 0.9 or 0.8mm hard round wire for molars while 0.7mm wire is used on smaller teeth like premolars. In the cast, it encircles the tooth almost completely thus giving a good embracing, adequate support and retention.

This clasp consists of two arms projecting from minor connector in the direction approximately perpendicular to the path of insertion. The occlusal rest is located at the junction between the clasp arms and its framework.

Ring clasp

This clasp consists of a simple arm that almost completely encircles the abutment tooth from one direction to engage the undercut in a ring-like pattern. This single long arm may carry occlusal rest both mesially and distally while the retentive end engages the undercut below the survey line. It is indicated for single standing molars especially the tilted ones.

Back Action Clasp

This is used mainly on molars and premolars that have their undercut in the mesio-buccal aspect. It is most suited for premolars which often lean outward and forward. The occlusal rest is usually placed distally and should not be too far from the structure to which the clasp is attached.
Where the saddle is distal, it is ideal to connect the back action clasp to the mesial aspect of the tooth to the major connector. While the reciprocal arm move distally to engage the mesio-buccal undercut.

Splinting Action Clasp

It is the normal three-arm clasp which is extended or modified to immobilize weak or mobile teeth. The splint has to be rigid and lies above the survey lines both buccally/labially and lingually. It act as splint with good bracing and give adequate support. However, it is aesthetically poor because it is above the survey line.

3.4.2 Gingivally Approaching Clasp

Otherwise referred to as Roach or bar clasp and it engages the undercut from the gingival direction. It provides better retention because of the trip-action and has aesthetic advantage. Conversely, it has ineffective bracing and no support due to the absence of occlusal rest. Modifications of this type are;

Roach I and T or Y Clasp

These are constructed on diagonal survey line. The L form lies in the undercut while the formed position is placed above the survey line. In the case of the T-shaped clasp, the head of the T or Y lies entirely in the undercut. Other designs of Roach or bar clasp could take shapes like U, C or I. but these clasps have to be reciprocated to form combination clasp.

De Van Clasp

This is a combination clasp which is made up of the retentive bar or Roach clasp placed buccally and more retentive cast circumferential clasp arm placed on the opposite side for reciprocation. It makes use of proximal undercut and has occlusal rest.

Mesio-Distal Clasp

This clasp usually engages the proximal undercuts from the lingual or palatal aspect. It is mostly used on anterior especially canines. Though, it may be used on isolated upper bicuspids or molars which are buccally tilted.

Mesio-distal clasps are normally cast in gold and it embraces the canine on the mesio-palatal and distal sides.

3.5 Constructional Design of Clasps

You will observe from our discussion that clasps are made either by casting or by adapting wrought wire. Except in rare cases, casting is a method of choice for metallic plates because of good fit and other component parts such as rests and tags can be cast as part of clasp structure.

In the design, the clasp arm must be tapering in nature with reduced thickness as it approaches the tip. It should also be smooth without undulation or scratches. More importantly, clasp arms must never impinge upon the gingival margin of the tooth to avoid inflammation, pain, gingival recession or caries.

The shape of the tag is a continuation of the occlusal rest which must be carefully design to prevent gagging the bite. The general design of the denture must ensure that there is no possibility of sinking. All clasps must be as compact as possible to prevent interference with the cleansing action of the tongue, checks and saliva.

Finally, all clasps must be polished on both inner and outer surfaces. Their ends must be rounded and not pointed while the upper and lower margins must be smooth and rounded.

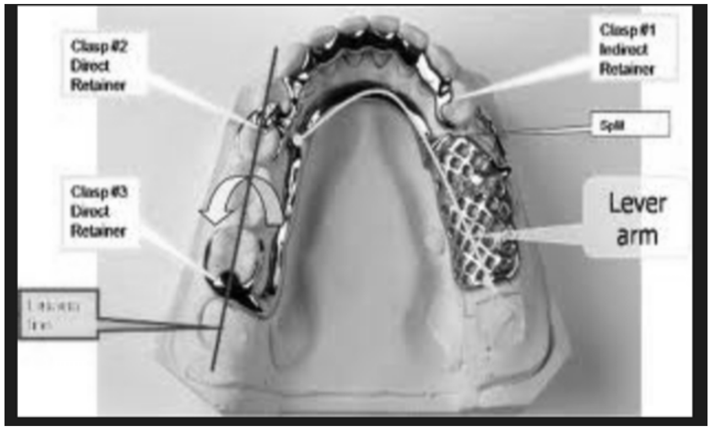

Fig. 11.2: Skeletal Plates with Circumferential Clasps, Occlusal Rests and Continuous Clasps

4.0 CONCLUSION

Our discussion on clasps is inexhaustive because of many associated factors. A pre-condition for choosing a suitable clasp for a particular denture design is the type of survey line. Blatterfein classification of survey lines recognises four categories namely, the high, diagonal, medium and low survey lines.

We also studied the two general types of clasps: the occlusally and gingivally approaching clasps but the modifications of each type are too broad to be covered in this unit. Therefore, you are advised to do further reading on this topic.

5.0 SUMMARY

In this unit, you learnt that clasp is a type of direct retainer incorporated into partial denture or skeletal plate design to provide mechanical retention, bracing and support to denture. Survey line is used to indicate the undercut and non-undercut areas as well as to determine the appropriate type of clasp for the tooth. Blatterfein classified survey lines into four, viz; high, diagonal, medium and low survey lines. The two broad classifications of clasps were also enumerated in this unit. These are occlusally and gingivally approaching clasps. The variance of the former includes circumferential clasps, ring clasp, back action clasp and splinting action clasps. Examples of gingivally approaching clasps are the Reach I, C,U, L, T or Y. De Van clasp and mesio-distal clasps.

Another important thing you leant in this unit is the principles guiding the design and construction of clasps. The tooth must be surveyed before choosing the appropriate clasp. The flexible portion must engage the located undercut, the rigid portion or shoulder should be above the survey line to provide bracing. All clasps must be free of gingival margin and should be polished on both sides.

6.0 TUTOR-MARKED ASSIGNMENT

1. Enumerate the Blatterfein classification of survey lines.
2. How would you design a named clasp for use in partial denture?
3. What are the other names for occlusally and gingivally approaching clasps respectively?
4. Discuss the type of clasps that is most appropriate for diagonal survey line.
5. Mention two kinds of clasps that are suitable for proximal undercuts.

7.0 REFERENCES/FURTHER READING

Farrel, J.H. (nd). *Partial Denture Designing*. London: Henry Kempton.

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UNIT 4 METALLIC FRAMEWORK

CONTENTS

1.0 INTRODUCTION

The metallic framework use in Prosthodontics is first made in wax in accordance to specific design. The pencil outline of the intended appliance is drawn on the cast showing all the component parts, that is, saddles, rests, retainers and connectors.

In this unit, you will be taken through the process and procedures leading to production of wax pattern ready for investing.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- identify various forms of metallic framework
- prepare wax pattern of skeletal plate
- describe wax withdrawal technique
- describe investment model technique
- explain how to apply the principles of spruing

3.0 Main Content

3.1 Metallic Skeletal Plate

The wax pattern of metallic plate starts with the preparation of the saddle. Prior to this, model should be surveyed and blocked out accurately. The saddle area is smeared with a good adhesive and tin-foil is burnished over it. Separating medium may be applied before over-laying the saddle area, clasps, rests and bars with sheet casting wax.

However, because of the thinness of the sheet casting wax, it is advisable to soften in lukewarm water rather than passing it over a naked flame. The temperature of the water should not be too high to cause melting of the thin sheet casting wax.

After proper adaptation, inlay wax can be slowly added to increase the thickness and strength of the saddle, bar, rests and clasps. Carving, smoothening and blow-piping can be done to correct thickness of the pattern. Perforations may be done to expose the tin-foil in the saddle area. At his stage, you have to incorporate T or V-projections as hooks to serve as mechanical retention between the metal and acrylic resin.

The wax pattern will be sprued, invested, cast, divest, trimmed, burnished and polished accordingly ready for setting-up of teeth.

The following figures show the different forms of metallic framework.

Fig. 4.1: Different Forms of Metallic Framework

3.2 Making the Wax Pattern

Wax pattern is the image of the metallic framework made in wax. You may wonder why the need for wax pattern? This is because, the lost wax technique usually employed in making dental appliances require using the wax pattern for making a mould in investment material. Heat is then applied to evaporate the wax while molten metal is poured to fill the space left by the lost wax in the mould.

Two methods of preparing wax pattern are usually employed and these are:

- Wax withdrawal technique: In this case, you build the wax according to design on the master cast, sprue and coat with investment, withdraw and invest.
- Investment model technique: This method involves forming the wax pattern on duplicate cast made in investment material, sprue, coat and invest accordingly.

3.2.1 Wax Withdrawal Technique

The aim of this technique is to produce a wax pattern that can easily be removed from master cast for investing. You have to start this procedure by surveying the master cast and designing the plate, rest, clasp as well as bar that serves as major connector.

Relief the saddle area and rugae with tin-foil or guage 7 soft metal, the soften sheet of casting wax either in warm water or over a Bunsen flame. Two sheets of gauge 4 or 5 casting wax may be adapted to achieve adequate thickness. Alternatively, a single sheet of gauge 7 casting wax may be adapted. The clasps should be built up with blue wax tapering in width and thickness. With the aid of Lecron carver or Ash No.5 instrument, cut out the excess wax to the penciled outline of the design. Incorporate the retentive tags in form of V-shape or inverted V. Then, trim and polish the wax pattern.

Carefully remove the wax pattern from the model without distortion. Readapt and seal down ready for spruing.

SELF-ASSESSMENT EXERCISE

Why do we incorporate the retentive tags in the pattern?

3.2.2 Investment Model Technique

As earlier stated, this technique entails the use of duplicate cast made in investment material. Therefore, you need to know how to reproduce the master cast in investment material. This procedure was discussed in unit 9, section 3.2.

After obtaining the duplicate cast in investment material, the procedure for making the wax pattern is similar to that of the wax withdrawal technique discussed above.

3.3 Spruing

By definition, a sprue is the channel by which the molten metal enters the mould. Most often, many sprues are used to provide channels for molten metal during casting operation. Sprues may be formed from wax wires, plastic or metal wires. Wax sprues vary in size and shape and may be obtained by means of a sprue former. Thicker ones may be made by hand or can be purchased in preformed patterns. Usually, a sprue should have reservoir which provide a reserve of molten metal from which the plate may draw as it contract on cooling to avoid porous casting.

Fig. 4.2: Wax Pattern with Sprues *In Situ*

3.3.1 Principles of Spruing

The fundamental principles of spruing include:

- Sprues must be smooth on the surface to reduce turbulence when molten metal enters the mould
- It should be round in section to reduce friction
- It should be short and equal in length to give quick entry to the metal
- Sprues may vary in length, shape and thickness
- It should not cause the metal to turn through sharp angles
- It should be flared at the junctions to avoid fine edges of investment
- It should have riser sprues to permit quick exit of air from the mould

- It should be sufficiently numerous to permit quick entry of the metal.

4.0 CONCLUSION

The procedure for making the wax pattern of metal plate was highlighted. The Pencil design of the pattern is made on a model which has been surveyed and blocked out. In the wax withdrawal technique, the pattern is made on stone cast while the investment duplicate cast is used for investment model technique. In either case, the procedures for adapting the wax and spruing the pattern are the same. The fundamental principles of spruing were highlighted.

5.0 SUMMARY

Your study in this unit centered on the construction of metallic framework in wax pattern. This is the theoretical background required to produce a functional appliance in the dental laboratory. Two techniques of making wax pattern of skeletal plates are identified, viz; the wax withdrawal and investment model techniques. The former entails the preparation of wax pattern on master cast which is sprued and subsequently removed for investing. While the latter involves duplication of master cast in investment material, the duplicate cast so obtained is used to produce the wax pattern which is sprued and invested with the pattern in situ. The unit also touched on the principles of spruing.

6.0 TUTOR-MARKED ASSIGNMENT

1. Describe the procedure for the construction of metallic framework in wax pattern on investment model.
2. Compare and contrast the two techniques of making skeletal plate.
3. What is a sprue? State the fundamental principles of spruing.
4. Mention four important features of metallic framework.

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UNIT 5 COMBINATION OF METALLIC AND NON-METALLIC DENTURE BASE MATERIALS

CONTENTS

1.0 INTRODUCTION

The metallic framework discussed in the previous unit merely forms a part of metallic partial denture. As you might be aware, metallic denture framework is a constituent part of metal partial denture. Therefore, in this unit attempt would be made to construct a functional dental appliance using a combination of dental alloys and polymeric dental material.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- identify the materials for the construction of metallic denture
- state the importance of combining metallic with acrylic resin
- illustrate finished metallic dentures
- explain how to fabricate a combination appliance.

3.0 MAIN CONTENT

3.1 Materials for Fabricating Metallic Denture

As you already know, metallic denture is a combination of metallic alloys and acrylic resin materials. The metal component consists of part the saddle, either plate, strap or bars together with other elements such as clasps, rests, and other relevant retainers. The acrylic component is the part of the saddle, the labial and buccal flanges as well as the teeth.

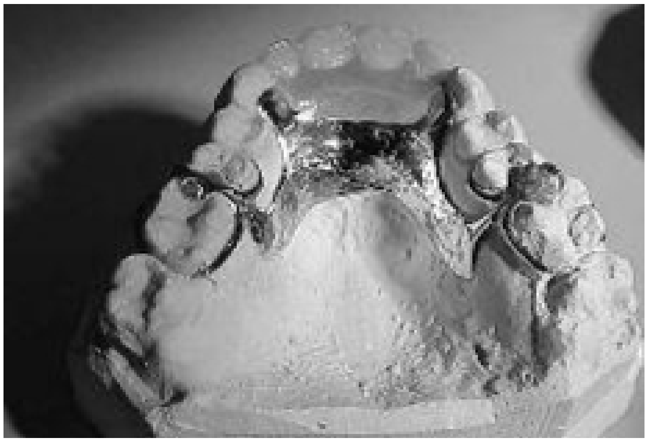

Fig. 5.1: Metallic Partial Denture *In Situ* on the Model

The materials for making metallic dentures are as follows:

3.1.1 Types of Alloys for Metallic Framework

The technological fabrication of a one-piece cast involve the use of sophisticated equipment such as strong technical motor, parallelometer, thermostatic bowl for duplicating material, sand blasting device, device for mechanical polishing and electro-polishing, glowing furnace and special casting device based on induced electric current.

However, the dental alloys commonly used for casting the metal components have been discussed intensively in units 2, 3 and 4 of this course. These are mainly the:

- Gold alloys
- Cobalt-chromium alloys
- Swaged stainless steel.

3.1.2 Polymeric Materials

The most widely used polymeric denture materials is chemically referred to as polymethyl methacrylate and it is popularly called acrylic resin. It can be used as denture base material as well as tooth material. After a completely finished metallic frame, the acrylic material is applied unto it in form of teeth and denture base material for flanges because of its aesthetic advantage.

The two types of acrylic materials are:

- Heat-cured acrylic materials
- Self-cured acrylic materials

The two polymeric denture materials are supplied in powder (polymer) and liquid (monomer) components. The difference between the heat and self-cured resin lies in their chemistry of polymerization. Detailed discussion on these materials is not within the scope of this course. You are advised to read further on Dental Material Science.

SELF-ASSESSMENT EXERCISE

State the importance of acrylic resin in metallic denture construction?

3.2 Reasons for Metallic Dentures

There are many reasons why metallic dentures are indicated or prescribed. This is partly because of its superior properties and partly due to the deficiency or weakness of completely acrylic materials. These are:

- Metals are more resistant to fractures than acrylic resins and this enable reduced form of denture bases
- The reduced size contribute to a better and faster adjustment of the patient to new conditions in the oral cavity
- Some patients complain of burning sensation with the use of acrylic resin denture
- Similarly acrylic resin may cause inability to sense temperature changes of food hence the need for metal base
- Recurrent allergy and microbial infection may also occur with all acrylic dentures
- You can achieve better result with a combination of metals and acrylic materials.

3.3 Fabricating the Metallic Denture

You start by obtaining the primary impression with irreversible hydrocolloid. Custom tray is fabricated and secondary impression is taken with zinc oxide Eugenol paste. The master cast obtained from this impression is duplicated with refractory material as discussed in unit 9. The refractory cast is used for the fabrication of the customised metal plate.

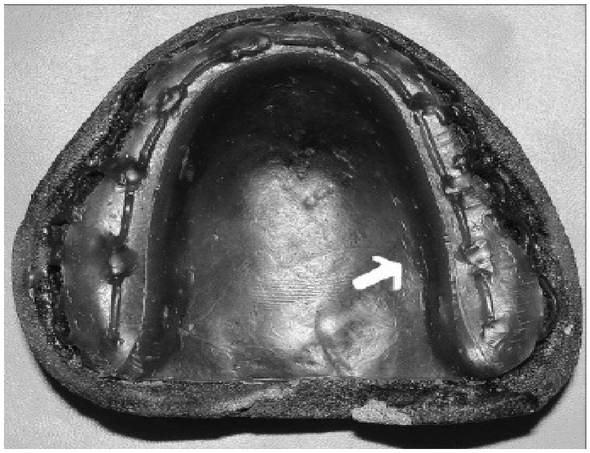

Fig. 13.2: Diagram of Wax Pattern of Plate

You can now adapt a sheet of green spacer wax on the palatal portion of the cast covering the crest of the ridge and extending 2-3 mm beyond it. Loops of 2-3mm length made of wax are attached to the peripheral border of the previously adapted palatal spacer wax. These loops would enhance the interlocking of acrylic resin. It is important to note that the height of these loops should not interfere with the arrangement of artificial teeth.

A butt joint is created palatal to the crest at the junction of acrylic and metal to enhance the strength of the metal acrylic junction and create a smooth joining thus obviating a step formation. This butt joint is made with a 2mm cylindrical blue wax beading adapted palatal to crest of the ridge. A bard parker knife is run 45^0 to the border of the bead.

a) b) Finished occlusal rim with metal palate

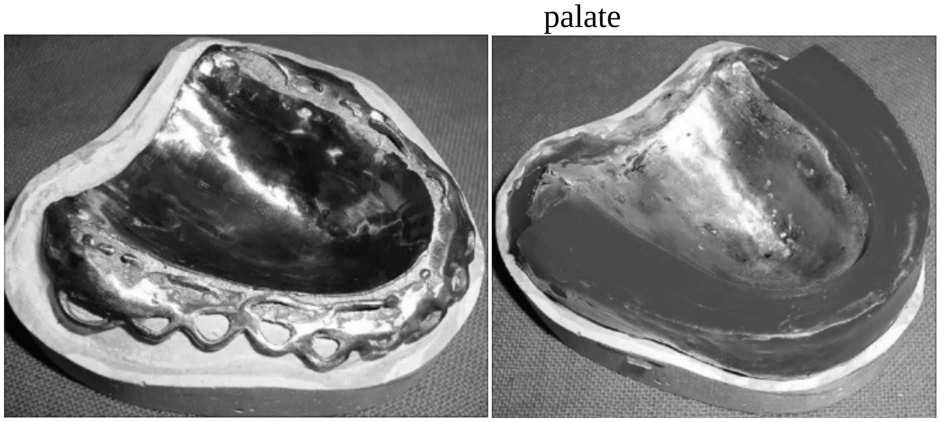

Fig. 5.3a): Metal Palate with Loops Placed on Master Cast

After the design of the palate in wax is done, attach wax sprues, invest in casting ring, burn out the wax in glowing furnace and cast. Divest, cut the sprues, then burnish and polish the metal plate. After finishing, the metal plate is placed on the master cast to makes the maxillary rim for jaw relation. The jaw relation is recorded and mounted on the articulator. Transfer markings on the registration block and set-up the teeth in accordance to the principles of balanced occlusion and articulation.

The wax pattern is flasked, boiled out, packed, cured, de-flasked, trimmed and polished to high quality with improved aesthetics.

.

(a)

(b) full dentures

Fig.5.4: Diagrams of Finished Metal-Acrylic Partial

4.0 CONCLUSION

You are made to know that metal frame is only a constituent part of metallic denture. The other part is the acrylic component which consist of the teeth and flange(s) for aesthetic purpose. Here, you know that the dental alloys for casting metal frame are gold alloys, cobalt-chromium alloy and stainless steel alloy. The plastic component is the acrylic resin. A combination of these materials is used for making a functional metallic denture.

5.0 SUMMARY

In this unit, you learnt that metallic denture is a composite appliance comprising the metal component as well as plastic component. Alloys such as gold, cobalt-chromium and stainless steel are used for making metal frame while the polymeric component is polymethyl methacrylate. Metallic denture, partial or full is superior to all acrylic dentures because of burning sensation and thermal conductivity. The procedure for the construction of metallic denture from impression to casting the metal plate as well as setting up and finishing of metallic denture was discussed.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is the importance of metallic dentures?
2. List five equipment used in the fabrication of metallic dentures.
3. Mention the two types of polymethyl methacrylate you know.
4. The _______is made with 2mm cylindrical blue wax beading.
5. Identify the important stages in the fabrication of metallic denture.

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MODULE 4 PRINCIPLES OF SUPPORTING UNITS FOR PARTIAL DENTURE

UNIT 1 ONLAYS

CONTENTS

1.0 INTRODUCTION

In this unit, you will study one of the supporting units for partial denture. Onlays are used for different purposes in partial denture construction. They may also be used as major connector when they are made to join one saddle to another. Before further explanation on onlays, you need to know the objectives of this unit.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

1. define onlays
2. describe onlays
3. state the advantages and disadvantages of onlays
4. state the functions of onlays.

3.0 MAIN CONTENT

3.1 Definition of Onlay

An onlay is a restoration which is sited on the tooth rather than inside the tooth but different from simple cap. Retention for onlay is provided by dowel extending into the dentine of the tooth.

3.2 Description of Onlay

Onlay is like an occlusal rest which is made to cover the whole surface of the tooth. Onlays are normally cast in either gold or Co-Cr alloy. Complete onlays are not common because of its expensive nature rather, a combination of gold and acrylic resin are used. The cast gold has direct contact with the tooth while the acrylic resin is added to complete the thickness of the onlay. Onlays must be so shaped as to be self-cleansing and must be beveled to fine margin.

3.3 Advantages and Disadvantages of Onlay

The combination of metal and acrylic onlay has a number of merits and demerits as follows:

3.3.1 Advantages

- It produces a lighter onlay
- It has better aesthetics because the acrylic tooth colour simulates the natural colour of the tooth.
- It is easier to spot grind because of the acrylic resin that comes in contact with opposing tooth.
- It is cheaper than all metal onlay.

3.3.2 Disadvantages

- Abrasion is more rapid and this may require frequent re-surfacing
- There may be need for masking agent or an opacifier to ensure perfect aesthetic colour.

3.4 Functions of Onlay

The functions of onlay are as follows:

- Support: Onlay function like an occlusal rest by preventing denture from sinking into the tissue. But because it is thicker and broader than occlusal rest, it has less tendency for fracture and distortion

- Correction of occlusion: Onlays are mostly used to correct problems of closed occlusion as a result of generalised attrition and reduced height. Therefore, onlays use to increase the vertical dimension
- Balanced articulation: Onlays may be constructed to correct articulation problem
- Splinting action: A mobile or unhealthy tooth may be splinted by onlay until better tooth health is attained
- Retention: When the onlay is designed to extend below the survey line, there is direct retention effect.
- Indirect retention effect: Where the onlay is far from the clasping axis or line of fulcrum axis, it may have indirect retention effect on that part that lies at the other side of the fulcrum.

4.0 CONCLUSION

Onlay is a restoration appliance that covers the entire surface of the tooth. It is different from inlay which is located within a cavity in a tooth. Onlay is also different from crown because it does not cover the entire clinical part of the tooth but the occlusal surface only. Onlays are usually cast in gold or cobalt-chromium alloys though a combination of metal and acrylic onlay is very common.

5.0 SUMMARY

You now know that onlay is one of the supporting units in metallic partial denture. Unlike the occlusal rest, it covers the whole grinding surface of the tooth. Onlays are used for many purposes in metallic prosthodontics in dentistry ranging from support, correction of occlusion and articulation to providing direct and indirect retention.

6.0 TUTOR-MARKED ASSIGNMENT

1. Outline the functions of onlay.
2. Explain how onlay may be used for indirect retention.
3. Differentiate an onlay from inlay and crown.

7.0 REFERENCES/FURTHER READING

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UNIT 2 RESTS AND HOOKS

CONTENTS

1.0 INTRODUCTION

This unit shall give you further insight into the supporting units for metallic partial denture. Although, unit 10 subsection 3.1.2 has introduced you to the concept of rests, its definition and examples, this unit will explain the basic principles for the design, construction and functions of these supporting appliances.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- enumerate design requirements of occlusal rest
- explain the purposes or functions of occlusal rest
- describe the position and design of other types of rests.

3.0 Main Content

3.1 Rests

You can define rests as metallic extensions located on the teeth to prevent vertical displacement of the denture towards the soft tissue. Occlusal surfaces are ideal for rests because they present horizontal surfaces that can prevent tooth movement as a result of vertical load. However, rests that are not positioned on occlusal surfaces are named according to their position or location on the tooth/teeth. E.g. Cingulum rest on the Cingulum of anterior tooth etc.

3.1.1 Occlusal Rest

It is the metal extension of the partial denture onto the occlusal surface of standing tooth. Usually it rest within a box preparation on the occlusal surface called seat. If it is properly made, occlusal rest provides the best type of support. The most appropriate sites are the occlusal surfaces of healthy molars and premolars so that they can withstand the masticatory force and prevent sinking of the denture into the tissues. Since occlusal rest must fit the occlusal surface of the tooth accurately, the cast type provides better fit and it is most preferred.

SELF-ASSESSMENT EXERCISE

State two health conditions a tooth must fulfill in order to bear occlusal rest.

3.1.1.1 Principles of Designing Occlusal Rest

- The design must be such that the transmitted force is along the vertical axis of the tooth to prevent tilting.
- The design should be wide and thin and be hollowed to avoid interference with opposing tooth
- Occlusal rest must be designed to be rigid and non-flexible to prevent the sinking of the denture into the tissue.
- The margin must be beveled without sharp edges
- It must be shaped such that it is self-cleansing preferably saucer-shaped.
- It must be finished with high lustre to prevent adherence of food debris
- Where it is possible, occlusal rest should be used in conjunction with clasp.

3.1.1.2 Functions of Occlusal Rests

- Support – Occlusal rest usually transmit the vertical load to the abutment like a typical tooth borne denture. For Kennedy Class III type of partial denture, you may design occlusal rest on both abutments to provide the best support.
- Improvement of occlusion – Occlusal rest may be constructed for cases with occlusion deficiencies. In this case, a properly designed occlusal rest results in balanced occlusion and balanced articulation.

- Indirect Retention – This may be achieved if the rigid occlusal rest is placed far from the fulcrum or clasping axis and helps to prevent lifting of the opposite side of the denture from the mucosa.
- Deflection of Food – The saucer-shape of the occlusal rest must be designed such that it will not only prevent adhesion of food but completely deflect food particles.

3.1.2 Incisal Rest

As the name suggests, the rest is positioned in the preparation on the Incisal edge of the tooth especially the upper canine. The incisal rest may cover the whole length of the edge or just a small portion of the incisal edge.

3.1.3 Cingulum Rest

The preparation that houses the rest may be made on the Cingulum of canines or other anterior teeth. But what you must consider is that the vertical load must be directed along the long axis of the tooth to prevent tilting of the anterior tooth/teeth.

3.1.4 Circumferential Lingual Rest

What makes this one special is that its preparation covers the mesial, lingual and distal width of the tooth. It is usually placed below the survey line. It has horizontal point of support which helps to prevent labial tilting of the tooth.

3.1.5 Internal Rest

It is a type of precision attachment which is intra-coronal and the preparation is made in an inlay. The rest is located within this preparation. This type of rest is named according to the part of the tooth the inlay is located. An example is the internal occlusal rest.

3.2 Embrasure Hook

Embrasure is the small triangular-like space between the curved surfaces of the teeth. Embrasure hook is an extension of a removable partial denture into the embrasure above the contact area between two adjacent teeth which resists movement in a cervical direction.

4.0 CONCLUSION

This unit dealt with the concept of rest and hook in broader perspective. Rests are mainly used to provide support for metallic plate in partial dentures. There is detailed discussion of occlusal rest which is the commonest type of rest in partial denture design.

However, other types such as incisal rest, Cingulum rest, circumferential lingual and internal rest follow the same principle of design and construction as occlusal rest.

5.0 SUMMARY

Generally speaking, rests are metallic extension of denture plate which helps to transmit the vertical load to the teeth. Rests are named according to their position on the teeth hence the occlusal rest on the occlusal surface, incisal rest along the incisal edge while Cingulum rest is found on the Cingulum of anterior teeth. Rests are usually located on small preparations made on healthy teeth.

6.0 TUTOR-MARKED ASSIGNMENT

1 Explain the concept of rest.
2 Outline the design requirement of occlusal rest.
3 What is an internal rest?
4 Mention two types of rest that are commonly found on anterior teeth.

7.0 REFERENCES/FURTHER READING

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UNIT 3 CONTINUOUS CLASP AND CONNECTING BARS

CONTENTS

1.0 INTRODUCTION

We are going to end our discussion of supporting units of skeletal plate with focus on continuous clasps and connecting bars. Continuous clasps are a type of indirect retainer while bar is a type of major connector. In this unit, you will study the meaning, design principles and types of these two phenomena.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- define continuous clasp and bar in relation to metallic denture plate
- state the functions of continuous clasp
- outline the design principles of continuous clasp
- describe different types of bars used in skeletal plate design

3.0 Main Content

3.1 Continuous Clasp

Remember that you studied clasps in unit 11 of this course, therefore, you should not have problem understanding continuous clasp. Going by its name, continuous clasp is an extension of the normal arm clasp. That is, it covers more than one tooth and it is usually located on the lingual or palatal aspect of anterior teeth resting on the Cingulae. It is rigid and strong; therefore, it is always positioned above the survey line. It is otherwise known as *Kennedy bar*.

3.1.1 Functions of Continuous Clasp

Some of the functions of continuous clasp are:

- Indirect retention: - It has an indirect retaining effect on the posterior part of the denture since it is anteriorly positioned.
- Splinting Action – It helps to immobilise any weak tooth in the system since it connect many anterior teeth.
- Bracing – It is positioned above the survey lines and engages the teeth effectively thus preventing lateral movement of the denture.
- Support – It helps in distributing the load to the teeth concerned.
- Act as connector – It is a minor connector since it joins one occlusal rest to another.

3.1.2 Design Principles of Continuous Clasp

- It must be rigid, broad and thin
- It should lie on the cingulae or horizontal surface
- It should be free from the gingival margin thus obviating gum stripping
- It should be smooth and self-cleansing with high polish.

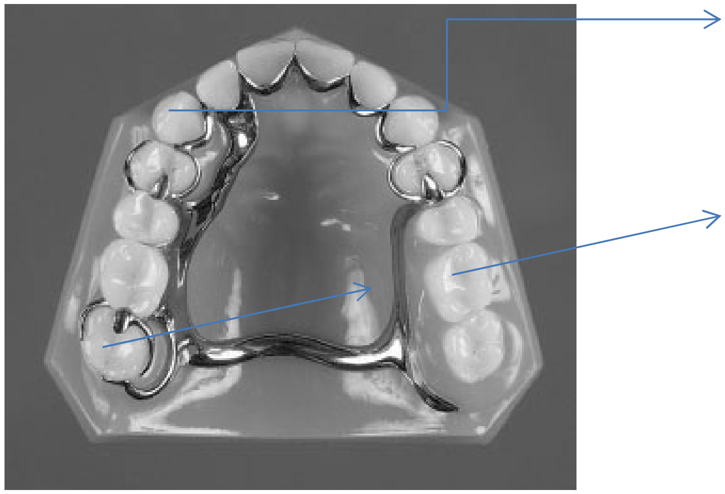

Fig. 3.1: Continuous Clasp and Posterior Palatal Bar

3.1.3 Contra-indications for the Use of Continuous Clasp

There are some factors that make the use of continuous clasp difficult or undesirable. These are discussed as follows:

- Diastema – These are spaces between teeth and it negates the use of continuous clasp for aesthetic reason. But where the use is very necessary, the design may be modified as in split continuous clasp.
- Inclined teeth – Teeth that are lingually positioned does not present horizontal surface for continuous clasp to rest.
- Deep bite – A case where the lower anterior bite on the palatal aspect of the upper make it impossible to construct continuous clasp on the upper because of insufficient space between the incisal edge and the Cingulum.
- Short clinical crown – This imply that there is insufficient space between the incisal edge and the gingival margin thus making the continuous clasp either too thin or encroaching the gingival margin. It is not advisable to use continuous clasp in this case unless it is modified.

3.2 Bar as Major Connector

Bar is a major connector that joins one saddle to another. It is rarely indicated for removable partial denture. However, there are many available designs in metallic frames for both upper and lower prostheses. Some of these designs are discussed as follows.

3.2.1 Posterior Palatal Bar

The posterior palatal bar is usually designed very close to the junction of the hard and soft palate. At the midline area, it curves to avoid the palatal fovea whereas it lies on non-compressible tissue at the tuberosity area. Posterior palatal bar has good stability as it lies on the horizontal part of the palate and it is well tolerated by patients.

3.2.2 Middle Palatal Bar

This bar is located slightly anterior to the posterior palatal bar though it is broader than the normal palatal bar. It has better stability than the posterior bar since it rest on less compressible tissue area. It has no indirect effect as it is placed close to the fulcrum.

3.2.3 Anterior Palatal Bar

It is usually formed by the combination of two palatal arms. It is used where continuous clasp is contra-indicated and because of its anterior position, it is very effective as indirect retainer. Sometimes, it is combined with posterior palatal bar to form a more efficient ring bar.

Fig. 3.2: Major Connectors

3.2.4 Palatal Strap

This is otherwise referred to as palatal plate. Palatal strap is just an extension of palatal bar with larger coverage area. Hence, the anterior palatal strap is actually a broad anterior palatal bar. It may be constructed in either acrylic resin or metal with necessary rigidity. It may also have standing teeth abutment with direct retainers at all corners.

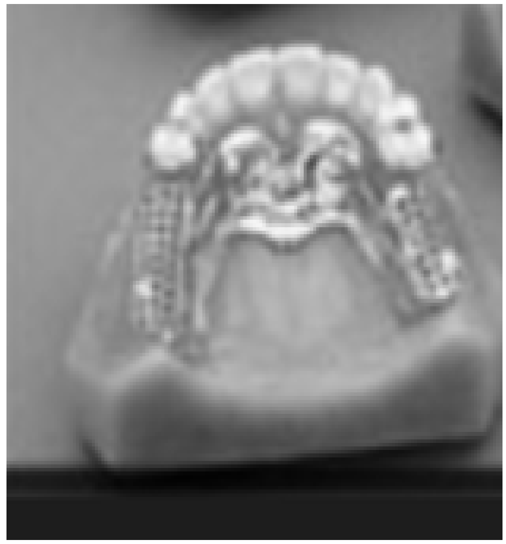

Fig. 3.3: Palatal Strap

3.2.5 Lingual Bar

Lingual bar is a bar that is installed on the tongue side of the dental arch and connects bilateral parts of mandibular removable partial Denture. Technically speaking, it is a major connector located lingual to the dental arch joining two or more bilateral parts of a mandibular partial denture.

Lingual bar is usually situated 1-2mm below the gingival margin. It is designed above the functional level of the floor of the mouth so that it will not impinge on the mucosa. The upper border of the lingual bar should be parallel to the gingival margin. Tin foil should be used to provide adequate relief between the tissue and the lingual bar. To improve stability, the lingual bar could be reinforced with either direct or indirect retainer such as clasp or continuous clasp.

The pre-fabricated type of lingual bar can be found in three forms:

- ✓ The half-round shape
- ✓ Oval shape and
- ✓ Half-pearl shape

Fig.3.4: Diagram of Lingual Bar

3.2.5.1 Indications for Lingual Bar

- Diastema – The presence of diastema between lower anteriors may contra-indicate other connectors like lower apron or continuous clasp for aesthetic reason
- Space - Lingual bar is suitable where narrow space between the gum margin and floor of the mouth may not permit the use of lingual plate or strap
- Where the health condition of the gum cannot support plate during the wearing of denture.

3.2.5.2 Contra-indication for Lingual Bar

- Lingual inclination – If the relief of lingually inclined teeth or tissue undercut will make the lingual bar too prominent for the tongue
- The presence of in-standing teeth or supra-numerary will affect adaptation and insertion of the lingual bar
- Space – where the space between the gingival margin and functional floor of the mouth is so narrow or thin to accommodate the lingual bar
- Prominent lingual torus.

SELF-ASSESSMENT EXERCISE 1

How does space affect the use of lingual bar?

3.2.6 Labial and Buccal Bars

You may say that these are similar or analogous to lingual bar but are positioned on the labial or buccal aspect of the ridge. The labial and buccal bars are not in common use though effective as any other connectors. It may be used on both upper and lower jaws. It is flatter and broader than lingual bar because of its increased length. Like the lingual bar, there is no direct contact with the tissue or ridge; therefore, you must relief the tissue area with adequate thickness of tin-foil gauge. This help to prevent trauma and gum-stripping.

Fig. 3.5: Chromium alloy Mandibular Labial Bar on Master Cast

SELF-ASSESSMENTS EXERCISE 2

What is the difference between labial and lingual bar?

4.0 CONCLUSION

In broader perspective, you have studied a type of minor and major connector. Continuous clasp is a minor connector uniting two bilateral occlusal rests. It also helps to provide indirect retention to other part of the partial denture. On the other hand, a bar is a metal segment of greater length than width uniting two or more bilateral parts or saddles of partial denture. Bar is a major connector with wide variety of designs.

5.0 SUMMARY

The major discussion in this unit centered on continuous clasps and connecting bars. Continuous clasp is an extension of three arm clasp resting on the lingual aspect of anterior teeth. Its major functions are to provide splinting action, bracing, indirect retention as well as support to the teeth concerned. It is designed to be free from the gingival margin and rest on the cingulae. Bar is a major connector which unites the bilateral components of partial denture. There are mainly two types which include the palatal and lingual bar. The palatal bars are found in the upper arch and various designs include the anterior, middle and posterior bar. The palatal strap is just an extension of palatal bar just like we have the lingual Apron in the lower which is an extension of lingual bar. However, the lingual bar is strictly on lower arch connecting bilateral parts of mandibular partial denture. A variance of these bars are the labial and buccal bars which are usually located on the labial or buccal aspects of either upper or lower dental arch.

6.0 TUTOR-MARKED ASSIGNMENT

1. How would you design a continuous clasp?
2. Differentiate between a bar and strap in skeletal design.
3. State the factors that contra-indicate the use of lingual bar.
4. Mention four types of bar you know.
5. Defined continuous clasp and state its functions.
6. ________ is another name for continuous clasp.

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MODULE 5 GENERAL PATTERN OF INVESTMENT PROCEDURES

UNIT 1 INVESTING, WAX ELIMINATION AND HEAT-SOAKING

CONTENTS

1.0 INTRODUCTION

This unit will teach you the detail of some steps you undertook in unit 12 during the construction of metallic framework. The investing techniques adopted should be able to produce a mould for the wax pattern while the wax elimination method facilitates the burning out of wax in the glowing dental furnace. The heat-soaking is done preparatory to casting operation.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the procedure for investing the wax pattern using casting ring
- describe the method of burning out wax from the mould without residue
- explain heat -soaking of the ring preparatory to casting

3.0 MAIN CONTENT

3.1 Investing the Wax Pattern

Investing is the method of forming the mould of the wax pattern in the casting ring using the appropriate investment material.

You will start this procedure by painting the wax surfaces with wetting agent e.g. liquid soap which reduces surface tension and allow air to escape leading to smoother casting. Subsequently, a small mix of investment material is used to coat the surfaces of the wax pattern using camel hair brush. The appropriate size of the casting ring is selected such that it is 6-8mm wider than the cast. You may either Vaseline the inner wall of the ring or line it with moistened asbestos tape. This practice allows unrestricted expansion (setting, hygroscopic or thermal) which compensate for the cooling shrinkage of the alloy.

At this juncture, the investment material is mixed with water or original liquid in accordance to the manufacturer's instruction. Mixing may be done in a vacuum mixer or manually and gently poured along the side of the casting ring on model vibrator. Fill the casting ring to the top level with investment and allow setting or hardening between 40-60 minutes.

Precaution: It is important to introduce the casting ring into the casting machine to check for balancing and alignment before placing in the furnace for heating.

SELF-ASSESSMENT EXERCISE

What factors do you consider in choosing the appropriate investment material?

3.2 Wax Elimination

After setting of the material, the casting ring is placed on its side in cold furnace and heated. The purpose of heating is to allow the wax to flow out of the mould leaving a hole in which molten metal is poured after glowing the ring. Heating should be done slowly at first to liberate both the ethyl alcohol content and wax by bringing the temperature to 450^0C over a period of one hour. This would be followed by rapid heating thus raising the temperature to 1000^0C in the next one hour. At this stage, no traces of wax in the mould and there is complete burn out of wax without residue.

SELF- ASSESSMENT EXERCISE

State the purposes of slow and rapid heating.

3.3 Heating-Soaking

This phenomenon is used to describe the practice of sustaining the mould at casting temperature in the oven before transferring the job to the casting machine. Remember that we have raised the temperature to 1000^0C; it is kept at this temperature for another hour. This will ensure a comprehensive thermal expansion as well as keeping the mould ready for casting. At this stage, you remove the casting ring from the oven and transfer to the casting machine.

4.0 CONCLUSION

This unit centered on the preparatory steps to casting of metallic frame. The procedure for investing the wax pattern and eliminating the wax content was discussed. The heat cycle was completed with the soaking process necessary to keep the mould ready for casting.

5.0 SUMMARY

In this unit, you learnt how to invest the wax pattern using the appropriate investment material. The gypsum-bonded material is suitable for gold cast while phosphate or silica bonded is recommended for Co-Cr casting. The wax pattern is first coated with wetting agent and then investment material before pouring the mixture of investment material into the ring to form the mould. The setting time ranges between 40-60 minutes.

Wax elimination is done by heating the furnace from cold to 450^0C for one hour and followed by another one hour of rapid heating to 1000^0C for Co-Cr casting. This temperature is sustained for one hour during heat-soaking period.

6.0 TUTOR-MARKED ASSIGNMENT

1. Discus the procedure for investing wax pattern for metallic Prosthodontics frame.
2. What do you understand by heat-soaking?
3. The setting time of casting investment material range between………….to ……………….. Minutes.
4. State four reasons for heating the mould containing wax pattern.
5. Heat soaking is done at……………..temperature for a period of ……………..

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UNIT 2 CASTING IN VARIOUS TYPES OF CASTING MACHINES

CONTENTS

1.0 INTRODUCTION

In the last unit, our study focused on investing the wax pattern in the casting ring using appropriate investment material. Subsequently, the set mould was made to undergo heat cycle in the furnace preparatory to casting operation. In this unit, we shall study the two common types of casting machines as well as the techniques employed in casting molten alloy into the heated mould. The two machines are centrifugal and solbring machines.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- identify centrifugal casting machine
- describe solbring casting machine
- describe the casting techniques in dental laboratory.

3.0 MAIN CONTENT

3.1 Casting Machines

Casting machines are special machines used in dental laboratories to make dentures, inlays, onlays, crown and bridges in metallic alloys.

There are basically two types of machines used for casting in dental laboratory, these are:

- Centrifugal casting machine
- Solbring casting machine

3.1.1 Centrifugal Casting Machine

This machine is based on the principle of centrifugal force which pushes the molten metal away from the centre towards the heated mould. In this machine, the alloy is melted in a separate crucible to eliminate sulphur contamination from investment material. There are two types of centrifugal casting machine, viz:

- Spring operated centrifugal machine
- Induction casting centrifugal machine

The major difference between the two is the method of activation. The former is activated by turning the spring in anti-clockwise direction while the latter is electrically operated.

3.1.1.1 Spring Centrifugal Machine

The machine has horizontal cradle which faces the crucible. The crucible and cradle are mounted at one end of the centrifugal arm which is pivoted at the middle and have a counter weight at the opposite end. Some horizontal rotating machines have a cranked arm which swings through 90^0 into alignment with the main arm when the machine is set in rotation. This provides a high initial acceleration to the molten metal. The initial acceleration can be achieved by using more turns when the spring is coiled. Although, care must be taken not to induce too great initial acceleration which may damage the investment mould.

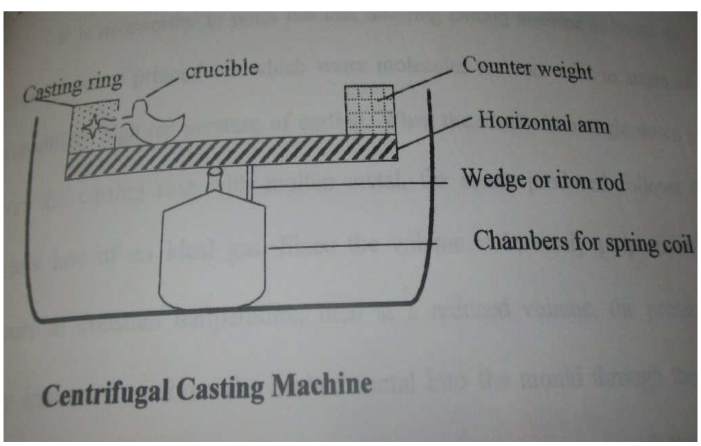

Fig. 2.1: A Spring Centrifugal Machine

3.1.1.2 Induction Centrifugal Casting Machine

Modern digital types are available and are electrically operated with light indicators. The crucible with inguts is positioned correctly within the machine. Then, the heating coil is made to envelop the crucible when the machine is set. Heating can commence slowly at first but when the casting ring is introduced into the machine, the regulator is put at high temperature mark. The light indicator alerts the dental technologist when the casting temperature is reached. Once the machine is activated, the heating coil moves out of the way and the centrifuge begins pushing the molten metal into the mould.

SELF- ASSESSMENT EXERCISE

Mention the two types of centrifugal casting machines.

3.1.2 Solbring Casting Machine

This machine is designed on the principle of steam pressure. It is a simple mechanism comprising the heavy metal base unto which a fixed vertical metal support is mounted. A movable arm is connected to the support at a hinge metal joint. The hinge permits forward and backward movement of the handle during the casting operation. A circular metal lid is attached to the movable arm with the aid of detachable rod. This is to facilitate easy removal of the lid at the time of stocking it with wet asbestos paper which is the source of steam needed to provide the casting force. There are three pins on the metal base which are adjusted to hold the casting ring firmly in place prior to heating the inguts on the crucible of the mould.

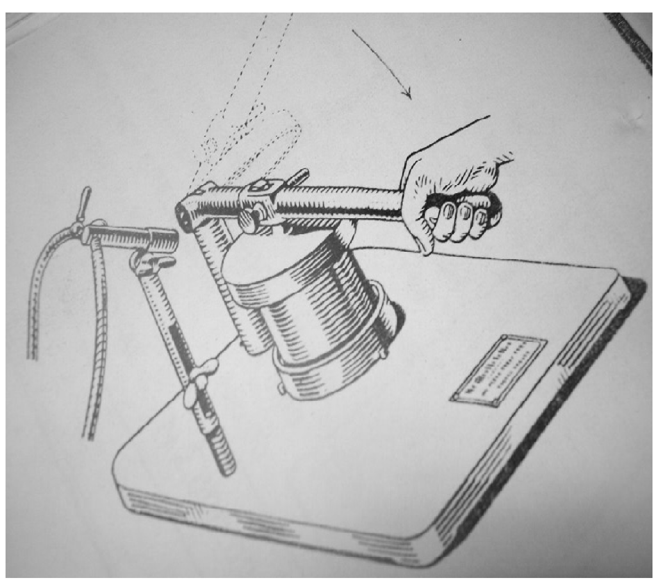

Fig. 2.2: A Solbring Casting Machine

3.2 Casting Techniques

The casting techniques are the methods you adopt in moving molten metal (alloys) into the heated mould. Earlier, you have seen the two types of machines used for casting operation. The technique will depend on the particular machine being used for casting. Consequently, we shall discuss two casting techniques:

- Centrifugal casting technique
- Steam pressure casting technique

3.2.1 Centrifugal Casting Technique

This technique relate to the use of centrifugal casting machine. Remember that the mould must be heated in the dental furnace after testing the casting ring in the cradle. Then you will turn the arm of the spring centrifugal in a suitable number relative to the size of casting. The locking rod is inserted to preserve the potential energy of the coiled spring. Start heating the inguts in fireclay crucible before removing the ring from furnace. The inguts is seen to collapse under its own weight with the influence of heat. At this point, position the hot casting ring into the cradle. Further heating with minimum flux will make the metal to spin. Remove the locking rod to release the weighted arm which automatically induces the initial acceleration that propels the molten metal into the mould. Allow the rotating arm to slowly move to a halt, remove the casting ring face up and after five minutes, plunge into cold water.

SELF-ASSESSMENT EXERCISE

At what point do you remove the locking rod for casting to commence?

3.2.2 Solbring Casting Technique

Remember that solbring machine used for this method is based on steam-pressure as the casting force. It is an important precaution to check the ring for position on metal base before heating in the oven. While heating the ring in the oven, remove the metal lid of the solbring machine and stuck it with two to three sheets of wet asbestos paper and put in situ. Remove the red hot casting ring from the oven and put in pre-set position on the metal base. Position the inguts on the crucible of the mould and direct the reducing zone of the flame to melt the alloy. Continuous heating with minimum flux causes the molten alloy to spin. At this point, gently lower the horizontal arm until the lid with wet asbestos completely covers the casting ring to induce sufficient steam pressure that forces the molten metal into the mould. Hold firmly in place until the casting operation is complete. After a period of five minutes, plunge the ring in cold water to remove the cast.

4.0 CONCLUSION

This is the unit where the actual production of metallic dental frame is done. The major equipment in the production of metallic prostheses is the casting machine. It is through these machines that molten alloys are forced into the mould to obtain the cast metal appliance. The two types of dental casting equipment are the centrifugal casting machine and solbring casting machine. The technique employed depends on the type of equipment used.

5.0 SUMMARY

In this unit, we discussed the two types of machines used in dental casting operation. The centrifugal casting machine is based on the principle of centrifugal and centripetal forces which are applied concurrently to push the molten alloys into the heated mould. This is mainly used for large casting like metallic frame for partial denture. On the other hand, the solbring casting machine is designed for steam pressure. A variance of it uses the air pressure to push the molten alloy into the mould. The procedure for casting using either of this equipment was also discussed.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is the difference between the two types of centrifugal casting machine?
2. The two types of solbring casting machines are …………………….and ………………………..
3. Describe the procedure for casting metallic partial denture using a typical centrifugal casting machine.
4. What is the purpose of dental flux in casting operation?
5. Give a vivid description of a steam pressure casting machine.
6. The operating principle of solbring machine is based on which gas law?

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UNIT 3 FINISHING

CONTENTS

1.0 INTRODUCTION

In the previous unit, we cast our dental metallic frame using either of the two techniques - the centrifugal and solbring casting techniques. We also divest the job by immersing it in cold water to remove the cast. Here, we are going to learn how to make the job suitable and ready for the patient. Finishing the cast prosthesis is a batch process that involves rough finishing, fine finishing and polishing as we shall see in this unit.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- state the concept of finishing as it relates to metallic denture
- explain the process of rough finishing
- appraise the finish line on finished metallic prosthesis
- polish metallic prostheses.

3.0 MAIN CONTENT

3.1 Finishing Metallic Prostheses

Definition: - Finishing can be any operation that alters the surface of a work-piece to achieve certain property. Processes include degreasing, cleaning, pickling, etching or polishing metallic surfaces to create a work-piece with desired surface characteristics. Materials for finishing include solvents and surfactants for cleaning, acids and bases for etching and solutions of metal salts for plating.

3.1.1 Purposes of Finishing

Finishing alters the surface of metal products to enhance

- Corrosion resistance
- Wear resistance
- Electrical resistance
- Tarnish resistance
- Chemical resistance
- Reflectivity and appearance
- Torque tolerance
- Solderability
- Durability
- Good hygiene
- Patient's comfort and satisfaction

3.1.2 Types of Metal Finishing

Metal finishing is used to treat the exterior of metal prosthesis by applying a thin complementary layer to its surfaces. Some of the common methods are:

- **Electroplating –** This is achieved by passing an electric current through a solution containing dissolved metal ions and metallic dental frame to be plated. The dental prosthesis is made the cathode in an electrochemical cell attracting ions from the solution. You must note that plating is typically a batch operation in which the prosthesis is dipped into a series of bath containing various reagents to achieve surface characteristics.
- **Brushed metal –** Unlike plating, it is a method used to remove surface imperfections. It creates uniform, parallel grain surface texture to smooth out the prosthesis. Abrasive belt or brush is usually employed to achieve this effect.
- **Grinding –** The grinding machines uses friction, attrition and or compression to smooth out the prosthesis surface. Within the dental laboratory, we use trimming machines with either diamond or Tungsten carbide bur and in some cases cutting disc to grind the rough surface.
- **Sandblasting –** Also called bead-blasting or abrasive blasting which forces sand, steel shots, metal pellets or other abrasives

into a substrate at high speed. It helps to remove adherent investment material and produce a smooth, clean appliance.

- **Buff polishing –** The polishing lathe in the dental laboratory is a good example. It uses a cloth wheel to buff the dental prostheses surface resulting in glossy sheen.
- **Powder coating –** It is a type of coating applied as a free-flowing dry powder. The powder may be thermoplastic or thermoset polymer and typically applied electostatically and then cured under heat to allow it flow and form a “skin”

3.1.3 Factors Considered in Choosing Metal Finishing Process

Some of these factors are:

- **Production Speed –** It is important to consider how fast and convenient a particular method is before applying the technique. You are not expected to use tedious long process like plating when you can quickly use brushed metal to achieve same result.
- **Cost Effectiveness –** Some equipment can deliver faster cycle rates though, they may be expensive.
- **Metal Hardness –** Harder metal usually require more intensive finishing technique. The finishing of cobalt-chromium cast is more cumbersome than cast gold alloys, as this involves sad-blasting, grinding and tougher abrasives.

3.2 Rough Finishing

Rough finishing is also known as grinding. This is coarse in nature and usually a preliminary finish of the dental appliance. The process includes grinding off of casting, deburing or cutting excess cast extension like sprues and reservouirs.

Procedure

Clean the appliance in water and perform sad-blasting operation in case of Cobalt-Chromium cast. Visually examine the cast alloy structure correctly and identify any casting fault and access viability. You should also pickle in acid solution to remove oxides and other impurities. In case of precious metal cast like gold alloys, place a dust tray directly under the work to collect droppings during trimming.

Hold the sprue firmly with pliers and cut the sprues one after the other with rotating cut-off disc or Fret saw. Remove the pimples and other surface roughness with diamond bur or Tungsten carbide burs. Grind the polishing surface of the metal frame with a coarse wheel and followed by smooth wheel or rubber stone to achieve surface smoothness.

3.3 Fine Finishing

This type of surface finish is also called satin finish. Here, the polishing lines will be soft and less reflective. It is semi-bright finishes that still have some polishing lines that are very minor. It starts with medium pumice followed by fine flour of pumice until scratches are removed. This may be achieved with small bristle brush with Tripoli bloc or fine pumice on an ordinary lathe brush.

3.3.1 Finish Line

Finish line of a metallic Removable Partial Denture (RPD) is the junction of the plastic denture base with the metal of the framework. In metal denture base, positioning of resin-metal junction (external finish line) is very important to minimise weight, maximise strength and ensure proper palatal contours.

Improper positioning of metal-resin finish lines may adversely affect phonetics. The resultant prosthesis should exhibit surfaces that re-establish proper anatomic, physiologic and phonetic contours.

SELF-ASSESSMENT EXERCISE

What are the benefits of finish line?

3.4 Polishing

Polishing is the finishing process of smoothening and imparting high luster on dental prostheses. Polishing does not primarily remove layers of the denture base but rather causes the surfaces layer of the metal to slowly flow along the surface. This is also known as burnishing which is a plastic deformation of a surface due to sliding contact with object. The appliance becomes shiny or lustrous by rubbing. The two types of polishing are:

- Electrolytic polishing
- Mechanical polishing

The two methods result in a very smooth lustrous surface finish called mirror finish or Beilby layer. Beilby layer is an amorphous layer formed on the surface of metals via mechanical working, wearing or mechanical polishing.

Our concern in this unit is the mechanical polishing of the cast metal frame.

Mechanical Polishing Process

This may start with fine Pumice mixed with water to thin homogeneous consistency in a rubber trough of the polishing lathe. Polishing brush of about 10mm length of bristle is attached to the spindle of the lathe and set in motion. The metallic Partial denture frame is held firmly in both hands and loaded with pumice, transverse the surface against the rotating brush which forces the bristles into interstices area to smoothen the denture. The short bristle brush is exchanged for one with longer bristle. Avoid touching the teeth of the denture with rotating brush to prevent scratches. Wash the denture in running water ready for final polishing.

At this point, all the scratches must have been eliminated. The final polishing is achieved with rouge block or powder on a Calico or Wool Mop. Position the cast on the master model and check for the accuracy of major connector, rests, clasps and adjust occlusal contact. Heat treat if necessary, and restore the polish.

Fig. 3.1: A Finished Metallic Partial Denture

SELF-ASSESSMENT EXERCISE

What is the difference between burnishing and polishing?

4.0 CONCLUSION

There is an extensive discussion on the finishing of metallic appliance in this unit. Some of the reasons for finishing are to improve the appearance, make the job comfortable and appealing to the patient as well as for durability, tarnish and corrosion resistance. Finishing was discussed in three broad categories, viz:

- Rough-finishing
- Fine finishing and
- Polishing

5.0 SUMMARY

In this unit, finishing is described as the totality of steps that alters the surface of an appliance to create a desired surface characteristic. Some common methods of finishing dental appliances are electroplating, grinding, sandblasting, powder coating and buff polishing. The laboratory procedure of achieving finishing is broken into three stages for convenience and orderliness. These are rough finishing involve cutting sprues, de-burring and grinding of the cast. Fine finishing is next and it is aimed at producing semi-bright appliance ready for polishing. Polishing is the final stage of finishing where gloss or reflective appearance is imparted on the appliance. Though, there are two types of polishing, electrolytic and mechanical polishing. The procedure for the latter was discussed extensively.

6.0 TUTOR-MARKED ASSIGNMENT

1. Other names for sandblasting are…….and ……
2. What is finish line?
3. Outline the procedure for rough finishing of a typical RPD.
4. Acids and bases are used for …while metal salts are used for….
5. List five purposes of finishing.

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UNIT 4 SOFT (RESILIENT) LINING PRACTICE

CONTENTS

1.0 INTRODUCTION

In the last unit, we studied how to finish a cast alloy restoration to provide comfort to the patient or denture wearers. Finishing was considered in three stages. Can you still recollect? Anyway, these are rough finishing, fine finishing and polishing.

In this unit, you will learn about the soft or resilient lining practice which is an optional procedure performed on finished denture for special cases. Soft-liner acts as shock absorber or cushion between the gum and hard metal base of the denture. New dentures can be fabricated with soft-liners or soft liners can be placed on existing dentures.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- identify a denture with resilient liner
- state the reasons for soft-lining practice
- enumerate the advantages and disadvantages of soft-lining
- fabricate denture with soft-lining.

3.0 MAIN CONTENT

3.1 Soft-Denture Liner

Soft-denture liner or resilient liner is a flexible, spongy and cushioned layer placed between the hard base of a denture and soft tissues in the mouth. Some of the properties of this material include tear resistance, odourless, tasteless and non-toxic. It is relatively easy to adjust and clean. Above all, it has little effect on the denture material itself. The liner may be inserted during or after the construction of the denture. An example is self-curing silicon material supplied as a paste in tube.

3.2 Indications for Use

The need for a thin layer of soft-denture base material on the fitting surface may be due to:

- **Tolerance –** When the denture wearer is not comfortable with hard denture base because the ridge is either knife-edged or a thinner than usual layer of mucosal tissues covering the alveolar structures. In this case, the crest of the ridge becomes the pressure point, hence the need for soft-liner.
- **Allergy –** A patient may be allergic to either acrylic resin or alloy structures which form the base of the denture. Almost all patients can tolerate soft-liner.
- **Surgery –** When there is removal of excess bone particularly in the middle of the palate area soft-lining may be used to act as pressure bandage in reducing swelling and inflammation.
- **Bone Resorption –** Soft liner may be used with an immediate denture until sufficient bone healing has occurred after tooth extraction which is usually a minimum of six months.
- **Implant –** In case of implant placement, the denture is relieved in the area of implant and soft reline material is placed to prevent direct contact between the denture base and the implant.

3.3 Advantages and Disadvantages Soft-Lining

There are many benefits and demerits of soft-liner as follows:

3.3.1 Advantages of Soft-Lining Material

- **Comfort –** Soft denture liners may be perfect for patients with sensitive underlying tissues because it is gentler on the tissues than hard liners.

- **Conformity –** Sometimes, you notice that the jaw bone of the patient will shrink after wearing dentures for a long time. This will lead to the formation of sharp ridge that causes pain, but soft liner will compress and conform to the changing jaw bone.
- **Chewing –** Soft liners fits more tightly in the mouth than hard structures, therefore the wearer is able to chew food much better.
- **Stability –** Unlike hard structures that may require adhesives for stability, soft denture liners will conform more to the inside of the mouth for better stability.
- **Health** – It helps to improve health of the gum tissues by absorbing some of the pressures of mastication.
- **Retention** – it helps to determine the maximum retention possible by utilising undercut in the bone and gum which hard-liners may not achieve.

3.3.2 Disadvantages

Some of the disadvantages of soft liners are:

- **Contamination** – These liners are very porous, so they will easily collect micro-organisms which can cause oral diseases. Therefore, soft-liners have to be replaced regularly to avoid contamination.
- **Adjustment –** The wearer have to see his denturist periodically for adjustment. These liners also make dentures difficult to repair.
- **Maintenance** – Remember that we mentioned earlier that soft denture liner easily attract microorganisms hence the wearers must clean them more frequently than ordinary denture.
- **Strength** – In case of acrylic denture, more materials are removed to create space for soft-liners. This tends to weaken the denture requiring metal framework to be installed inside the denture.
- **Cost –** They are more expensive than typical hard dentures and will also deteriorate more quickly which must be replaced.

3.4 Procedure

This is simply the step-by-step operation undertaken to place or attach the soft denture liner on the fitting surface of the denture. Remember that we mentioned earlier that soft-liner may be fabricated with new denture or placed on existing dentures. Though, the two methods can be carried out in dental laboratory, an illustration of a clinical procedure with fast setting soft-liner shall also be discussed.

3.4.1 Laboratory Procedure of Attaching Soft-liner to a New Denture

The denture is finished in usual manner, try-in the patient's mouth and the occlusal adjustment completed. The denture is then returned to the master cast while the plaster matrix is formed to the occlusal and palatal or lingual surface of the denture.
The denture is mounted on a free-plane articulator and the vertical dimension recorded. The denture is removed from the cast and a minimum of about 2mm of the base material is cut from the fitting surface short of the periphery of the denture. The denture is kept clean and dry.

Then coat the fitting surface with silicon adhesive (supply by the manufacturer). This provides a good bond between the denture base and resilient liner. The cast is then coated with sodium Alginate. When dry, the silicon paste is squeezed unto the slab or page and the accelerator liquid is added. This is thoroughly mixed together and then applied unto the fitting surface of the denture with spatula. The articulator is closed and maintained under pressure for about 15 minutes to allow complete polymerization.

Finishing – Note that resilient liner is difficult to trim and polish. Flash at the periphery is removed by scissors followed by rotating abrasive trimmer. It is important to trim from liner to denture base to prevent liner being torn-off at the base. Final smoothening is done by hand with fine sand-paper.

3.4.2 Clinical Procedure

The soft tissues of the mouth as well as fitting surface of the denture must be cleaned and dried. The liner comes in powder and liquid form which are mixed to form what look like liquid honey. At this stage, the mixture is applied to the fitting surface of the denture.
The denture is inserted and gently brought into normal position for approximately two minutes. The patient is asked to bite down on cotton roll for another two minutes. Subsequently, the jaw is moved in various directions to aid comfort. The excess material may be removed after six minutes as the material sets finally.

4.0 CONCLUSION

Soft lining material otherwise referred to as resilient liner is usually applied on the fitting surface of denture to reduce masticatory pressure on the tissue. The indications for its use are discussed while the advantages and disadvantages were enumerated. You are made to know the detailed procedure of how to fabricate a denture with soft-liner in the laboratory. A loose denture could also be relined with soft-liner where it is indicated.

5.0 SUMMARY

Soft lining denture material is a flexible spongy material placed on the fitting surface of the denture to cushion the effect of masticatory stress on the underlying tissues and bone. Some of the indications for its use include intolerance of hard liner, allergy to alloy or acrylic denture, bone **resorption**, surgery and implant operation. The advantages of soft denture liner include comfort, conformity, stability, retention and improved health to the patient. However, we also highlight some of the demerits as contamination, difficulty in adjustment and maintenance. Others are increased cost and reduced strength of the denture.

Read more on the laboratory fabrication of soft-lining dentures.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are the merits of soft denture liner?
2. ……………… is an example of soft-liner.
3. How would you know if a patient require soft-lining denture?
4. Explain how to finish a soft-lining material on denture.
5. Mention two ways to prevent contamination of soft-lining materials from microorganisms

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UNIT 5 FITTING THE APPLIANCE ON PATIENT

CONTENTS

1.0 INTRODUCTION

This last unit seems to be the most important if we are to borrow from the principle of production in economics. Production, they say, is not complete until the goods get to the final consumer. Fitting or insertion of our completed metallic prosthesis is the process by which the appliance gets to the final consumer – the patient. This is the moment eagerly awaited by the patient, who has cooperated in both time and effort toward this event. It must be a satisfying experience to both the denturist and the patient by repaying the skill and training of the former and the patience of the latter. Denture insertion, therefore, represent the culmination of a series of carefully considered and exacting procedures on the part of the denturist.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- name the factors affecting denture insertion
- fit a completed metallic partial denture
- administer post-insertion instructions on patient.

3.0 MAIN COURSE

3.1 Factors Affecting Denture Insertion

This shall be discussed under two sub-headings

- Technical factors
- Behavioural factors

3.1.1 Technical Factors

The manual dexterity and technical know –how of a denturist is called to question in the fabrication of well-fitting denture. The comfort of well-fitting denture is derived from a careful interpretation of tissue morphology and adaptation of denture bases for proper fit. The factors of retention, stability, functional occlusion and tissue support are reflection of good laboratory procedure which you have seen from the beginning of this course.

The path of insertion and withdrawal is determined prior to the construction of the denture by tilting during model surveying. For example, if a model is given anterior tilt (heels depressed), then the insertion would be from the front backward and vice-versa for posterior tilt.

The determination of the direction of placement and removal of RPD on its supporting oral structures can be varied by altering the plane to which the guiding abutment surfaces are made parallel. The choice is a compromise to fulfill five demands:

- To subject abutment tooth to a minimum or no torquing force.
- To encounter the least interference
- To provide needed retention
- To establish adequate guiding-plane surfaces
- To provide acceptable aesthetics.

3.1.2 Behavioural Factors

There is a wide spectrum of behavioural problems associated with denture insertion. There is the easily satisfied patient who returns after the insertion visit for only one or two minor adjustment. On the other hand, you see a patient who becomes an office fixture waiting for adjustment on frequent basis. He or she complains of excessive discomfort, poor function, non-specific and bizarre symptoms that lead to frustration for the patient and denturist. The important factor here is that the denturist should recognize that problem may exist and plan an orderly procedure for problem solving.

- **Patient Motivation**

The complexity of behavioural factor may cause the denturist to misinterpret patient response and enthusiasm during the initial stage. However, the sense of finality associated with completed denture may change the threshold of acceptability. The deep seated frustration may be due to patient inability to fully comprehend denture service.

- **Communication**

Establishment of good communication between the denturist and patient provides useful clues on the expectation of patient at the time of insertion. The ability of the denturist to listen and his skill at translating clues offered by the patient are valuable at the time of insertion. Note that poor communication can engender the spirit of non-cooperation and this will lead to failure.

The denturist should be able to predict the outcome and expectation of patient from the specific questions like: will the completed denture remove the wrinkles on my lips? Will they look like my own teeth?

3.2 The Insertion Procedure

You should bear in mind that denture insertion is not separate and distinct from all other phases of denture construction. It is an appraisal of all preceding and contributory processes including impressioning, record-taking, wax-patterning, investing, burning out, heat-soaking, casting, devesting, mounting, tooth arrangement, processing and finishing. If all these are judged satisfactory, the denture is ready for insertion.

A careful inspection of both tissue and polished surfaces is done with particular reference to foreign bodies, acrylic spicules, bits of plaster or stone that may prove traumatic to tissues. Any correction to the tissue surface should be done with minimum base removal. Frenal and buccal attachments are very important at the time of insertion. These functional entities should be carefully relieved. Therefore, cut the anterior frenum in a vertical direction in sagittal plane and buccal attachment in an oblique antero-posterior direction.

The denture borders are carefully inspected before they are seated intraorally. These borders are reduced to their original functional height by removing all excess materials that cause over-extension. Thinning borders that may cause sharp edges should be avoided.

Once the denture have been adequately treated to ensure occlusal harmony in centric occlusion, removal of irritating factors on tissue surfaces, provision for freedom of movement and balanced articulation, it is carefully polished. The appliance is now placed in the mouth to fully seat on the saddle area without rocking. By this insertion, you may have to apply a gentle finger pressure to the clasps, rests and bars or plate to obtain a tight fit.

3.2.1 Removal of the Appliance

The usual protocol is the reverse of insertion. By using gentle finger pressure, lightly tug the clasp at the back of the mouth to disengage your appliance. Depending on the fit of the appliance, you may disengage one side of the appliance first before the other end for easy removal. Gently withdraw the appliance towards the front of your mouth in one smooth motion.

SELF-ASSESSMENT EXERCISE

State four objectives of well-fitted denture

3.3 Post-Denture Insertion Instructions

Patients usually received polished dentures with favourable centric occlusion. They should also be indoctrinated on the use and management of such dentures. They should be instructed about the limitations of dentures upon full functions such as its effect on communication at the time of insertion.

Among the factors that are emphasized at denture insertion are the following:

- Oral hygiene – The patient may be given a denture brush and instructed on its use. Emphasis is placed upon prevention of food and debritus accumulation on the denture surface.
- Mastication – Patients are cautioned to cut food into very small pieces and to chew carefully on either or both sides of the mouth.
- They should be shown how to use fingers as auxiliary cutting instrument for food intake by pushing against upper anterior teeth or by holding food against lower canines and pulling against them.
- Patients are counseled not to wear dentures at night if there is a history of bruxism.
- Patients with no history of bruxism and who are not tense individuals may be advised to wear their dentures at night during the post insertion phases. This help to develop greater tolerance to dentures over a shortened insertion period.
- Patients are advised not to wrap their appliance up in a restaurant as this may accidentally end up in a trash. These lost appliances need to be replaced at a cost to the unfortunate patient.

- Know where your removable appliance is at all time. When not in your mouth, ideally, it should be in the plastic case provided at insertion or any other improvises.
- Finally, follow your instructions to the letter. Wearing the appliance as prescribed promote tolerance and fulfillment of set objectives.

4.0 CONCLUSION

Denture insertion is the culmination of extensive and sometimes difficult treatment procedures. Therefore, denturist should not have the casual attitude of “Here they are. I hope you like them”. But rather should adopt the more serious and considered approach of “Here we are. Let us both do what we can to make you look good, be comfortable and enjoy what we have created”.

5.0 SUMMARY

Denture insertion is the placement of denture in the intraoral environment of the patient. A well-fitting denture is the pride of both the denturist and patient because the objectives of their joint effort are achieved. Factors affecting insertion and patient satisfaction are categorised into two – The technical and behavioural factors which must be well managed to produce a good fit and desired aesthetics and function.

Insertion of the appliance begins with an appraisal of processes involved in the fabrication from impressioning to finishing. Once these processes are free from errors, insertion becomes an easy exercise by placing the denture on the dental arch without rocking. You could also see that removal is the reverse of insertion. The patient must be taught how to carry out these two exercises as daily routine and adhere to other post insertion instructions.

6.0 TUTOR-MARKED ASSIGNMENT

1. List the aims of denture insertion from technical point of view
2. What is the relationship between denture insertion and denture removal?
3. What advices would you give to a denture wearer on the care and maintenance of his new prosthesis?
4. ---------and -------are the two surfaces of denture.

7.0 REFERENCES/FURTHER READING

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