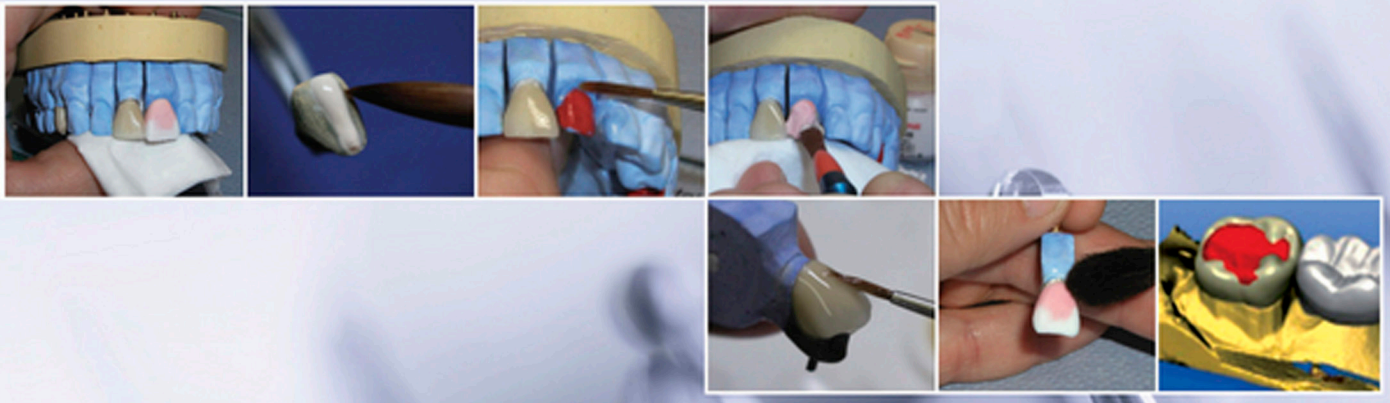
# BASICS OF DENTAL TECHNOLOGY

## A STEP BY STEP APPROACH | 2ND EDITION



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David G. Wildgoose | Duncan J. Wood

with website

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## A Step by Step Approach

**Second edition**


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WILEY Blackwell

This edition first published 2016


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*Editorial offices:* 9600 Garsington Road, Oxford, OX4 2DQ, UK
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*Library of Congress Cataloging-in-Publication Data*

Johnson, Tony (Anthony Phillip), author.
Basics of dental technology : a step by step approach / Tony Johnson, David G. Patrick, Christopher W. Stokes, David G. Wildgoose, Duncan J. Wood. -- Second edition.
p. ; cm.
Includes index.
Preceded by Basics of dental technology / Tony Johnson . . . [et al.]. 2011.
ISBN 978-1-118-88621-2 (pbk.) I. Patrick, David G., 1964- , author. II. Stokes, Christopher William, 1977- , author. III. Wildgoose, David G., author. IV. Wood, Duncan J., author. V. Title.
[DNLM: 1. Technology, Dental--methods. 2. Technology, Dental--instrumentation. WU 150]
RK652
617.6'9--dc23

2015006395

A catalogue record for this book is available from the British Library.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Cover image: background image - © Batke/Getty Images

Set in 10/12pt Myriad Pro by SPi Global, Chennai, India

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# Contents

# About the companion website

*Basics of Dental Technology* is accompanied by a companion website:

**www.wiley.com/go/johnson/basicsdentaltechnology**

The website includes:

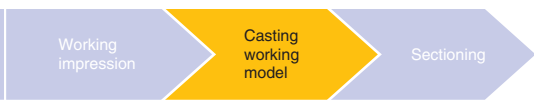
- Multiple choice questions
- Downloadable images

# Chapter 1 INTRODUCTION

## 1.1 Introduction

This book has been designed for use in the dental laboratory as a guide for the novice dental technician. Described in the manner of a 'cook book', the procedures in this handbook have been designed to be followed step by step. Presented in sections ordered by specialty, each procedure has been completed in a dental laboratory, with photographs illustrating all the important steps of each procedure. The work shown in this book has not been edited or tweaked, but is presented as the instructions given in this book were followed, to ensure that the outcomes are achievable by anyone following the guides (perhaps with a little practice!).

## 1.2 How to use this book




This book is designed for the student of dental technology for use on the bench in the dental laboratory. The construction of many dental prostheses and appliances requires progression through a series of stages, often from impression through to the finished product. You can use this book to work through each procedure step by step.

The graphic at the beginning of the sections will help you to see where any given procedure fits into the production process. An example of this is shown on the right.

For each procedure you will find a brief **introduction**, a list of the tools and **equipment required**, guidance on **working safely** and an illustrated step-by-step **basic procedure**.

In addition, the **hints and tips** sections give techniques to expand or refine the process, and the **extended information** sections give an insight into the scientific and clinical aspects that can enhance your understanding of the topic.

## 1.3 Equipment and instruments

The equipment listed below is commonly found in a dental laboratory, and with which any technician should be familiar.

### Plaster bowl, spatula and knife (Figure 1.3.1)

Common to all plaster rooms, these items are used for mixing, shaping and trimming plaster of Paris, Kaffir and die stone materials. Cleanliness of these items is important to prevent rapid setting of materials.

**Figure 1.3.1**

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Tony Johnson, David G. Patrick, Christopher W. Stokes, David G. Wildgoose and Duncan J. Wood.

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## Wax knives and carvers

These instruments are commonly used in the laboratory for a number of procedures. You should purchase your own good-quality knives and carvers.

**Small wax knife**: Most commonly used in the fabrication of crowns for placing and carving inlay wax. You may see technicians using two, a cold and a hot knife, to save time (Figure 1.3.2, instrument on the left).

Figure 1.3.2

**Large wax knife**: Used for melting, placing and carving modelling wax in the production of dentures. Again, it is common to see two knives being used, a cold and a hot knife (Figure 1.3.2, instrument on the right).

**LeCron carver**: This carver is popular for the carving of inlay wax in the production of crowns. It is used cold, but some techniques use it slightly warm, but not hot (Figure 1.3.3, instrument on the far right).

Figure 1.3.3

**Ash 5**: This carver is used cold to shape modelling wax in the production of dentures (Figure 1.3.3, instrument in the centre).

**Hylin carver**: This carver is popular for the carving of inlay wax in the production of crowns. It is used cold (Figure 1.3.3, instrument on the far left).

Figure 1.3.4

**PKT** (PK Thomas): A set of instruments (examples of two shown) designed to aid the precise positioning of molten wax in the production of crowns (Figure 1.3.4).

## Other hand instruments

Figure 1.3.5

**Ceramic brushes**: Available in a range of sizes similarly to artists' brushes (Figure 1.3.5), with sizes from 0 to 20 with 0 being the smallest and 20 the largest. These brushes are made from sable and should be treated with care. A size 6 brush is popular for the placement of ceramics in the production of crowns. Smaller brushes are useful for staining, and a larger brush for condensing ceramic.

Figure 1.3.6

**Ceramic spatulas**: These instruments (Figure 1.3.6) are used for mixing, placing and carving of ceramic powders. They are produced from a material that will not contaminate the ceramic with metal particles that may cause discoloration.

Figure 1.3.7

**Micromotors**: Modern micromotors (Figure 1.3.7) are very advanced in terms of engineering, control and quality. They are powered by low voltage electricity and usually controlled via a foot or knee controller, allowing the speed to be set anywhere between 5000 and 40 000 rpm. The chuck is opened and closed by twisting the handpiece to secure or remove a bur.

## Burs

There is a huge range of burs currently on the market and manufacturers devote several pages of their catalogues to them. Below is a brief outline of the main types.

**Tungsten carbide (TC)**: These are very popular burs used for many applications within the laboratory from trimming plaster to acrylic and metal. They are available in a large selection of shapes and sizes (Figure 1.3.8). The most useful are the plaster trimmers, flame-shaped for trimming acrylic and small round (often called rosehead) burs for accessing small areas.

Figure 1.3.8

**Steel burs**: As above, but not as hard wearing (and cheaper).

**Stone burs**: Abrasive stone burs are available in different grades, shapes, sizes and materials. The shapes range from cones to points to discs (Figure 1.3.9) and the different materials are indicated (often by colour) for different applications, that is, for the trimming and finishing of ceramics, acrylics or alloys.

Figure 1.3.9

**Diamond discs and burs**: Increasingly popular over the past decade, these tools are used for the shaping of ceramics and composites. They are available in many shapes and sizes (Figure 1.3.10).

Figure 1.3.10

**Rubber abrasives for metals**: These are available as wheels, cones or points and are used mainly in the finishing of metal surfaces (Figure 1.3.11).

**Abrasives for acrylics**: The simplest is a mandrel that holds a small piece of sandpaper, but rubber-bonded abrasives are now popular (Figure 1.3.12).

Figure 1.3.11

**Brushes and mops**: The main application of these is the polishing of metal surfaces in combination with wax-based polishing compounds (Figure 1.3.13).

## Pliers and cutters

For orthodontic appliance manufacture (or for any other occasion where a wire may need to be bent or cut) the technician will have a selection of tools.

Figure 1.3.12

**Adams 65**: Square-ended pliers used in the bending of orthodontic stainless steel wire (Figure 1.3.14).

**Adams 64**: Square- and round-ended pliers used in the forming of springs and curves in orthodontic wires (Figure 1.3.15). (Sometimes referred to as 'half-round'.)

Figure 1.3.13

**Maun cutters**: Used for the cutting of orthodontic stainless steel wires (Figure 1.3.16).

**Parallel pliers**: Used for firmly griping a variety of items (Figure 1.3.17).

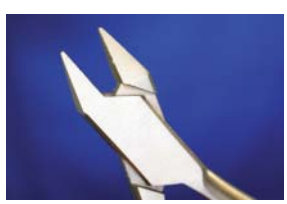


Figure 1.3.14

## Large laboratory equipment

Most laboratories will have most or all of the following (illustrations of some of the following equipment will appear later in the book).

**Model grinder**: A bench-mounted, water-lubricated, tungsten carbide wheel used to grind plaster products (Figure 1.3.18).

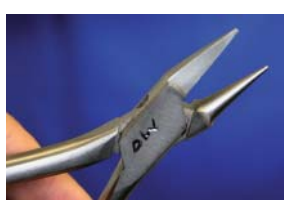


Figure 1.3.15

**Polishing lathe**: Used with brushes and pumice, or mops and polishing wax in the polishing of acrylics and alloys (Figure 1.3.19). Modern lathes have integrated dust extraction and lighting and have two speeds: 1500 or 3000 rpm. The polishing

Figure 1.3.16

Figure 1.3.17

Figure 1.3.18

Figure 1.3.19

Figure 1.3.20

Figure 1.3.21

Figure 1.3.22

lathe can be fitted with a variety of brushes and mops, for example, a bristle brush for applying abrasive pumice to acrylics (Figure 1.3.20) or a cotton mop for polishing acrylics or alloys (Figure 1.3.21).

**Steam cleaner**: Used extensively in the dental laboratory for cleaning models and restorations.

**Pressure bath**: These use compressed air to keep self-curing acrylics under pressure during curing. They also have the facility to keep water warm to aid the process.

**Hydroflask**: Used full of water for putting self-curing acrylic under pressure whilst curing, in the repair of dentures, for example (Figure 1.3.22).

**Vibrating table**: Used during the mixing and pouring of plaster materials to help avoid air bubbles.

**Vacuum mixer**: Essential in the production of models for fixed prosthodontics and for mixing investment materials. This machine mixes plaster materials mechanically in a sealed pot whilst sucking the air out of the plaster mix.

**Boiling out machine**: This machine keeps water hot enough to remove wax from moulds (e.g. in the production of complete dentures). It has a compartment in which moulds can be placed and automatically sprayed, or often there is a hand-operated shower for manual spraying.

**Presses**: Presses are usually bench mounted and used to close denture flask (moulds). Hydraulic presses are also available for the same purpose. These work in the same way as a hydraulic car jack and require less force than manual presses.

**Clamps**: Denture flask clamps are used to keep flasks under pressure during the curing process required for heat-cured acrylics.

**Denture flasks**: Brass flasks used to create two-part moulds of wax trial dentures in the conversion to acrylic dentures.

**Curing bath** (dry heat or water): Used for the curing of heat-curing acrylic. Large enough to accept the mould and spring clamp, these machines have an automatic heating cycle to ensure optimum curing of the acrylic.

**Porcelain furnace**: These small, automated vacuum furnaces are specifically for the firing of ceramics (Figure 1.3.23). They are computerised and programmable, and can store the data for the various firing cycles required for different ceramics.

**Burnout furnace**: Relatively large for a dental technology laboratory, these furnaces are used in the heating of moulds and crucibles prior to casting. Modern furnaces are programmable to allow for preheating and the holding of high temperature during the heating cycle.

**Casting machines**: There are several types of casting machines combining the different casting forces (centrifugal, air pressure/vacuum) and different heating methods (induction, electrical resistance, gas torch, oxyacetylene).

**High-speed grinder**: Bench-mounted motor used with a cut-off disc or grinding wheel, for removing sprues and finishing cobalt–chromium alloy denture frameworks.

**Spot welder**: Used to weld stainless steel wire or components in the production of orthodontic appliances.

**Ultrasonic bath**: Used extensively for cleaning restorations or components of restorations in conjunction with different cleaning solutions.

**Drying oven**: A low temperature oven used for gently warming and drying refractory models used in the production of cobalt–chromium denture frameworks.

**Electrolytic bath**: Used in the 'polishing' of cobalt–chromium alloy frameworks.

**Technician's workbench**: The workbench is often fitted with drawers, a gas supply for Bunsen burners, electrical sockets, a micromotor, dust extraction and colour-balanced lighting.

**Lighting**: Lighting is an important feature of the dental laboratory in terms of long-term well-being for eyes working under demanding conditions. It is also essential to allow correct assessment of colour when producing aesthetic restorations. Tungsten or fluorescent lights can alter the perception of the shade being matched.

**Shot-blaster**: There are several types of shot-blaster using different sizes of abrasives (such as aluminium oxide or glass beads) for different purposes. Non-recirculating blasters are used in conjunction with extraction in the preparation and finishing of metal surfaces, for example, in the production of metal-ceramic restorations. Recirculating blasters are used with larger grit materials in the removal of investment materials from cobalt–chromium frameworks.

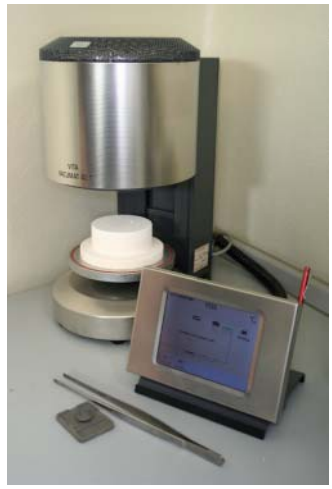


Figure 1.3.23

## 1.4 Health and safety in the dental laboratory

There are many hazards in the dental laboratory and many procedures that have an element of risk attached to them; however, if we take time to assess the risks and hazards, hopefully we will be able to minimise, or in some cases eliminate, the potential for harm.

It is the responsibility of all who work in the dental laboratory to ensure that we work safely and that we minimise the risk of injury to ourselves and others. It can be said that the effect of our use or misuse of equipment and materials can affect the degree of risk from known health hazards in the laboratory. In order to make sure that the working environment is a safe one there are some simple steps that can be taken, such as carrying out a 'risk assessment' and identifying any hazards present.

### What are hazards?

A hazard is anything that could possibly be damaging.

### What are risks?

How something might be damaging to you or others.

### Risk assessment

A risk assessment is an examination of what could cause harm to people. A risk assessment is done so that one can decide whether enough precautions have been taken to prevent accidents or injury.

Workers and others have a right to be protected from harm caused by a failure to take reasonable control measures.

## How to assess the risks in your workplace

The easiest and most effective way that you can assess the risks and put in place measures to minimise the risks in your workplace is to follow the five-step plan given below.

**1. Identify all hazards**

Walk around your workplace to see what may cause harm, check manufacturer's instructions on chemicals and think about long-term harm such as noise and dust.

**2. Decide who might be harmed and how**

Everyone does not have to be named, but specific groups of people have to be considered, such as plaster room workers or acrylic room workers; members of the public also need consideration if they have access.

**3. Evaluate the risks and decide on the precautions**

Once the risks have been identified, it has to be decided what can be done to minimise or eliminate the risk. This can be done by some simple means such as limiting access to hazardous chemicals or using less harmful chemicals and substances. Use protective clothing and organise work so that exposure is minimised.

**4. Record all your findings and make sure to put them in practice**

If proper notes are made it will be easier to implement safe working practices; also, remember to involve all staff so that a cohesive plan can be adopted by all to ensure the continued safety of all staff.

**5. Regularly review your assessment and update when needed**

All things are subject to change – number of employees, chemicals, working practices, etc. – so it is a good idea to review any risk assessment on at least a yearly basis so that any changes that have to be made can be done with relatively little disruption.

Assessing risks need not be an onerous task and if 'Risk Assessment' records are kept up to date, they can be carried out quickly and effectively with little hindrance to daily working practices.

Before starting to follow any procedure in this book, you should carry out a risk assessment. To help you, the **Working safely** section for each procedure outlines the main hazards.

# 1.5 Sterilisation and impression handling

## Cross-infection in the dental laboratory

Cross-infection is a very real risk in the dental laboratory and one that should be taken seriously by all staff. Although it is the responsibility of the dentist to ensure that all items that are sent to the dental laboratory are sterilised, it is wise to treat

everything with caution and not assume that we need not take basic precautions to minimise cross-infection.

The greatest risk to all members of the dental team is the patient and impressions that carry saliva; mucus and blood can pass disease on very easily. Workers in the dental laboratory do not usually see patients and in many cases are far away from the surgeries for which they carry out work. Being removed from the patient interface can lead to a feeling of not being directly involved with the clinical aspects of dentistry, but the impressions that we receive are a direct link with the patient and the clinic, and therefore must be treated accordingly.

Often the dentist will not know whether a patient has a communicable disease. Furthermore, the patient may not even know if they have a condition such as human immunodeficiency virus (HIV) infection or hepatitis so we have to make sure that we put into operation a cross-infection control procedure. Not only are we at risk from the patient but the patient also can be put at risk from the things that we do in the laboratory.

## Cross-infection control procedure and policy

All laboratory staff should understand the cross-infection control procedure required in the dental laboratory and follow good practice.

(1) All staff involved in the production and preparation of dental models from impressions must be immunised against tetanus, hepatitis B, poliomyelitis, rubella, tuberculosis and diphtheria, and a record of their hepatitis B seroconversion must be held by the laboratory owner.

(2) The dental laboratory must provide personal protective equipment (PPE) for each laboratory worker, such as protective clothing, gloves, eyewear and masks that must be worn during all production procedures.

(3) All impressions and other items that have been in the patient's mouth or in contact with the patient/clinician/nurse, in any way, should have been sterilised and show evidence that they have been sterilised by the clinic sending them. They should be enclosed in a sealable plastic bag and have a sticker on them stating the date and time the sterilisation procedure was carried out.

(4) All areas handling impressions and dental casts must be cleaned with the appropriate disinfectant.

(5) In the event of a needlestick-type injury, the wound should be made to bleed, washed thoroughly under running water and covered with a waterproof dressing. The accident should be recorded in the accident book, and immediately advice sought from a qualified first aider as to whether any further action may be required.

(6) All potentially infected waste must be put in the correct bag. Appliances that are returned to the dental practice should be disinfected in a 1% solution of sodium hypochlorite for 10 minutes, rinsed under running water, and then packaged in a clean, single-use container within a 'clean area' of the laboratory.

(7) Eating and drinking is only permitted in designated areas.

(8) It is not the responsibility of the technician to sterilise any items of work leaving the dental laboratory. However, this should always be made clear to the clinic receiving the work, whose responsibility it is to sterilise any items of work before they enter the patient's mouth.

For further information contact the Dental Laboratories Association (DLA), British Dental Association (BDA), British Dental Trade Association (BDTA) or the Health & Safety Executive.

Figure 1.6.1

Figure 1.6.2

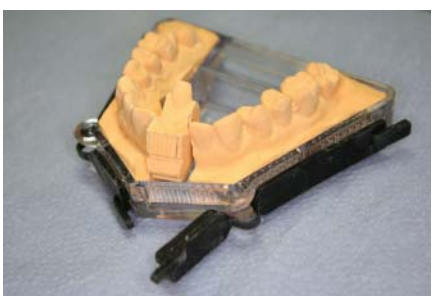


Figure 1.6.3

## 1.6 Introduction to model making

Most procedures in the dental laboratory are carried out on some form of plaster model, which is produced from an impression. There are several different model types that are produced for different applications.

In common to all is that care and attention to detail is required to produce an accurate, flaw-free model, which in turn will allow an accurate appliance, restoration, prosthesis or analysis to be made.

The types of model that will be discussed are the following:

- Models for prosthodontics (Figure 1.6.1)
- Orthodontic study models (Figure 1.6.2)
- Sectional models for indirect restorations (Figure 1.6.3).

### Materials considerations

Dental models are almost always made from a plaster-based material. Before using these materials, it is important to have an understanding of their composition and handling characteristics.

#### Plaster of Paris

This is a type of building material based on calcium sulphate hemihydrate, and is often referred to as the 'beta form'. It is created by heating gypsum (the raw mineral) to about 150°C, which drives off the water to make the powder that is used in the dental laboratory. This powder is then mixed with water (typically 50 ml of water to 100 g of powder) to make a thick creamy mix suitable for dental applications.

Plaster of Paris is recognised in the dental laboratory as a white powder (other dental model materials are often coloured to differentiate them from it). The working time is about 3–4 minutes, and the initial set occurs after about 10 minutes. There is a slight expansion on setting in the order of 0.2–0.3%. The setting reaction is exothermic, so plaster of Paris models feel warm to the touch as they set. A rule of thumb to gauge if a model has set sufficiently to be handled is to check that it is cool to the touch (indicating that the setting reaction has completed).

#### Kaffir D

A more expensive gypsum-based, model-making material (and referred to as the 'alpha-form'), Kaffir D, has been heated in an autoclave (a sealed pressurised container) at around 130°C. The outcome is that more water is driven off and the powder produced is more regular in shape, finer and less porous. Less water is required to produce a mix suitable for dental model making (typically 20 ml of water to 100 g of powder), and the product is a significantly harder and stronger material.

Kaffir D is recognised in the dental laboratory by its yellow colour. The working time and setting time is usually slightly longer than normal plaster, but the expansion on setting is less at around 0.08–0.1%.

If it is used in equal parts with plaster of Paris, (referred to as a 50:50 mix), Kaffir D can be used for making edentulous models. A 50:50 mix results in a softer, weaker material than Kaffir D on its own, but harder and stronger than plaster of Paris. When making dentate models, a higher strength is required and Kaffir D should be used on its own.

### Class IV die stone

This is the strongest, hardest and most accurate gypsum-based model material used in the laboratory. Sometimes called artificial stone, die stone, densite, improved stone or 'alpha-modified', it is formed by boiling gypsum in a 30% aqueous solution of calcium chloride and magnesium chloride. This process produces the smoothest, most compact particles of the three types described here.

A mix suitable for dental model making is typically 20 ml of water to 100 g of powder (although you should check the manufacturer's instructions), and the product is a significantly harder and stronger material. Care should be taken when mixing these materials to ensure that the optimum strength and accuracy is achieved. This is the only one of the three materials described here that is regularly mechanically mixed under vacuum.

Manufacturers often colour Class IV die stone (many different colours are used) to help distinguish it from plaster of Paris and Kaffir D. The working time and setting time is the longest of the three materials described here, with a working time of about 5 minutes, and a setting time of 20 minutes. The expansion on setting is around 0.05–0.07%.

Class IV die stone materials are used whenever a very strong and abrasion-resistant model is required or where the model may need to be sectioned, such as most crown and bridge work and constructing some cast metal partial denture frameworks.

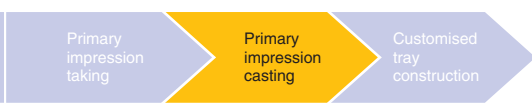
### Notes on mixing

With each of the materials above, changes in the powder to water ratio will affect the working and setting times, material strength and hardness and setting expansion.

As a rule of thumb, by using more water the setting time is extended, but the strength of the set material is reduced. Increasing the mixing time will reduce the setting time, but will tend to increase the setting expansion.

Additives, such as sodium chloride (table salt) and other 'setting solutions', act to significantly increase the setting time of a plaster mix, and can be useful when a fast set is required (such as for plaster impressions and articulating models).

## 1.7 Models for prosthodontics – casting primary impressions




Accurate impression taking and model making are essential to the successful production of a prosthetic device. If either procedure is carried out poorly, the appliance constructed on the model will not accurately fit the patient's mouth.

Primary impressions are taken in 'stock trays', which are ready-made trays. These are available in a range of sizes; however, they rarely fit the patient's mouth perfectly. The poor fit results in inaccuracies that are discussed further in the

Figure 1.7.1

**Extended information** section below. To overcome these inaccuracies, a 'customised tray' is constructed (see Chapter 2), which is tailor-made for the patient on the primary model (Figure 1.7.1).

## You will need:

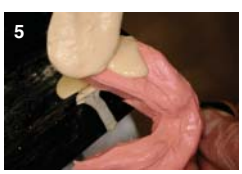
- Gloves
- Plaster of Paris/dental stone (Kaffir D)
- Plaster bowl, spatula and knife
- Weighing scales
- Measuring cylinder
- Vibrating table
- Model trimmer
- Indelible pencil

## Work safety

Protective gloves should always be worn when handling impressions; refer to Section 1.5 on sterilisation and impression handling. Inhalation of plaster powder should be avoided.












## Basic procedure

1. Rinse the impression under the tap to remove any remaining disinfectant, tissue or napkin. Shake off the excess water.
2. For each impression add approximately 120 ml of water to a plaster bowl. To this, add approximately 300 g of powder in a 50:50 ratio of plaster of Paris and dental stone (Kaffir D).
3. Mix with a spatula, avoiding air bubbles being trapped in the mixture until all lumps of powder are crushed and incorporated and a smooth consistency is achieved.
4. For the upper impression, place a small amount of the mixture onto the palate of the upper impression and hold firmly against a vibrating table or hand vibrate against the side of the mixing bowl to allow the material to fill the surface detail.
5. For the lower impression, add to the retromolar pad region on one side only and vibrate the mix into the impression.
6. Do not allow the model material to flow quickly over the impression; instead produce a wash of material. Air trapped between the model material and the impression will cause voids in the model surface.
7. Extra care should be taken with partial denture impressions, as it is essential that the material fills each tooth. Using a fine bristle brush to encourage the mix into the tooth areas is a useful technique.
8. Add material until the impression is full, leaving a slightly domed top.
9. Form a base on the bench approximately the diameter of the impression and 30 mm deep. Now wash your bowl and spatula.
10. Invert the impression on to the base once it is capable of supporting the weight of the impression, just before the initial set. The impression tray should be parallel to the bench top and the base should be approximately 25 mm high.

*Continued over*

11. When the material has set such that the excess can be removed without disturbing the remainder, remove the excess material from around the impression using a plaster knife. Ensure that the area between the tray and the bench are full.

12. To ensure easy removal of the impression from the model, the plaster should extend 2–3 mm on to the impression, but should not extend onto the metal or plastic impression tray.

13. After 30 minutes the impression should be removed. Remove any plaster locking the tray on to the model with a plaster knife. Hold the base of the model to the bench top with one hand and pull the impression up vertically using the handle. For dentate models, remove along the long axis of the incisor teeth.

14. Put the impressions to one side.

15. Using the model trimmer, trim the back of the models such that the midline of the model is at right angles to it.

16. Stand the model on this edge and reduce the thickness of the base until flat and parallel to the alveolar bone or occlusal plane. Do not reduce the thickness to such an extent that the palate or sulcus is perforated.

17. Trim the periphery of the model by placing on the flat base, leaving a 'land area' of 2–3 mm around. This protects the impression surface and allows the user to differentiate between the impression and the side of the model.

18. Clean up the edges using a plaster knife, being careful not to scratch the model.

19. After drying, label the models using an indelible pencil.









## Extended information

Inherent problems with primary impressions are as follows:

- Over-extension: Over-extensions of the buccal sulcus are due to the use of excessive impression material. This material is displaced into the sulcus during impression taking and pushes the cheeks out, creating a false record of the sulcus.

- Distortion: As the impression tray does not fit well, the impression material is not uniform in thickness. This causes distortion due to the material contracting on setting and during storage. Where the material is thin, only a small amount of contraction will occur, but where there is increased thickness, larger amounts will occur leading to distortion.

*Continued over*

## Hints and tips

- Use a clean bowl and spatula. Contaminants will cause the plaster to set more quickly.
- Do not over-mix the material, as this will also cause it to set more quickly.
- Mixing under vacuum is the most effective method of achieving a smooth, air-free mixture.

- **Lack of surface detail: The material used for primary impressions is usually mixed to have a relatively high viscosity in order that it remains within the impression tray. For recording surface detail, a low-viscosity material is required.**

**To overcome these problems whilst working, or secondary, impressions are taken using a customised or 'special' tray.**

**Figure 1.8.1**

## 1.8 Models for prosthodontics – boxing-in impressions

The method described in Section 1.7 for casting primary impressions could be criticised on two counts. Firstly, that on inverting the impression onto the plaster base, distortion of the impression material may occur if the base plaster is too firm, particularly if unsupported impression material is present. Secondly, as the plaster sets, the water in the mixture will rise, creating a weaker material at the surface of the model.

To overcome these potential faults, the impressions to be cast may be 'boxed-in' (Figure 1.8.1) and the model poured such that the fitting surface of the model is at the bottom of the model (inverted) during setting. The disadvantage with this method is the increase in working time and potential damage to the impression periphery during the wax attachment to the impression.

### Work safety

Protective gloves should always be worn when handling impressions; refer to Section 1.5 on sterilisation and impression handling. Inhalation of plaster powder should be avoided.

### You will need:

- Gloves
- Plaster of Paris/dental stone (Kaffir D)
- Plaster bowl, spatula and knife
- Weighing scales
- Measuring cylinder
- Vibrating table
- Model trimmer
- Indelible pencil
- Soft wax strips
- Boxing-in wax sheets
- Bunsen burner

### Basic procedure

1. **Position soft wax strips around the periphery of the impression to leave about 3 mm of the sulcus showing. Seal to the impression with molten wax.**
2. **Wrap the sheet wax around the wax strip to form a box (you will need to fill in the centre of lower impressions with additional wax).**
3. **Mix the model material as described in Section 1.7 and carefully pour into the impression. The plaster will settle on the impression surface and water will rise to the top.**
4. **After setting, remove the wax and trim and finish the model as described in Section 1.7.**

## 1.9 Models for prosthodontics – casting working (secondary) impressions

Secondary impression taking | **Secondary impression casting** | Registration rims production

A working model is produced from the working (or secondary) impressions. These are easily identified in the laboratory as the impressions will have been taken in a customized impression tray. The working model will form the basis of any future prosthesis, and so is cast with additional care, and from a stronger plaster mix to reduce the risk of damage or abrasion.

With the following exceptions, the casting of working impressions is identical to the casting of primary impressions.

### You will need:

- Equipment list from Section 1.7
- Permanent felt-tipped pen

### Work safety

Protective gloves should always be worn when handling impressions; refer to Section **1.5** on sterilisation and impression handling. Inhalation of plaster powder should be avoided.

### Basic procedure

1. **Use a permanent felt-tipped pen to mark a line around the periphery of the impression about 3 mm up the buccal reflection of the cheeks. This ensures that the final model will be complete.**
2. **When the cast impression is turned over onto the plaster base, allow the plaster to rise up the outer wall of the impression to the felt-tipped pen mark. This will provide a reflection of the sulcus on the model and allow a land area of 2–3 mm width to be formed.**
3. **Cast the model in 75:25 stone/plaster mixture to increase the hardness of the material and provide better abrasion resistance. This will minimise the damage caused when forces are applied during denture construction and processing of the acrylic resin.**
4. **The cast impression should be left to set for at least 45 minutes prior to removal of the impression.**
5. **Zinc-oxide/eugenol impression material will require softening in hot water before the trays can be removed.**
6. **The trays should be loosened all round the model and then removed slightly anteriorly in a vertical direction from the model without twisting. Twisting could cause damage to the model.**
7. **The finished model is trimmed to provide 2–3 mm of land area and a 1–3 mm reflected sulcus.**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## 1.10 Models for prosthodontics – models for cobalt–chromium frameworks

Secondary impression taking | **Secondary impression casting** | Metal framework production

Working models for cobalt–chromium or other metal partial denture bases should be cast using Class IV die stone. This gives the model increased strength and abrasion resistance, which is needed to withstand the frequent placement and removal of the metal base during construction.

Apart from the description above, the casting of models for cobalt–chromium denture bases is the same as previously described for 'casting primary impressions' (Section 1.7).

### Work safety

Protective gloves should always be worn when handling impressions; refer to Section 1.5 on sterilisation and impression handling. Inhalation of plaster powder should be avoided.

### You will need:

- Equipment list from Section 1.7
- Vacuum mixer and mixing pot
- Replace dental stone with Class IV die stone

### Hints and tips

Removal of the impression may cause damage to lone-standing teeth. Where vulnerable teeth exist it may be necessary to section the custom-made impression tray with a cut-off disc to allow safe removal of the impression.

### Basic procedure

**Cast the impression as for working models (Section 1.7) with the following exceptions:**

1. **Class IV die stone should be vacuum mixed.**
2. **Class IV die stone should be left for at least 4 hours to set.**

Impression casting | Appliance design | Component construction

## 1.11 Orthodontic study models

### You will need:

- Orthodontic stone (white)
- Orthodontic model trimmer or three set squares: 20°, 39° and 60°
- Orthodontic model base-formers
- Plaster knife and spatula
- Vacuum mixing machine and mixing pot (100 g per model)
- 600-grit glass paper

Study models are used to provide information of a patient's occlusion. Orthodontic study models are produced such that the angulation of their exterior surfaces does not suggest any abnormalities or malalignment of the teeth. The bases are trimmed symmetrically about the midline to aid the eye in judging the symmetry of the dental arches. This trimming of the models also allows them to stand in the correct occlusal relationship and makes them easier to handle and store.

There are two methods of producing study models:

**One-stage method**: The impression is poured and inverted onto on to the base and trimmed as described previously. A mould may be used to form the angles of the base.

**Two-stage method**: Models are cast that are a minimal size, referred to as rims, and then set into bases at a later date.

### Work safety

Protective gloves should always be worn when handling impressions; refer to Section **1.5** on sterilisation and impression handling. Inhalation of plaster powder should be avoided.

### Basic procedure

1. **Clean the impression trays and check whether the impression is central within the impression tray. If not, mark the centre line on the impression to aid placement. Rinse the impressions under running water.**
2. **Vacuum mix the stone to a stiff consistency for 30 seconds to eliminate air bubbles.**

*Continued over*

3. Fill the moulds with stone or make a base on the bench top.

4. Place a small amount of stone on the posterior border of the impression and let it flow to the anterior teeth whilst holding the impression on the edge of a vibrating table.

5. Remove the stone by tapping the impression on the side of the mixing bowl. This should leave a light covering of stone within the impression and help eliminate any air holes in the finished model.

6. Refill the impression as before and place to rest ready for inverting.

7. Invert the impression onto the moulds, keep the bottom of the tray level with the bench surface and centre the impression over the mould and check the midline position.

8. Trim excess plaster away from around the mould and leave to set.

9. The trays should be loosened all round the model and then removed slightly anteriorly in a vertical direction from the model without twisting. Twisting could damage the model.

10. Check the models thoroughly for flaws.

11. Remove the base moulds.

12. Firstly, make sure that the upper and lower models can be occluded without the wax bite, then make sure that the wax bite fits – be careful not to damage the incisors. The wax bite for study models should not cover the incisors; if it does, trim it off.

    Model trimmers have built-in aids to enable the bases to be trimmed to the desired angles. The midline of the upper palate is used to assess the symmetry of the upper arch and as a reference to which the angles of the bases are cut.

13. Using the model trimmer, trim the bases of the upper and lower models until parallel.

14. Trim the back edge of the upper model so that the midline of the model is at right angles to it.

15. Place the models in occlusion using the wax bite, and trim the back edge of the lower model to match the upper.

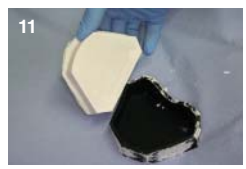
16. Set the angle on the platform of the model trimmer to 70°. With the models in occlusion, place the back edge of one model against the guide on the platform and trim the buccal side of the models until the sulcus is reached. Repeat for the other side.

17. Repeat step 17 for the other side.

*Continued over*



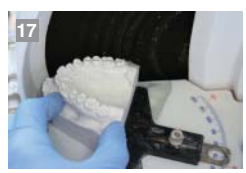

















18. Set the angle guide to 25°. Trim the distal corner by placing the trimmed buccal surface against the guide.

19. Repeat step 19 for the other side.

20. With the angle still at 25°, trim the anterior surfaces to form a point at the midline by placing the back edge in contact with the angle guide.

21. Trim the front edge of the other model to follow the line of the arch.

22. The finished models can be given a final polish with sandpaper if required.

## Hints and tips

Bases should be symmetrical with:

- Anterior surfaces finishing approximately at the canine
- Buccal surfaces finishing at the distal of the last molar
- Distal surfaces should end about midway across the last molar.

The lower model base should be approximately one-third thicker than that of the upper.

Study models can be finished with fine sandpaper to produce a smooth finish free from marks left by the model trimmer.

## Extended information

**Study models are used in orthodontics for three main reasons:**

1. **To provide a three-dimensional record of a patient's occlusion**
2. **To assess the position of the teeth in relation to the midline, allowing the amount of drift and symmetry to be monitored**
3. **To see progress in treatment.**

**Orthodontic study models are generally poured in white dental stone rather than plaster of Paris. Stone is preferred due to its hardness, durability and stability over a long period of time. Impressions are taken in alginate and therefore care must be taken to avoid loss of integrity.**

**The impression should be poured as soon as possible to retain its integrity and to avoid syneresis. This is where gel molecules in alginate are drawn closer together and as a result fluid exudates appear at the surface, which will result in poor surface quality.**

**At one time it was recommended that the base of the upper model should be trimmed so that its top surface corresponded with the Frankfort plane, resulting in rather tall and bulky models. The use of cephalometrics in relating the teeth and occlusion to the face and head has resulted in this being unnecessary.**



## 1.12 Introduction to sectional models

Sectional models allow parts of the model to be removed independently and replaced accurately. Models for indirect fixed restorations are made in this way to allow each prepared tooth to be an individual section. There are two types of sectional models: tray systems and pinned systems.

Pinned systems are considered more accurate and are indicated where multiple dies are being used on the same model, for example, where a bridge is being constructed and accuracy is essential. Tray systems are easier and quicker to produce and are sufficiently accurate for simple cases.

Prior to casting a sectional working model, check:

- The type of impression material that has been used
- That the stock tray is rigid or the custom tray is well designed.

When checking the quality of the impression, common problems are:

- Impression material becoming unstuck from the tray
- Incorrect relocation of impression where a two-stage technique is used
- Teeth contacting the tray through the impression material
- Incomplete mixing of material (looks streaky and has tacky surface)
- Contaminants such as saliva
- Air voids in areas requiring accuracy
- Drags – which appear as elongated areas due to the removal of impression prior to setting
- Incomplete surfaces owing to insufficient material or premature setting
- Incomplete arch, when a complete arch is required.

## 1.13 Producing a sectional model using a tray system (Figure 1.13.1)

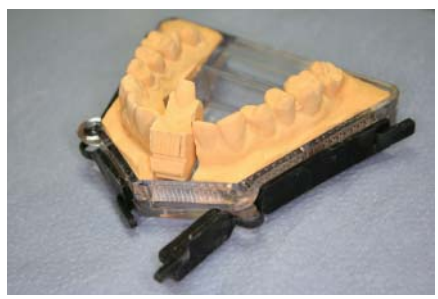


**Figure 1.13.1**

### You will need:

- A good-quality impression (see Section 1.12)
- Prescription card
- Permanent marker
- Scalpel
- Surface tension relieving agent
- One tray base with retention lugs or pins
- Boxing-in wax
- Class IV die stone (100 g per model)
- Water
- Plaster knife and spatula
- Vacuum mixing facilities (including pot)
- Vibrating table
- Plaster bur
- Steam cleaner

### Work safety

Care should be taken when handling the die stone powder as inhalation can be dangerous. Observe warnings on the surface tension reducing agent. Protective gloves should always be worn when handling impressions.

### Basic procedure

1. **Trim the periphery of the impression to the height of the top of the impression tray or to 3–5 mm above the gingival margin, whichever is highest.**

2. **Trim the palate of the impression to the same height as the periphery if not required for the treatment plan.**

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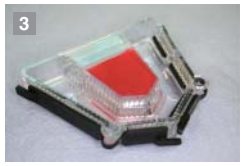






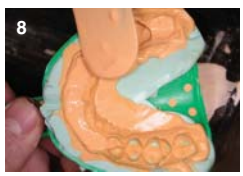


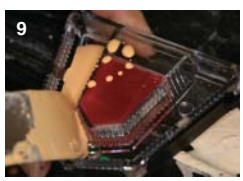








3. Prepare the tray by inserting the retention lugs and palatal block-out plate where required.

4. Looking through the base of the tray, position the impression such that the teeth are in the centre of the horseshoe-shaped trough. Record this position by making three marks with a permanent marker.

5. Spray the impression material with a surface tension reducing agent. Gently blow off the excess agent from the impression using an air line until dry.

6. Weigh the die stone powder into a dry mixing pot (typically 100 g). Add water (typically 20 ml) to the pot and hand mix briefly to incorporate the powder into the water.

7. Vacuum mix for approximately 40 seconds.

8. With the impression on the vibrating table, pour the mixed die stone into the impression. To avoid air bubbles, start from the distal of one side and slowly fill the impression by chasing the die stone around. Make sure you see the material fill each tooth in turn. If in doubt, pour out and refill.

9. Fill the tray base level with the top. Add any remaining mixture to the top of the impression.

10. Wash the pot and stirrer whilst the material is fluid.

11. Turn the impression onto the base once the shine on the surface of the die stone has dulled (the die stone is beginning to set). You will need to check periodically for this.

12. Using a plaster knife, remove any excess material from around the tray and impression. Leave to set for at least 60 minutes.

13. Remove any die stone preventing removal of the impression from the base using a plaster knife.

14. Remove the impression by gently easing vertically in line with the long axis of the teeth. Use a plaster knife to gently lever the tray if removal is difficult.

15. Remove the model from the tray. First remove the tray retention lugs, and then tap on the base of the tray (gently) to release the model.

16. Trim the excess die stone to neaten the model using a plaster trimming bur.

17. The periphery of the tray base should be seen clearly.

18. Clean all parts using the steam cleaner to finish.

## 1.14 Producing a sectional model using a pinned system

There are numerous types of pins available; these differ in material and anti-rotational design. Pinned systems take longer to produce but are more accurate.

### You will need:

- A good-quality impression (see below)
- Prescription card
- Permanent marker
- Scalpel
- Surface tension relieving agent
- Model pins (and sleeves if required)
- Model drill system
- Cyanoacrylate glue
- Boxing-in wax
- Class IV die stone (100 g per model)
- Water
- Plaster knife and spatula
- Vacuum mixing facilities (including pot)
- Vibrating table
- Plaster bur
- Steam cleaner
- Plaster-separating solution

### Work safety

Care should be taken when handling the die stone powder as inhalation can be dangerous. Observe warnings on the surface tension reducing agent. Protective gloves should always be worn when handling impressions.

### Basic procedure

1. **Trim the periphery of the impression to the height of the top of the impression tray or to 3–5 mm above the gingival margin, whichever is higher.**
2. **Trim the palate of the impression to the same height as the periphery if not required for the treatment plan.**
3. **Spray the impression material with surface tension reducing agent.**
4. **Gently blow off the excess surface tension reducing agent from the impression using an air line until dry.**
5. **Weigh the die stone powder into a dry mixing pot (typically 100 g).**
6. **Add the water (typically 20 ml) to the pot and hand mix briefly to incorporate the powder into the water.**
7. **Vacuum mix for approximately 40 seconds.**
8. **With the impression on the vibrating table, pour the mixed die stone into the impression. To avoid air bubbles, start from the distal of one side and slowly fill the impression by chasing the die stone around. Make sure you see the material fill each tooth in turn. If in doubt, empty and refill.**
9. **Wash the pot and stirrer whilst the material is fluid.**

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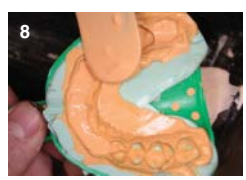

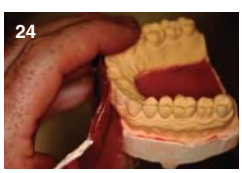

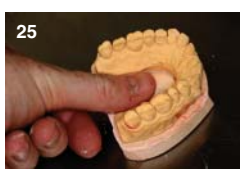


10. Leave the impression to set, tray-side down, for at least 60 minutes.
11. Using a plaster knife, remove the horseshoe-shaped model by gently easing vertically in line with the long axis of the teeth.
12. Trim the base of the model on the model trimmer to create a flat base.
13. You need to identify the teeth that are going to be worked on, as these will require two pins (or a double pin) to stop it rotating once sectioned.
14. The remaining sections of the model should also have more than one pin to stop rotation.
15. Drill two holes per section using a model drilling machine.
16. Check that the holes are located well within the edges of the model (as shown).
17. Fix the pins to the drilled holes using glue.
18. If required, place sleeves on each pin.
19. Block out the palate using boxing-in wax.
20. Place two layers of beading wax around the periphery of the model.
21. With the occlusal surfaces on the bench top, create a box using sheet wax high enough to cover the pins.
22. Spray the base of the die stone with plaster-separating solution.
23. Fill the boxed-out area with a mix of 50:50 plaster and Kaffir D to the top of the sleeves.
24. Allow the new base to set for at least 20 minutes. Remove the bulk of wax and place the model in hot water both to remove excess wax and to use the mismatch in thermal expansion of the die stone to the Kaffir D to help the two parts of the model separate.
25. Separate the two parts by pressing down in the centre of the palate.
26. Steam clean the model to finish.



## 1.15 Sectioning the model

Sectioning allows removal of dies or parts of the model as required for restoration production (Figure 1.15.1). Parallel saw cuts are made through the model to enable removal of sections.

Ideally, the model should be completely dry before sectioning (at least 12 hours should have elapsed since casting).

## You will need:

- Dry die stone model (see Sections 1.13 and 1.14)
- Fret saw
- Plaster bur
- Pencil

Figure 1.15.1

## Work safety

Use dust extraction when cutting and trimming the die stone.

## Basic procedure

1. Pinned models can be sectioned whole, but tray system models should be removed from the tray base by removing the retaining lugs.
2. Mark the ideal cutting lines with a pencil. These should be parallel.
3. Place the saw blade on the plaster and carefully start the saw cut, avoiding both the margin and the adjacent teeth. Keep the cut straight and following the pencil line. If the saw cut deviates, it may be necessary to cut from the bottom up.
4. Repeat for each cut required.
5. Tidy the saw cuts with a bur and clean all components with the steam cleaner. Ensure tray base locating grooves are free from debris.
6. Refit all components and ensure that the die can be removed independently of the adjacent sections.







## Hints and tips

When using a fret saw, apply very light pressure, using long saw strokes.

## Extended information

Class IV die stones are commonly used for the production of sectional models due to the ease of use and relative cost. Other materials in use are:

- Scannable die stones: indicated for some CAD-CAM production routes
- Epoxy resins
- Copper plating

## 1.16 Introduction to articulating models

Articulators are mechanical devices that reproduce the movements of the mandible. Models are mounted on the articulator to allow the teeth to be seen in function. Simple hinge articulators are also available that hold models in intercuspal position (ICP).

To reproduce the movements accurately the models must be positioned at the correct distance from the condyle (hinge of the jaw). There are two methods of achieving this. The first is to use an **average** relationship between the teeth and the condyle, the second is to use a facebow to mechanically record this relationship on the patient and use this recording to position the models on the articulator.

### Occlusal registration records

For dentate patients, the models may be mounted with or without an occlusal registration record. If the teeth interdigitate (mesh) well and it is clear that the models will be easy to relate, then no record will be used. However, if there is little interdigitation of the teeth, the clinician will send an occlusal registration to aid the technician in locating the models together. Registrations may be taken in wax, silicone or impression plaster.

For partially dentate patients, the clinician may use a partial registration rim to fill the edentulous areas and stabilise the models during the mounting procedure.

For edentulous patients, wax registration rims are produced, which are used in the mouth to record the necessary information: occlusal plane, centre line, position of teeth, vertical dimension and centric relation.

## 1.17 Articulating models on a simple hinge articulator

**Figure 1.17.1**

Simple hinge articulators (Figure 1.17.1) are limited in their range of use because they are unable to mimic the mandibular movements. However, the articulator is useful for holding study models together, holding models during the manufacture of simple appliances and for maintaining the vertical dimension during relining or repairing a denture.

### Work safety

Care should be taken when using the model trimmer to ensure that your fingers or any other part of your body or clothing does not come into contact with the wheel. Eye protection should be worn at all times when using the model trimmer.

### You will need:

- Models
- Registration blocks (edentulous) *or* occlusal registration (dentate)
- Simple hinge articulator
- Model trimmer
- Plaster of Paris
- Plaster bowl, spatula and knife
- Sticky wax