SURVEYOR AND SURVEYING

By

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Library Dissertation Submitted to the

Kerala University of Health Sciences, Thrissur, Kerala

In partial fulfillment of the requirements for the degree of

MASTER OF DENTAL SURGERY

in

BRANCH 1

PROSTHODONTICS AND CROWN & BRIDGE

Under the guidance of

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Chelad

2021-2024

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INTRODUCTION

INTRODUCTION

An essential key to success in the practice of removable partial prosthodontics is thorough planning of each structural detail of the prosthesis. The surveying process is an integral part of the planning process. A typical dental arch, for which a partial denture is to be planned, consists of asymmetrical, disparate clusters of teeth, separated by the areas of the edentulous residual alveolar ridge of varying lengths and breadths. The standing teeth usually lack parallelism with each other, whereas the surfaces of the crowns of the teeth are irregularly convex in shape. The challenge confronting the designer is to create a prosthesis that will go smoothly on the teeth and over the edentulous ridge, and that when in place, it will resist the dislodging forces that tend to unseat it.

A *dental surveyor* is defined as "a paralleling instrument used in the construction of a prosthesis to locate and delineate the contours and relative positions of abutment teeth and associated structures."[1]

Surveying the partially dentate casts is an indispensable step while fabricating a removable partial prosthesis. The surveying of models is to determine the path of insertion of the removable prosthesis. This insertion path must be decided before a prosthesis design. Casts are surveyed to determine the favorable and unfavorable undercuts that will contain the future clasp assemblies. The casts' tilt can be altered until we get a position where all undercuts are in a favorable position for fabricating the prosthesis. This tilt of the cast has to be preserved for future use; hence, tripoding is performed

DEFINITION & OBJECTIVES

DEFINITIONS

Dental surveyor:

A paralleling instrument used in making a dental prosthesis to locate and delineate the contours and relative positions of abutment teeth and associated structures.(GPT – 9)

Development of dental surveyor

Dr. A.J.Fortunati is thought to be the first person to employ a mechanical device to determine the relative parallelism of tooth surfaces. The first such device to be produced commercially, the Ney instrument, was made available in 1923; it remains the most widely used surveyor in the dental field. The Wills surveyor by Jelenko is second most widely used.

Objectives of surveying

- Determine the most advantageous path of insertion/ removal for the RPD.
- Locate proximal tooth surfaces that are or can be made parallel to act as guiding surfaces.
- Locate and measure recesses or undercuts for mechanical retention.
- Identify areas of potential hard or soft tissue interferences.
- Determine a path of insertion/ dislodgement consistent with esthetic requirements.
- Delineate the height of contour of the abutment teeth and identify the areas of undercut that must be avoided, reduced, blocked out or preserved.
- Help in planning restorative procedures .
- Record the most ideal cast position for future reference.
- Establish a formal plan for RPD design and the required mouth preparation.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Schmidt AH in 1953[11] stated that principles of surveying, significance of survey line, relation of clasp to the survey line and the opportunity presented by tilting the cast to control the location of undercuts are basic factors which enable the prosthodontist to solve any removable partial denture problem.

Boitel RH in 1962[12] advocated Bachmann's Parallelometer for prosthetic laboratories for its wide features such as Surveying of diagnostic cast, Seating precision instruments, Drilling pinholes into casting and porcelain facing, Waxing and carving precision attachments.

Kaloyannides in 1973[13] first proposed a simple device that comprised a protractor for measuring the tilt of the cast in the anteroposterior as well as transverse direction and recording the values of the same as indicated by the device . The dentist could note these values along with the anatomic points for further communication with the technician rendering it easy to reproduce the cast tilt

Richard e coy in 1974[14] evaluated the importance of survey and design of diagnostic casts for removable partial dentures. The author summarizes the procedure of cast surveying and the features that are to be analyzed on a diagnostic cast.

Gokhan yilmaz in 1975[15] presented the use of optical surveying of casts for removable partial dentures. Parallel light beams are produced by light bulbs with small dense filaments and condensed lenses contained in a box. The beams are made parallel with the vertical rod of the conventional surveyor by fixing the box firmly to an iron bar. Since the basic principles of the mechanical surveyor and this instrument are alike, the term optical surveyor has been selected. The border of the bright and dark zones indicates the survey line.

Arthur m lavere in 1977[16] in his article presented a simple procedure for survey and design of diagnostic casts. He concludes that survey and design should be done in a sequential manner as follows:

- Locate a path by fitting the cast.
- Mark the survey lines and tripod the cast.

- Outline the rests and guide planes.
- Draw minor connectors.
- Draw major connectors.
- Draw retention mesh for acrylic resin.
- Draw acrylic resin base extension
- Draw direct retainers.

Knapp et al in 1979[17] modified the cemented pin method. He used a pear-shaped bur to create perforations of 4 to 6 mm diameter and 5 to 8 mm depth on the lingual space of the mandibular cast . Later, the cast was surveyed conventionally, and the bur was placed in the surveying arm such that its shank acted as the analyzing rod. This assembly was now lowered inside the perforation and sealed in place using cold-cure acrylic resin . Reorientation of the cast only required the bur shank's insertion in the surveyor's vertical arm. The author suggested that the bur could be removed from the acrylic using pliers for mounting.

Sykora in 1980[18] stressed the disadvantage of the traditional cast indexing method of being eliminated during cast handling in the lab . As the solution to the before-mentioned problem, he advocated using MS leveling device (Unident Limited, Nova Scotia). This device could be attached to the part of the cast outside the framework using what he described as "soft periphery wax". It was then adjusted so that the air bubble pointed in the center of the device's cross-marking. This assembly is fixed using sticky wax. The cast could be reoriented by positioning the bubble on the device again in the center.

A new "position recorder device" was given by **Sarnat and Klugman in 1981**[19] . The device consists of a three-ended plate made of plastic with two concave sides, large enough to accommodate all sizes of arches. Each end of the plate includes retentive holes corresponding to the single anterior and two posterior points used for tripoding. Besides the holes was a marking area that could note the tooth number used for marking. The plate's center had an attached mandrel handpiece that accommodated the surveying arm. Now, the cast was coated with separating media to record the tilt, and modeling wax was made to flow through the holes. Cold water was used to harden the wax. The dentist could now send the assembly to the lab.

For repositioning, the device is first to fit on the cast then the handpiece mandrel is locked in the surveyor

De Fiori and Miranda in 1983[20] described a technique including the cemented pin method . First, they register the path of insertion by Wagner's way. Then they made an acrylic plate of 2 mm thickness to conform with the cast and include the reference points. The middle portion of this plate is cut to remove the interference of the cemented pin on the cast. The reference points are lubricated, and self-cure resin is utilized to record the position of the points on the acrylic plate. Now, while the cast was positioned using the cemented pin, this construction was placed on the model. Carefully the pin is removed as the surveying arm raises, and another metal pin is inserted into it. The other end of the pin is glued to the acrylic plate using self-cure resin. This "transfer guide" can now be used for other working casts of the same patient

Steas in 1987[21] fabricated a device that he named a simple recording instrument using three metal strips, two short and one long . The short ones were 5.5 cm, and the long one was 7.5 cm in length. The more petite strips had two holes at the two ends, and the longer one had a single hole and a central slot cut out of 4.5 cm. These strips were attached to a bur that slid easily into the surveying arm. The other end of the strips also had nuts and bolts attached. The device became fully adjustable as one could easily adjust the nuts to contact three reference points on the cast and fix them in place using the bolts. The reference points is marked on the cast for further understanding. Hence this instrument could be stored and sent to the lab and reused for other patients too. Any point on the casts could be used as anatomic landmarks for tripoding.

In 1994 Ansari[22] produced a U-shaped plastic tray (made of tray material) by adapting modeling wax after doubling its thickness on any completely dentate cast . This tray was trimmed, and its borders smoothened out. Another batch of tray material was mixed to form a bridge across the U-shaped tray, and yet another set was used to create a cylinder in the middle of the bridge to accommodate the straight stylus of the surveyor. This was then trimmed and finished. For recording the tilt, the silicone putty was manipulated and placed in the U-shaped depression. A plastic tray was then placed in the surveyor with the stylus. Lowering this assembly on the surveyed cast recorded the index of the occlusal surface of the model. After

the material was set, it was separated, and the margins were trimmed to expose the cervical third of the buccal surfaces of the teeth. This could be stored and used by simply reattaching the index on the cast. This customized device could be reused by removing the putty when it was no longer needed to orient one cast.

Bezzon et al in 2000[23] modified the cemented pin technique to make it possible to detach the pin from the cast . They utilized a sheath and a pin that fit in it. The procedure of recording the tilt was the same as the cemented pin technique by making a slot for the sheath in the cast. After surveying, the sheath was inserted in the pin, then lowered in the perforation in the cast and fixed in place by pouring dental stone around it. This was then allowed to set, and hence a detachable pin for the model was obtained. The reorientation was easy as the pin needed to be implanted in the cast sleeve.

Dumbrigue and Chingbingyoung in 2003[24] used a "cast angle tool (CAT)" that measured the tilt of the cast . The ventral surface of the CAT was layered with vinyl polysiloxane putty material and was placed on the occlusal surface of the cast to form indentations on the putty. The CAT would indicate the value of the tilt in degrees in both sagittal and frontal planes with a preciseness of 1°. This tilt could be then noted down for each patient, and then the cast could be adjusted till the value noted is indicated in the CAT hence, reproducing the cast tilt.

In 2006, Sajjan[25] gave a "tripoder attachment" that had three graduated pointers that could be vertically adjusted and sleeves that could horizontally move along the track given and locked at any height by the thumb screw . Assembly affixed to the central shaft with blades that also allowed rotation around it. This shaft would then fit in the surveying arm. The height of the pointers could be changed, and the change was noted due to the presence of graduated markings. These pointers represented three reference points on the cast. The use of markings on the tool could be recorded for a cast and enabled the accurate repositioning of the graduated arms on the cast.

Kamble et al in 2013[26] gave an innovation in which they used a magnetic device (cobalt-samarium magnets) secured in place with two brass keepers at both ends using a nut and bolt . The diameter of the magnets and brass keepers was kept the same at 30 mm. Two units of this

assembly were prepared; the end of one of the bolts was ground to form a point, and in the other bolt, a hole was drilled to receive the straight handpiece mandrel. Surveying was implemented in the usual manner and a hole of 8×8×4 mm was made in the cast base. The assembly with the mandrel was then attached to the surveyor and the other end to the cast. Dental plaster was used to fix this magnet-containing assembly. This construction could be easily detached with a pull and reoriented by simply bringing the cast near a magnet.

Shakibamehr et al in 2013[27] gave a technique utilizing auto-polymerized acrylic resin . He manipulated the resin till it reached the dough stage. He then obtained a 2 mm thickness for the resin using a glass slab. The occlusal surfaces of the teeth were lubricated using petroleum jelly, and it was placed on the resin sheet. The resin was now inscribed with the indentations of the teeth. On the opposite surface of this sheet, a bulk of resin was placed, and a lubricated analyzing rod was lowered into it. For reorientation, the indentations were matched with the cast, and the analyzing rod was placed in the index.

Kamble and Parkhedkar in 2014[28] suggested another device containing a "dowel pin and sleeve" that was also a modified version of the cemented pin method . A hole of 6×6×4 mm dimension was created in the center between the alveolar ridges such that it did not cause any interference with the framework. The dowel sleeve device was assembled and locked in the surveying mandrel. This dowel pin is then brought down to fit in the made perforation. The perforation was wetted, and type III gypsum was poured around the sleeve. After setting, the dowel pin could be removed and replaced for reorientation.

Savabi and Shirban in 2015[29] graded the surveyor spindle in millimeters till it covered the whole spindle . They then fabricated a device consisting of one long strip with seven holes and two short narrow strips with five holes attached to a central handpiece mandrel. A screw and nut were attached to the end of each strip. These screws were to be adjusted in the order of the short strips first simultaneously and later the third screw in a way that they contacted three marked points on the cast . The surveyor spindle reading was noted, and the bolts held the screws in place.

Patil et al. in 2016[30] gave another method of customized registration of tilt of casts using silicone putty impression material on the surveyor tool . He surveyed the cast as usual, then attached an analyzing rod to the vertical arm and moved its tip within a 5 mm range of the selected tooth that he preferred to rather be in the corner of the arch. Condensation silicone of putty consistency was mixed and adapted on the cast to cover at least five teeth extending to the marginal gingiva and 15 mm of the analyzing rod. This increases the reliance on the qualities of the imprint material for tilt reproduction accuracy.

Afsal et al. in 2017[31] used a worn diamond disk for the tripoding record . The conventional procedure was carried out for surveying, and the worn diamond disk was placed at an adequate distance in the middle of the cast. A putty indentation was made, keeping out the anteriors and the occlusal surface of the posteriors. The index was allowed to be set after the excess was removed. For reorientation, the putty index-diamond disk construction was installed in the vertical arm. This strategy allowed for a clearer view of the index's indentations, which sped up the tripoding process. The drawback of this modification remains the same as in Dumbrigue's, Ansari's, and Patil's methods.

Lee et al. in 2017[32] utilized the implant impression coping and implant analog for tripoding . He selected the posterior aspect of the cast to prepare an upright groove by a tungsten carbide bur. Dimensions of the groove were made to be 10 mm deep and 20 mm long. He then connected the implant analog to a short and direct impression coping employing a long retaining screw. This retaining screw entered the vertical arm after the traditional surveying. The implant analog fit in the groove was stabilized in place using a thermoplastic adhesive (sticky wax) in a heat gun . The duplication of the cast was also simplified by simply replacing the direct transfer impression coping with the indirect transfer coping. This duplication was carried out using polyvinyl siloxane duplicating material after the reseating of the coping analog. This was then poured in a die stone (type IV gypsum). The reseating of the coping will transfers the cast orientation. The retaining screw goes in the surveyor's arm hence reproducing the cast tilt. This is the clearest and most straightforward of all the approaches.

Gali et al. in 2019[33] built a "three-point contacting device" out of triangular metal plates with a 3 mm thickness and a 5 mm diameter center aperture . A detachable Allen screw fit in this aperture. These plates were classified into sizes of the sides of the triangle 25 mm, 30 mm, 35 mm, 40 mm, and 45 mm. These measurements are based on averages of distances measured between the incisal edges and cusp points on several casts. This enabled the accommodation of arches of various sizes. The corners of the plate will correspond to the posterior and anterior reference points, and the plate itself will form the reference plane. A lead marker marked these points on the cast. For re-registration of the tilt, the cast had to be adjusted till the three points contacted the triangle plate. Even if the construction of the device could prove to be a task, the plus points embodied in the device are noteworthy.

HISTORY OF SURVEYOR

Before the invention of the dental surveyor, dentists evaluated axial contours and undercuts of teeth by visual survey of dental casts.[2] This was accomplished by holding a cast at arms length while viewing it with one eye closed. Then, using the other hand to hold a sharp pencil perpendicular to the occlusal plane, the practitioner would pass a pencil lead over the axial surfaces of the teeth to develop a survey line at the greatest diameter of each tooth (Fig 1)

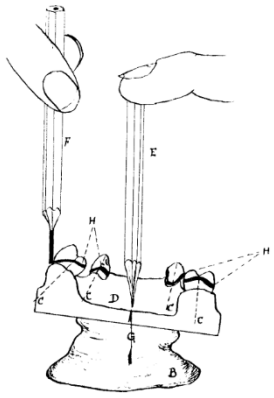


FIG 1

Paralleling devices were in use long before the development of the dental surveyor. Their purpose was to assure the proper alignment of precision attachments. None of these, however, was used to survey casts as a basis for removable partial denture design[3].

Around 1920, Dr. Chayes developed the Parallelometer (Figs 2A and B).[4] This instrument could be used both intraorally and at the laboratory bench to ensure parallelism of precision attachments. The instrument also could be used to identify non-parallel and/or undercut surfaces of prepared teeth.

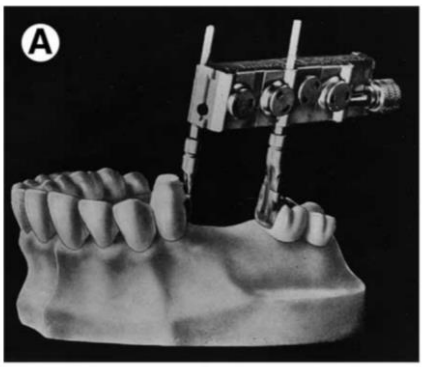


FIG 2

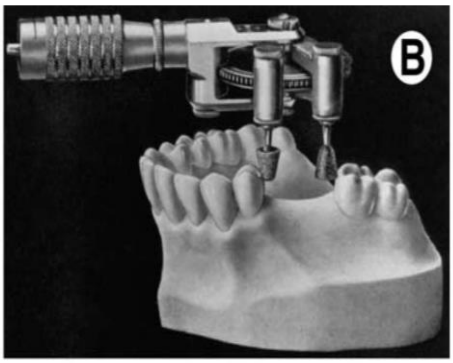


FIG 2

THE FIRST DENTAL SURVEYOR

In 1918, Dr A J Fortunati replaced the steel analyzing rod of a "Bridge Parallelometer" with a graphite rod, then accurately traced survey lines of the greatest convexities of the teeth. Dr. Kennedy was later credited with coining the term "height of contour" to refer to these lines.[5]

W. E. Cummer[6] reported that the technique of surveying casts was developed over a period of "some years" by the Philadelphia Dental Clinic Club. The Philadelphia Dental Clinic Club originally developed the Robinson Surveyor (Fig 3A). This instrument was probably the first surveyor designed as an instrument for removable partial denture planning.

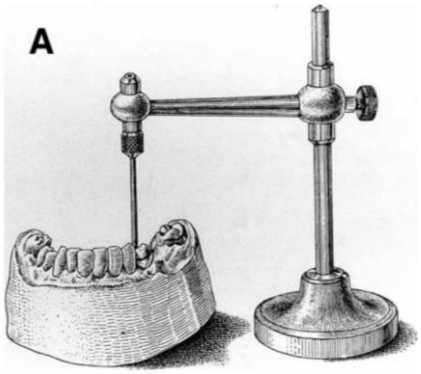
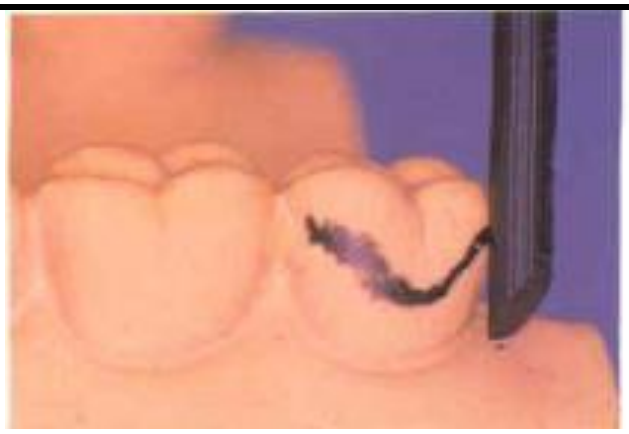


FIG 3

The first dental surveyor was commercially available in 1923. The features of a basic dental surveyor include

1. A level platform, parallel to the bench top.



2. A cast holder, which supports the cast to be analyzed and is free to move across the platform. It includes a clamp to hold the cast firmly in place and a ball-and-socket joint between the table and base.
3. A vertical arm that supports the suprastructure of the surveyor.
4. A horizontal arm that usually is parallel to the horizontal platform, and perpendicular to the vertical and surveying arms, which it connects.
5. A surveying arm that drops vertically from the horizontal arm and that is capable of vertical movement. Its lower end has a mandrel capable of holding surveying tools.
6. Interchangeable surveying tools including an analyzing rod, carbon marker, undercut gauges, and blockout tools.

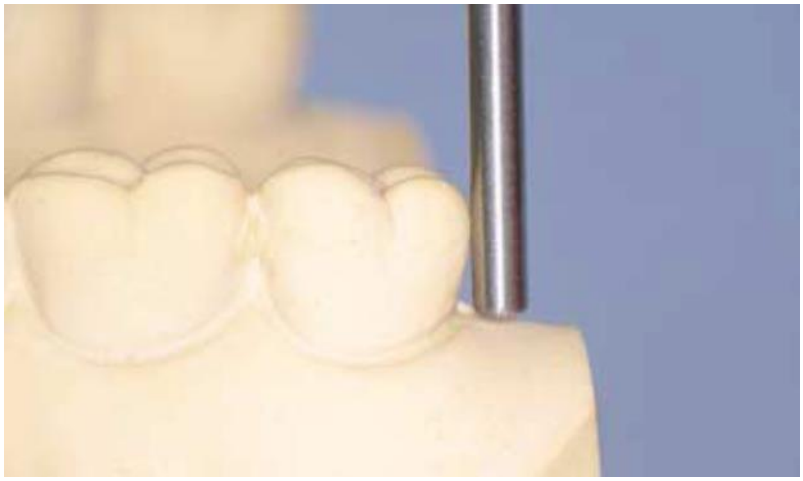


FIG 4 **Analysing rod** *This metal rod is placed against the teeth and ridges during the initial analysis of the cast to identify undercut areas and to determine the parallelism of surfaces without marking the cast*

FIG 5 **Graphite marker** *The graphite marker is moved around the tooth and along the alveolar ridge to identify and mark the position of maximum convexity (survey line) separating non-undercut from undercut areas. When surveying a tooth, the tip of the marker should be level with the gingival margin allowing the side of the marker to produce the survey line*

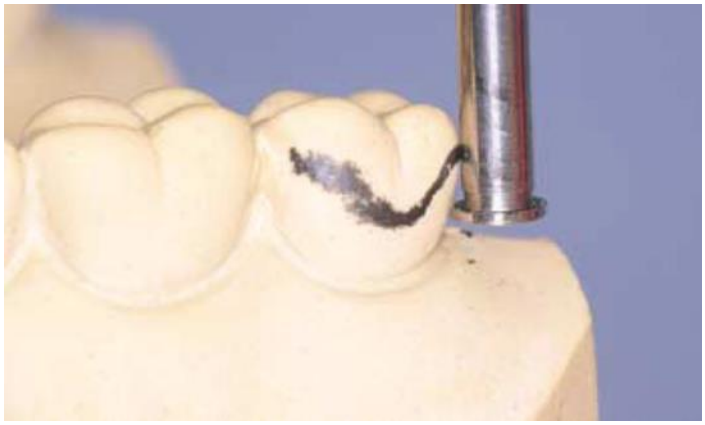


FIG 6 **Undercut gauge** *Gauges are provided to measure the extent of horizontal undercut and are available in the following sizes: 0.25 mm, 0.50 mm and 0.75 mm. By adjusting the vertical position of the gauge until the shank and head contact the cast simultaneously, the point at which a specific extent of horizontal undercut occurs can be identified and marked.*

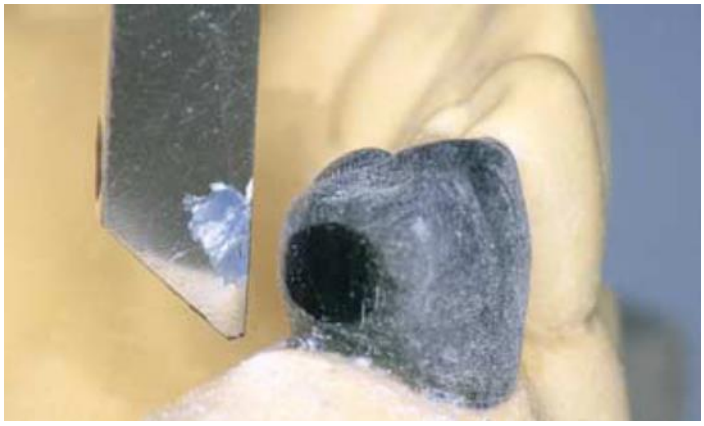


FIG 7 **Trimming knife** *This instrument is used to eliminate unwanted undercuts on the master cast. Wax is added to these unwanted undercut areas and then the excess is removed with the trimmer so that the modified surfaces are parallel to the chosen path of insertion*

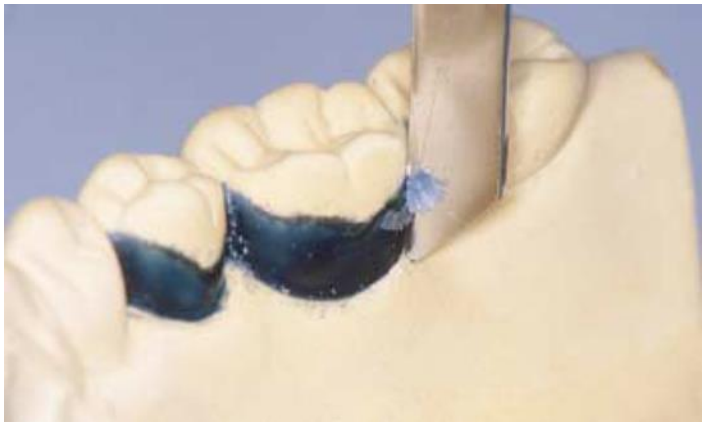


FIG 8 *The trimming knife can also be used to prepare guide surfaces on wax patterns of crowns for abutment teeth*

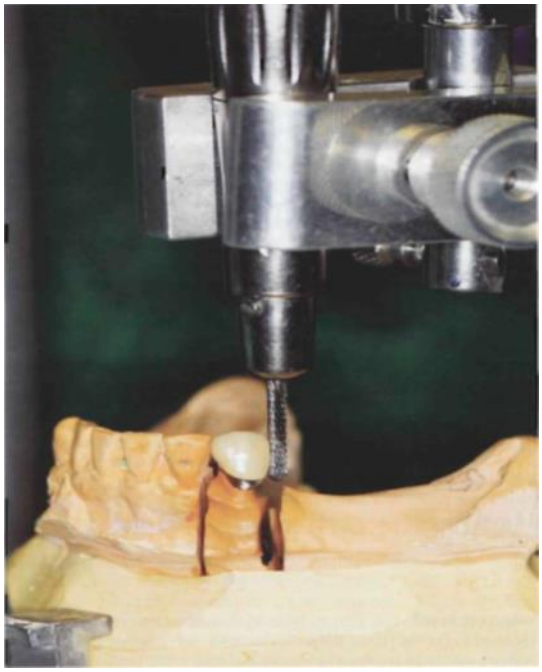


FIG 9 *Handpiece holders attach to the vertical spindle of surveyors and may be used to create and refine any parallel surface on a surveyed crown, as a drill press to prepare internal rests and recesses in patterns and/or castings, and to establish lingual surfaces above ledge, which are parallel to path of placement in abutment restorations.*

Improvements to the basic dental surveyor included the addition of a small light to better illuminate the cast and surveying tools and multiple surveying arms to save time when changing surveying tools. Also added were easy-to-read dial undercut gauges, handpieces for accurately preparing guiding planes, and electrical components to heat the blockout waxing tools.[7,8]

Broken arm surveyor

The broken arm not only facilitated surveying, but also allowed the surveyor to function as a milling machine through the adaptation of a straight handpiece to the surveying arm.[9](FIG 10)

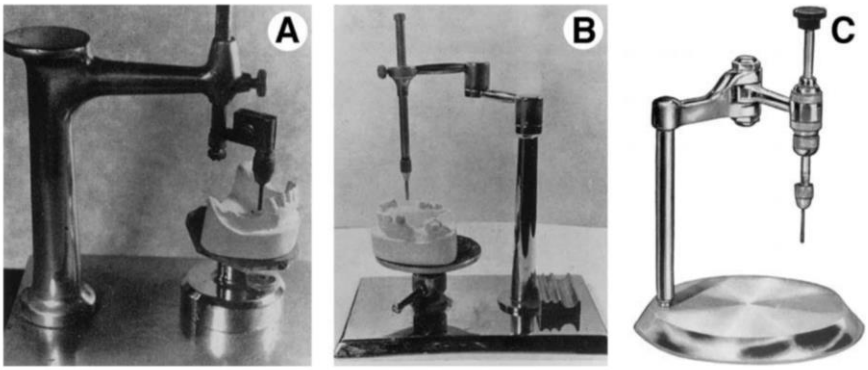


FIG 10

Blocking instruments

Using a pendulum surveyor was a novel approach to this process.This device had a surveying arm at least 3 feet long that could pivot at some predetermined point well above the cast holder (Fig 11). Hence the operator could move the surveying arm laterally, heat the attached waxing instrument in an open flame, and then return the apparatus to the master cast. At this stage, the heated waxing instrument could be used to shape and trim the blockout wax. Because the angle of the blockout was inversely proportional to the length of the surveying arm, the degree of blockout could be controlled by adjusting the arm length.

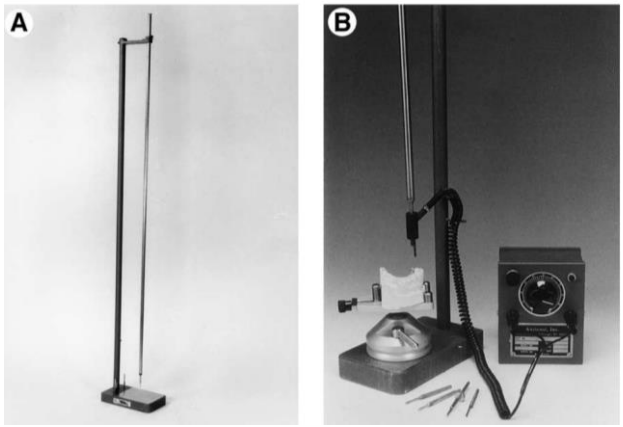


FIG 11

Milling machines

Developed for precision attachment applications, these instruments ensure the parallelism of guiding planes milled into castings

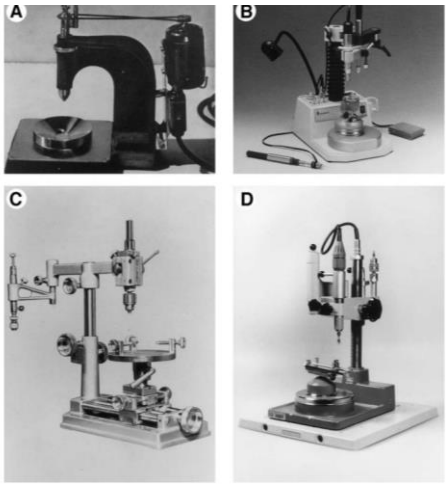
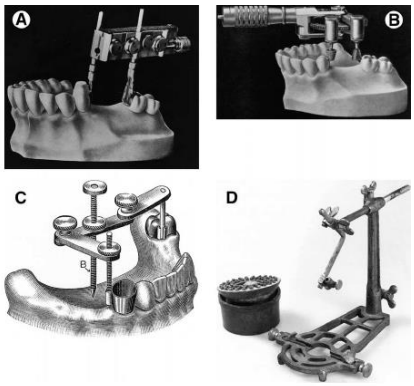


FIG 12

(A) The Chayes milling machine, an early example of this class of instruments. (B) The Austenal precision milling machine. (C) The Galloni Isoparallelometer with a cross-table, a finely made precision milling machine.(D) The Kavo precision dental milling machine.

EARLY PARALLELING DEVICES

(A) The Chayes Parallelometer (circa 1920) was not a surveying instrument. It was intended to ensure the parallelism of the Chayes precision attachment system.



(B) The Chayes Parallelometer System included a handpiece that could prepare 2 surfaces simultaneously.

(C) This paralleling device was used with Dr. A. S. Condit's system for anchoring removable partial dentures by means of tube attachments late 19th century.

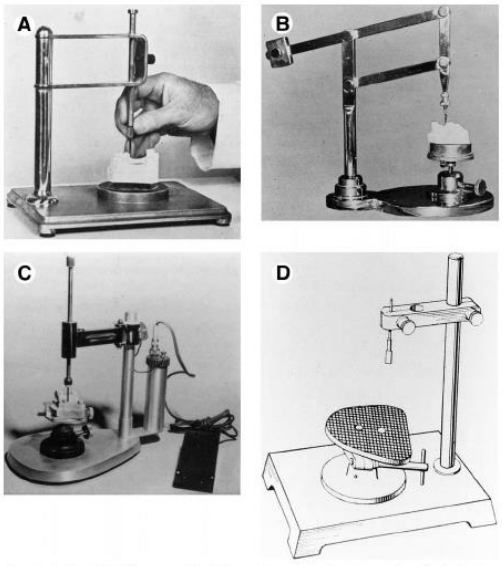
(D) This paralleling device was the soldering jig for the Griswold attachment system. An unknown individual later converted it into a dental surveyor by adding the ingenious adjustable cast holder. The stage could be tilted in any direction then fixed to the base with modeling clay.

A. The original Ney surveyor was introduced in 1923. It featured a convenient palm rest on the top of the vertical arm. Designed by Weinstein and Roth, it was the first surveyor to be commercially available to the profession.

B. The current model of the Ney surveyor was introduced in 1937. In principle, it is identical to its predecessor

(A) Developed by Noble G. Wills, this instrument was known as the Wills surveyor (circa 1937). It was the original surveyor marketed by the J. F. Jelenko Company and was preferred by many operators because of the spring-loaded surveying arm.

(B) Though no longer in production, the most recent design for the Jelenko surveyor still retained the spring-loaded surveying arm.



(A) The Original Wills surveyor (circa 1929) appears in a number of texts. It was marketed by Kerr Products of Detroit, MI. It came both with and without a work light and has been pictured with several different designs of cast holders. In this example, the cast is held in place with wax.

(B) The Kings College surveyor (circa 1940) had an adjustable cast holder and interesting parallel, pivoting, horizontal arms. It also featured a powerful magnet in the tilting table. The cast had an iron ring imbedded in its base, so there was no need for a fixing agent.

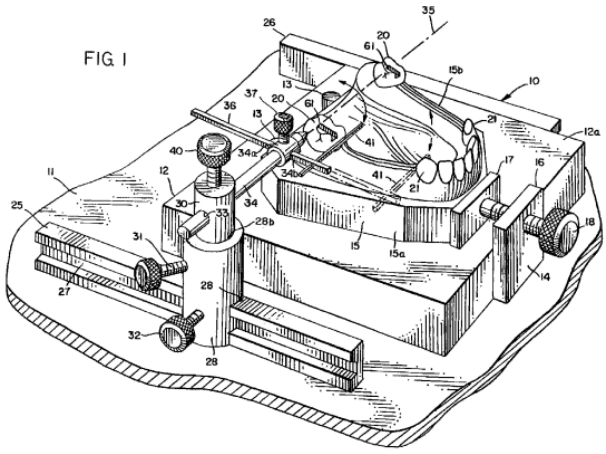
(C) This electronic surveyor, developed at the United States Air Force School of Aviation Medicine at Randolph Air Force Base, TX (circa 1958), was powered by dry cell batteries and was capable of passing a weak current through the surveying tool to the cast surface. Casts were treated with phenolphthalein, and contact with the surveying tool produced a fine, red survey line.

(D) The Columbia Parallelor (circa 1940) was very similar to the Ney surveyor. This company was bought out by another manufacturer who produced the Brown-Maier Parallel-meter, which had 2 operating arms on a swivel joint.

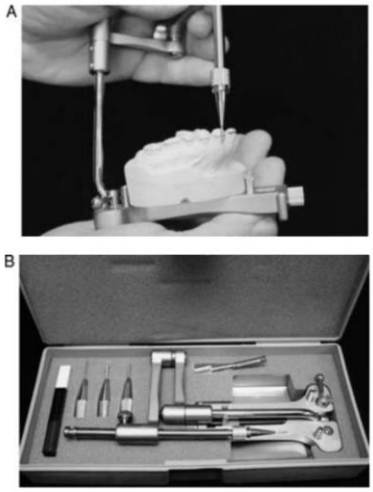
(A) The Roach surveyor, developed in 1944, was marketed by the Kerr Manufacturing Company. This may have been the smallest surveyor ever developed. The cast holder was fixed to the base, but the table could freely rotate through 360°. The horizontal arm was free to rotate 360° as well as to move vertically on the vertical arm. (From the author's collection.) (B)

At least one South American text shows the "Dee" Surveyor that was actually the Roach Surveyor produced under the manufacturer's name (ie, the Dee Company was a subsidiary of Kerr Manufacturing Company). An interesting modification of the Roach surveyor (circa 1950) is that of Dr. A. D. Rebossio of Argentina. He removed the vertical and horizontal arms from the Roach/Dee Surveyor, leaving only the rotating table/cast holder. He then used this as a cast holder on a full sized, basic surveyor similar to the Ney or Columbia surveyors.

M. Michael Salib of Inverness, Illinois designed an ingenious cast holder to facilitate surveying casts for dual paths of insertion



The Microsurveyor Compass from Japan is a small hand-held surveyor. It establishes the path of insertion by tilting its vertical arm rather than its cast holder. The Microsurveyor collapses for handy storage in a case that could fit into a lab coat pocket. This concept certainly makes surveying more convenient



Electronic Surveying

Electronic surveying of a scanned cast enables a pattern for a metal framework to be fabricated on the computer screen. The program defined the surface area of teeth apical to the survey line by identifying the downward facing triangles. The upper boundary of this area defined the survey line

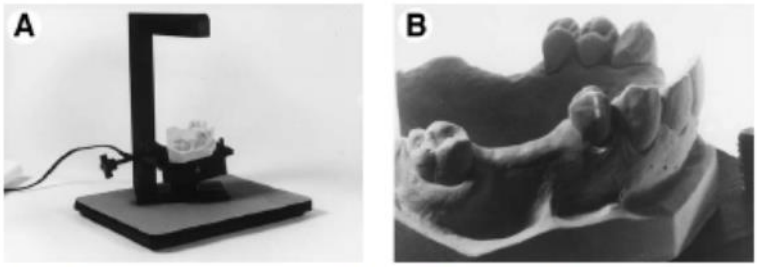


Figure 10. (*A*) A prototype surveyor made by Intra-Tek, Dallas, TX. A beam of laser light projects vertically downward from the distal end of the horizontal arm to serve as the surveying arm. Although this instrument does not produce a visible "survey line" at the height of contour of the teeth, it does dramatically expose undercut areas. (Courtesy of Dr. Mark Connelly.) (*B*) The laser light is visible only above the height of the contour, whereas the undercut below the height of the contour is cast in a dark shadow.

TECHNIQUE

3-D surface capture

1. Obtain a 3-D computer model of a cast of a patient using an optical surface capture device (Comet 250 scanner; Steinbichler Optotechnik GmbH, Neubeuern, Germany).

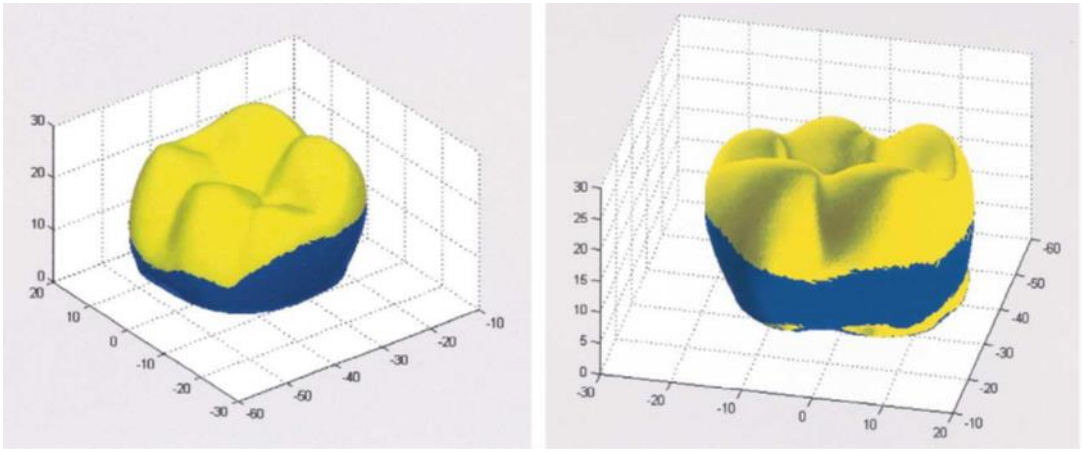
2. Align and combine the data points from each of these scans using CAD software (Polyworks; InnovMetric Software Inc, Sainte-Foy, Quebec, Canada) to provide a single coherent data set of the entire object. Use the resultant data points (termed a "point cloud") to create a 3-D surface model.

3. Produce a solid 3-D computer model on screen using a triangular-faceted polygon mesh (EvalViewer; Alias-Wavefront Inc, Toronto, Canada).

3-D computer-aided design [35]

Electronically survey the scan using the MatLab software package described previously. The depth of undercut can be copied from the definitive cast to determine clasp termination. Model the shape of the components of a removable partial denture framework on the scanned surface model using 3-dimensional CAD software (Surface Studio; Alias-Wavefront, Inc). Use an RP (stereolithography) machine (SLA 250/ 40; 3D Systems Inc, Valencia, Calif) to produce a plastic (WaterClear 10110 Epoxy Resin for Stereolithography; DSM Somos, New Castle, Del)

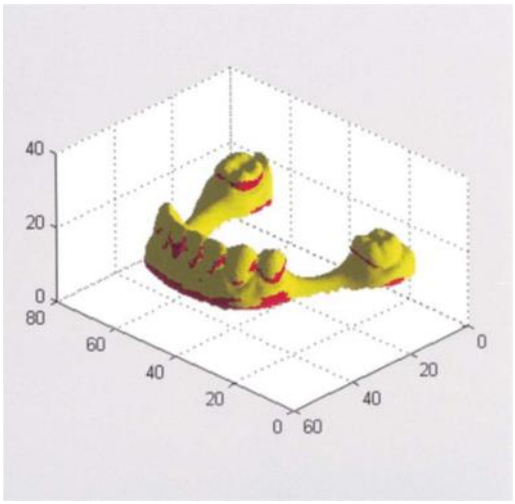
physical model of the components described above. Use RP (rapid prototyping) processes to create a sacrificial pattern of a removable partial denture framework, to be incorporated directlyinto existing casting procedures found in the typical dental laboratory



A B

A, Program used to identify survey line on 3-D scan of model of large tooth—distobuccal view.

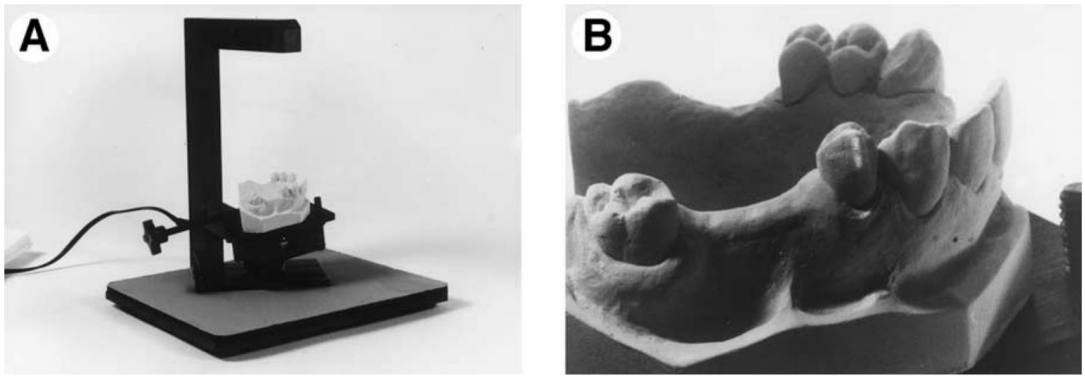
B, Lingual view of electronically surveyed tooth shown in A



Undercuts electronically identified on surveyed cast

Recent innovations

A recently designed surveyor dramatically exposes undercut areas by projecting a beam of laser light

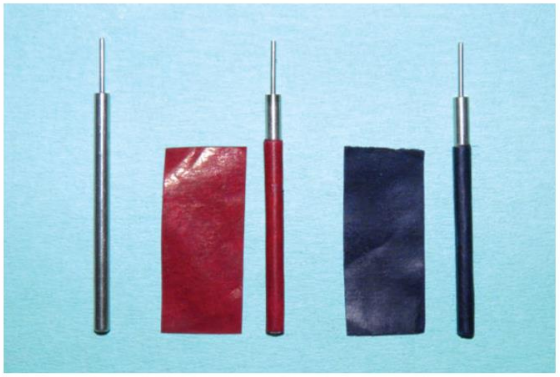


The laser light is visible only above the height of the contour, whereas the undercut below the height of the contour is cast in a dark shadow

- The Da Vinci distinguishes by its dual, multi-jointed arm design, allowing the user to effortlessly switch between the primary milling, drilling arm and the secondary tapping, surveying arm.
- Also featuring a Motor/Module designed to facilitating simultaneous horizontal and vertical milling and enhanced stent drilling capability.
- Unit includes high torque variable speed motor, six collets accepting assorted burs (friction grip, handpiece, 3mm and Ferraro burs), sample; milling fluid, milling wax, metal and wax milling burs. Its dual milling mode allows traditional milling on the master model or on an analogue (transfer) model. Additional features included a surveyor style platform that facilitates analogue model milling as well as traditional surveying.

Two-Colored Dental Surveying Tool as an Alternative for Carbon Marker[34]

A piece of blue and red articulating paper is rolled to the long axis of the analysing rod. The modified surveying tool is attached upside down on the vertical arm of the surveyor and the survey lines are marked before and after tilting the cast with red and blue rod respectively.



Analyzing the rod and articulating paper to make the modified surveying tool.

1 is analyzing rod, 2 and 4 are articulating papers, 3 and 5 are modified surveying tools.

A. Marking the survey line with the red tool. B. Marking the survey line with the blue tool.

PARTS OF NEY SURVEYOR

1.Platform on which the base is moved[10]

2. Vertical arm that supports the superstructure

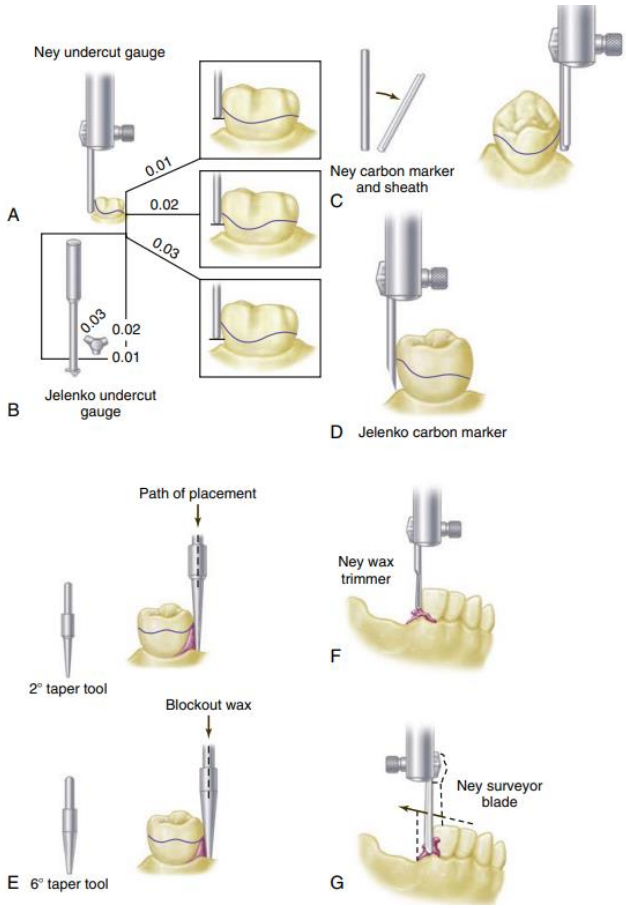
3. Horizontal arm from which the surveying tool suspends

4. Table to which the cast is attached

5. Base on which the table swivels

6. Paralleling tool or guideline marker (This tool contacts the convex surface to be studied in a tangential manner; the relative parallelism of one surface to another may thus be determined; with substitution of a carbon marker, the height of contour may be delineated on the surfaces of the abutment teeth and on areas of interference requiring reduction on blockout.)

7. Mandrel for holding special tools



Various tools used for dental surveyor

Various tools that are used with dental surveyors

A. Ney undercut gauges.

B. Jelenko undercut gauge.

C. Ney carbon marker with metal reinforcement sheath.

D. Jelenko carbon marker.

E. Tapered tools, 2- and 6-degree, tor trimming blockout when some nonparallelism is desired.

F. Ney wax trimmer for paralleling blockout. G, Surveying blade being used for trimming blockout.

The most widely used surveyors are the Ney and the Jelenko

Difference between Ney's surveyor and Jelenko

S.No	**Jelenko**	**Ney**
1.	Undercut gauge is of a special type which have 3 sizes in the same rod	3 separate sizes
2.	Holding of tools by spring load	Holding by friction
3.	Loosening the nut at the top of the vertical arm, the horizontal arm may be made to swivel.	The horizontal arm is fixed

PURPOSES OF SURVEYOR

PURPOSES OF SURVEYOR

The surveyor may be used for

- Surveying the diagnostic cast,
- Recontouring abutment teeth on the diagnostic cast,
- Contouring wax patterns,
- Measuring a specific depth of undercut,
- Surveying ceramic veneer crowns,
- Placing intracoronal retainers,
- Placing internal rests,
- Machining cast restorations, and
- Surveying and blocking out the master cast

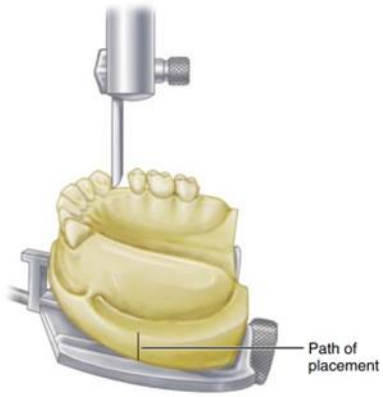
Surveying the Diagnostic Cast

Surveying the diagnostic cast is essential to effective diagnosis and treatment planning. The objectives are as follows:

1. To determine the most desirable path of placement that will eliminate or minimize interference to placement and removal.

   The path of placement is the direction in which a restoration moves from the point of initial contact of its rigid parts with the supporting teeth to its terminal resting position, with rests seated and the denture base in contact with the tissue.

   The path of removal is the direction of restoration movement from its terminal resting position to the last contact of its rigid parts with the supporting teeth. When the restoration is properly designed to have positive guiding planes, the patient may place and remove the restoration with ease in only one direction. This is possible only because of the guiding influence of tooth surfaces (guiding planes) made parallel to that path of placement.



Tilt of the cast on the adjustable table of a surveyor in relation to the vertical arm establishes the path of placement and removal that the removable partial denture will take. All mouth preparations must be made to conform to this determined path of placement, which has been recorded by scoring the base of the cast or by tripoding

2. To identify proximal tooth surfaces that are, or need to be, made parallel so that they act as guiding planes during placement and removal.

3. To locate and measure areas of the teeth that may be used for retention.

4. To determine whether tooth and bony areas of interference will need to be eliminated surgically or by selecting a different path of placement.

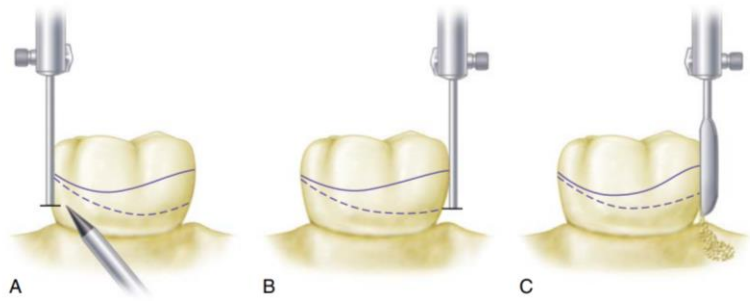
5. To determine the most suitable path of placement that will permit locating retainers and artificial teeth to the best esthetic advantage.

6. To permit an accurate charting of the mouth preparation to be made. This includes the preparation of proximal tooth surfaces to provide guiding planes and the reduction of excessive tooth contours to eliminate interference and to permit a more acceptable location of reciprocal and retentive clasp arms. By marking these areas on the diagnostic cast in red, using an undercut gauge to estimate the amount of tooth structure that may safely (without exposing dentin) be removed, and then trimming

the marked areas on the stone cast with the surveyor blade, the angulation and extent of tooth reduction may be established before preparing the teeth in the mouth. With the diagnostic cast on the surveyor at the time of mouth preparation, reduction of tooth contours may be accomplished with acceptable accuracy.

7. To delineate the height of contour on abutment teeth and to locate areas of undesirable tooth undercut those are to be avoided, eliminated, or blocked out. This will include areas of the teeth to be contacted by rigid connectors, the location of non retentive reciprocal and stabilizing arms, and the location of retentive clasp terminals.

8. To record the cast position in relation to the selected path of placement for future reference. This may be done by locating three dots or parallel lines on the cast, thus establishing the horizontal plane in relation to the vertical arm of the surveyor.



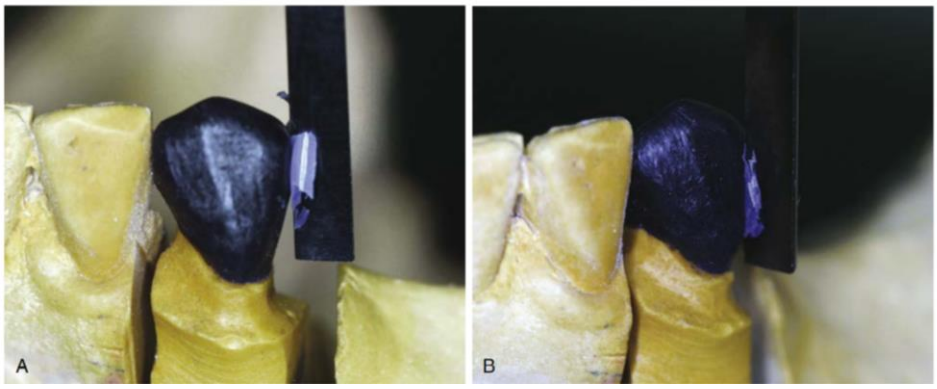
A, *Solid line represents the height of contour on the abutment at selected orientation of the diagnostic cast to the vertical spindle of the surveyor. Dotted line represents the desirable height of the contour for optimally locating components of the direct retainer assembly. A 0.01-inch (0.25-mm) undercut gauge is used to mark the location of the tip of the retentive arm of the direct retainer.* ***B****, By reducing the axial contour of the tooth by only 0.01 inch, the optimum height of contour can be achieved without exposing the dentin.* ***C****, Stone tooth is trimmed with a surveyor blade to the desired height of contour. The trimmed area is marked in red pencil and serves as a blueprint for similar recontouring in the mouth. If one can safely assume that the enamel is 1 to 1.5 mm thick in the area of contemplated reduction, only 0.25 mm of enamel needs to be removed to achieve the optimum height of contour.*

Contouring Wax Patterns

The surveyor blade is used as a wax carver during this phase of mouth preparation so that the proposed path of placement may be maintained throughout the preparation of cast restorations for abutment teeth.

1. Guiding planes on all proximal surfaces of wax patterns adjacent to edentulous areas should be made parallel to the previously determined path of placement.
2. Similarly, all other tooth contours that will be contacted by rigid components should be made parallel.
3. The surfaces of restorations on which reciprocal and stabilizing components will be placed should be contoured to permit their location well below occlusal surfaces and on non retentive areas.

Generally, a small amount of undercut from 0. 01 to 0. 02 inch (0. 25-0. 50) or less is sufficient for retentive purposes



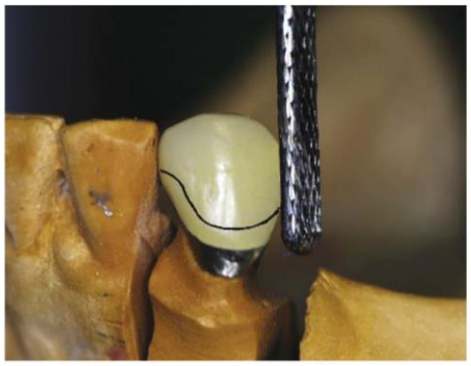
After the cast has been oriented to the surveyor at the predetermined path of placement, designated axial surfaces of the wax pattern are altered with the surveyor blade to meet specific requirements for placement of framework components. ***A****, Wax pattern is carved with the surveyor blade to produce a distal guide-plane surface parallel to the selected path of insertion.* ***B****, The same pattern is modified from the distal guide plane along the buccal surface to align the surface with the height of contour most favorable to the direct retainer specifications*

Surveying Ceramic Veneer Crowns

Ceramic veneer crowns are often used to restore abutment teeth on which extra coronal direct retainers will be placed.

The surveyor is used to contour all areas of the wax pattern for the veneer crown except the buccal or labial surface. The ceramic veneer portion cannot be fabricated exactly to the form required for the planned placement of retentive clasp arms without some reshaping with stones.

Before the final glaze is accomplished, the abutment crowns should be returned to the surveyor on a full-arch cast to ensure the correct contour of the veneered portions or to locate those areas that need recontouring. The final glaze is accomplished only after the crowns have been recontoured.



Resultant metal-ceramic surveyed crown , which is being refined to maintain the distal guide plane and buccal height of the contour previously designed. Final glaze has not been placed on the veneer crown and required alterations of surfaces to conform to ideal placement of the retainer (solid line) can be performed by machining. Final glaze is produced only after necessary recontouring is accomplished

Placement of Intracoronal Retainers (Internal Attachments)

In the placement of intracoronal retainers, the surveyor is used as follows:

1. To select a path of placement in relation to the long axes of the abutment teeth that will avoid areas of interference elsewhere in the arch
2. To cut recesses in the stone teeth on the diagnostic cast for estimating the proximity of the recess to the pulp (used in conjunction with roentgenographic information to estimate pulp size and location) and to facilitate the fabrication of metal or resin jigs to guide the preparations of the recesses in the mouth.
3. To carve recesses in wax patterns, to place internal attachment trays in wax patterns, or to cut recesses in castings with the handpiece holder (whichever method is preferred).

To place the keyway portion of the attachment in the casting before investing and soldering each keyway must be located parallel to the other keyways elsewhere in the arch.

Placement of Internal Rest Seats

The surveyor may be used as a drill press, with a dental handpiece attached to the vertical arm by a handpiece holder.

Internal rest seats are carved in the wax patterns and refined with the handpiece after casting, or the entire rest seat may be cut in the cast restoration with the handpiece. It is best to carve the outline form of the rest seat in wax and refine the casting with the handpiece.

An internal rest is waxed and cast to fit into the rest seat and an internal attachment is a matched key and keyway attachment.

The internal rest provides a positive occlusal support that is more favorably located in relation to the rotational axis of the abutment tooth than the conventional spoon-shaped occlusal rest. It also provides horizontal stabilization through the parallelism of the vertical walls, thereby serving the same purpose as stabilizing and reciprocal arms placed extra coronally. They are not indicated in distal extension cases as more torque may be applied to the abutment tooth . The ball-and-socket, spoon-shaped occlusal, or noninterlocking rest should be used in distal extension partial denture designs.

The use of the dovetailed or interlocking internal rest is limited to tooth-supported removable restorations, except when it is used in conjunction with some kind of stress-breaker between the abutments and the movable base.
Internal rest seats may be made in the form of a non-retentive box, a retentive box fashioned after the internal attachment, or a semi-retentive box. In the latter, the walls are usually parallel and non-retentive, but a recess on the floor of the box prevents the male portion's proximal movement.

Internal rest seats are cut with dental burs of various sizes and shapes. Tapered or cylindrical fissure burs are used to form the vertical walls, and small round burs are used to cut recesses in the floor of the rest seat.

Machining Cast Restorations

With a handpiece holder and a suitable cylindrical carborundum point the axial surface of cast and ceramic restorations can be refined. Proximal surfaces of crowns and inlays, which will serve as guiding planes, and vertical surfaces above crown ledges may be improved by machining, but only if the relationship of one crown to another is correct. Cast restorations should first be tried in the mouth and then transferred by means of a plaster or acrylic resin index impression to a reinforced stone cast for machining purposes. The new cast is then positioned on the surveyor, in compliance with the path of placement of the partial denture, and vertical surfaces are machined with a true-running cylindrical carborundum point.

Although machined parallelism might be seen as ideal and outside the scope of practical application, its benefits outweigh the additional processes needed to achieve it. The usage of these parallel guiding plane surfaces must be the focus of all following laboratory procedures after such parallelism has been achieved and replicated in a master cast.

Lab Handpiece Clamp. Handpiece holders attach to the vertical spindle of surveyors and may be used to create and refine any parallel surface on a surveyed crown, as a drill press to prepare internal rests and recesses in patterns and/or castings, and to establish lingual surfaces above the ledge that are parallel to the path of placement in abutment restorations.

Surveying the Master Cast

Because surveying the master cast follows mouth preparation, the path of placement, the location of retentive areas, and the location of remaining interference must be known before proceeding with the final design of the denture framework.

The objectives of surveying the master cast are as follows:

1. To select the most suitable path of placement by following mouth preparations that satisfy the requirements of guiding planes, retention, noninterference, and esthetics.

2. To make it possible to measure retentive areas and locate clasp terminals in relation to the flexibility of the clasp arm being used; flexibility will depend on a number of factors, including the alloy used for the clasp, its design and type, whether it has a round or half-round shape, whether it is made of cast or wrought material, and the length of the clasp arm from its point of origin to its terminal end; retention will then depend on

   (a) the flexibility of the clasp arm,

SURVEY LINES

- A line produced on a cast by a surveyor marking the greatest prominence of contour in relation to the planned path of placement of a restoration
- Typical:

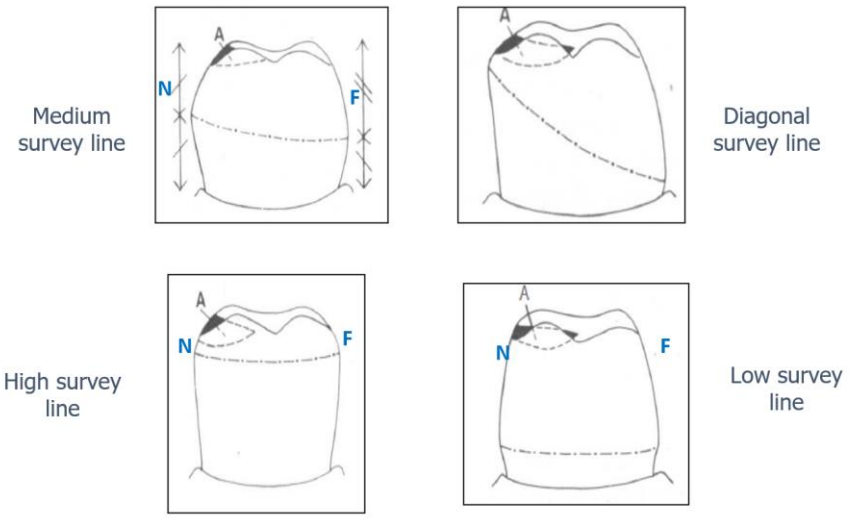
  Medium Survey Line

- Atypical:

  (A)Diagonal Survey Line

  (B)High survey Line

  (C)Low Survey line



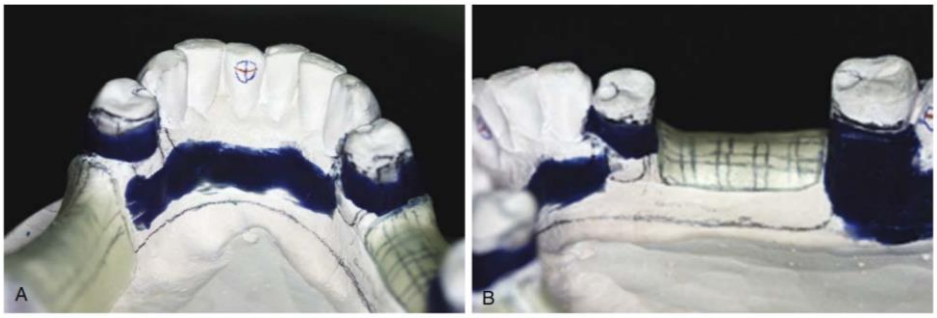
(b) the magnitude of the tooth undercut, and
(c) the depth the clasp terminal is placed into this undercut.

3. To locate undesirable undercut areas that will be crossed by rigid parts of the restoration during placement and removal; these must be eliminated by blockout.

4. To trim blockout material parallel to the path of placement before duplication.

The partial denture must be designed so that

- It will not stress abutment teeth beyond their physiologic tolerance;
- It can be easily placed and removed by the patient;
- It will be retained against reasonable dislodging forces; and
- It will not create an unfavorable appearance. It is necessary that the diagnostic cast be surveyed with these principles in mind. Mouth preparation should therefore be planned in accordance with certain factors that will influence the path of placement and removal



Master casts are modified by the addition of wax relief to nonbearing regions and by placement of blockout wax parallel to the path of insertion at regions beneath the height of contour where framework contact is not planned (i.e., all areas except retentive clasp tips). A, Blockout wax is provided for tooth contours beneath the height of contour on teeth #21 and #28. B, Similar blockout was accomplished for mandibular molar #31. Blockout is carved with a straight surveyor blade to ensure parallelism with the identified path of insertion

FACTORS THAT DETERMINE PATH OF PALCEMENT AND REMOVAL

FACTORS THAT DETERMINE PATH OF PLACEMENT AND REMOVAL

The factors that determine the path of placement and removal are guiding planes, retentive areas, interference, and esthetics. Additionally, if an implant is part of the design its long axis is considered in relation to the path or placement and removal

Guiding Planes

Proximal tooth surfaces that bear a parallel relationship to one another must either be found or be created to act as guiding planes during placement & prosthesis. Guiding planes are also necessary to ensure predictable clasp retention. Helps the patient to place & remove the denture easily without strain on the teeth contacted or on the denture itself and without damage to the underlying soft tissues

Retentive Areas

Retentive areas must exist for a given path of placement and must be contacted by retentive clasp arms that are forced to flex over a convex surface during placement & removal. For a clasp to be retentive, its path of escape must be other than parallel to the path of removal of the denture. Although desirable, retention at each principal abutment may not be balanced in relation to the tooth on the opposite side of the arch, however, positive cross arch reciprocation to retentive elements must be present. Retention should be sufficient only to resist reasonable dislodging forces.

Even retention can be obtained :

To change the path of placement to increase or decrease the angle of convergence of opposing retentive surfaces of abutment teeth.

To alter the flexibility of the clasp arm by changing its design, its size and length, or the material of which it is made.

Interference

The prosthesis must be designed so that it may be placed and removed without encountering tooth or soft tissue interference. A path of placement may be selected that encounters interference only if the interference can be eliminated during mouth preparations or on the master cast by a reasonable amount of block out. Interference that cannot be eliminated for one reason or another will take precedence over the factors of retention and guiding planes

Esthetics

By one path of placement, the most esthetic location of artificial teeth is made possible, and less clasp metal and base material may be displayed. The location of retentive areas may influence the path of placement selected, and therefore retentive areas always should be selected with the most esthetic location of clasps in mind.

Esthetics dictates the choice of the path selected when anterior teeth must be replaced with the partial denture. In such instances, a more vertical path of placement is often necessary so that neither the artificial tooth nor the adjacent natural teeth will have to be modified excessively. This necessitates the preparation of abutment teeth to eliminate interferences and to provide guiding planes and retention in harmony with that path of placement dictated by esthetic factors.

STEP BY STEP PROCEDURE IN SURVEYING A DIAGNOSTIC CAST

STEP-BY-STEP PROCEDURES IN SURVEYING A DIAGNOSTIC CAST

Attach the cast to the adjustable surveyor table by means of the clamp provided. Position the adjustable table so that the occlusal surfaces of the teeth are approximately parallel to the platform. Such an orientation is a tentative but practical way to start considering the factors that influence the path of placement and removal.

Recommended method for manipulating the dental surveyor. The right hand is braced on the horizontal arm of the surveyor, and the fingers are used, as illustrated, to raise and lower the vertical shaft in its spindle. The left hand holding the cast on the adjustable table slides horizontally on the platform in relation to the vertical arm. The right hand must be used to loosen and tighten the tilting mechanism as a suitable anteroposterior and lateral tilt of the cast in relation to the surveyor is being determined

Guiding Planes

By coming into contact with the proximal tooth surfaces the surveyor blade or diagnostic stylus, establish the relative parallelism of all the probable abutment teeth. Change the cast position anteriorly until these proximal surfaces are as parallel to one another as possible, or close enough that recontouring can make them parallel.

This will establish the anteroposterior tilt of the cast in relation to the surveyor's vertical arm for posterior modification spaces. The surveyor table can be tilted in all directions, however

only anteroposterior and lateral tilting are possible because it only has two axes. The latter is favoured because a plane can then be constructed recontouring when deciding whether to have contact with a proximal surface at the cervical area only or contact at the marginal ridge only. It should be obvious that restoration is the only way to create a guiding plane when there is only gingival contact.

As a result, the proximal surface must be created with some sort of restoration if a tilt that does not enable proximal contact. When choosing an appropriate anteroposterior tilt, the goal should be to create the largest possible combined area of parallel proximal surfaces that can serve as guiding planes. As guiding planes, another axial surface of the abutment teeth may also be employed. The most common way to achieve this is to have the direct retainer assembly's stabilizing component make complete contact with the axial surface of the abutment, which has been located or made parallel to the direction of placement. Using guiding planes in this situation requires taking into account the cast's lateral and anteroposterior tilts.

Retentive Areas

The amount of retention present below the height of convexity of the abutment teeth may be assessed by making contact with the buccal and lingual surfaces of those teeth with the surveyor blade. The simplest method to do this is to point a small source of light away from the dentist and toward the cast. The easiest way to see the angle of cervical convergence is as a triangle of light between the surveyor blade and the part of the tooth surface being examined closest to the apex.

Adjust the cast position by lateral tilting it until the main abutment teeth have similar retentive regions. They are both principal abutments if there are just two abutment teeth involved, as in a Kennedy Class I partially edentulous arch. On the other hand, if there are four abutment teeth involved (as in a Kennedy Class III, modification 1 arch), they are all primary abutments, and retentive zones must be present on all four. The posterior abutment on the tooth-supported side and the abutment on the distal extension side are thought to be the major abutments and retention needs to be equalized as a result if three abutment teeth are involved, as they are in a Kennedy Class II, modification 1 arch.

It's possible to classify the third abutment as secondary, and less retention is anticipated from it than from the first two. An exception is made when the denture is intended to be a Class I in the end and the posterior abutment on the tooth-supported side has a poor prognosis. The two stronger abutments in this scenario are regarded as the main abutments.

In order to tilt the cast laterally and create a satisfactory level of uniform retention, the table must be rotated about a imaginary longitudinal axis without changing the previously established anteroposterior tilt. The outcome is a position that allows for appropriate retention on the abutment teeth and offers or makes possible parallel guiding planes. It should be emphasised that some tooth alteration will always be necessary in order to obtain this most ideal position. Note that no attention has yet been given to potential obstructions to this tentative line of placement.

Interference

When inspecting a mandibular cast, look for any lingual surfaces that a lingual bar major connector would cross during insertion and removal. The two most frequent reasons for difficulties with a lingual bar connector are bony prominences and lingually inclined premolar teeth. If the interference is bilateral, surgery, lingual tooth surface recontouring, or both, may not be needed. A modification in the lateral tilt may prevent an area of tooth or tissue interference if it is only unilateral. An ideal site for retentive items and previously established guiding planes may be lost when modifying the course of placement to prevent interference. Then the decision must be made whether to remove the existing interference by whatever means necessary or to resort to restorations on the abutment teeth, thereby changing the proximal and retentive areas to conform to the new path of placement.

In a similar way, bony undercuts that will obstruct the seating of denture bases must be assessed, and a decision must be made regarding whether to surgically remove them, alter the path of placement at the expense of modifying or restoring teeth to achieve guiding planes and retention, or design denture bases to avoid such undercut areas. Shortening the buccal and labial flanges and extending the denture bases distolingually can accomplish the latter. However, it

should be kept in mind that, whenever possible, the largest area available for supporting the denture base should be used.

In the maxillary arch, interference to major connectors are rare. The bony surfaces on the buccal aspect of edentulous gaps and posterior teeth with a buccal inclination are the usual locations for interference. To achieve the necessary guiding planes and retention, it is necessary to decide whether to delete them, adjust the course of placement at the expense of repairing or restoring teeth, or design the connectors and bases to avoid them.

Surfaces of abutment teeth that will support or be crossed by minor connectors and clasp arms need to be assessed for potential interference. Even though interference to vertical minor connectors might be blocked out, doing so might irritate the patient's tongue and might leave unattractive areas that might trap food. Additionally, whenever possible, it is preferred that tooth surfaces that vertical connectors contact be employed as additional guiding planes. since too little relief could irritate soft tissue, too much relief is preferable to too little. It is always preferable to position the relief with a specific goal in mind.

If possible, a minor connector should run vertically along a tooth surface that is parallel to the path of placement (which is optimal) or tapered occlusally. If there are tooth undercuts that require the use of an excessive quantity of blockout, they may be avoided or decreased by making modest adjustments to the course of placement and/or eliminating them during mouth preparation. Following final acceptance of a placement path, the need for such an adjustment should be noted in red pencil on the diagnostic cast.

It is important to examine the tooth surfaces where the reciprocal and stabilizing clasp arms will be positioned in order to determine whether there are enough spaces above the height of convexity for the placement of these parts. An abutment tooth's occlusal dimension and occlusal loading increase when a clasp arm is added to the occlusal third of the tooth. Instead of on the occlusal third of the crown, nonretentive and stabilizing clasp arms work best between the middle and gingival thirds.

When preparing the mouth, tooth surfaces can be reshaped to remove any obstructions to the proper placement of the clasp arms. The diagnostic cast needs to show these locations. The course of placement or the design of the clasp may need to be slightly altered to avoid

interference-prone areas. For reciprocation and stabilisation, a bar clasp arm originating medially from the primary connector, for instance, might be used in place of a circumferential arm with a distal origin. The distal line angles of premolar abutment teeth and the mesial line angles of molar abutments are areas of interference that are frequently ignored. The circumferential clasp arms typically experience an obstruction in these regions. They are not accounted for in the plan for mouth preparation if they are not discovered during the initial survey.

When such an undercut exists, the following three alternatives may be considered:
Like any other region of interference, they can be filtered out. The origin of the clasp must therefore stand away from the tooth in proportion to the quantity of blockout utilised, making this approach by far the least effective. Even though this may be less offensive than having it placed occlusally, it may be offensive to the tongue and cheek and could lead to food entrapment.

The retentive area may be avoided by using a bar clasp arm to approach from the gingival side. If there are no further reasons not to employ a bar clasp arm, such as a severe tissue undercut or an excessively high retentive area on the tooth, then this is frequently an acceptable solution to the issue.

They might be eliminated if the offending tooth's shape is reduced during mouth preparation. This enables the effective use of a circumferential clasp arm that originates deeply below the occlusal surface. If the tooth needs to be altered during oral preparation, the diagnostic cast should be marked with a coloured pencil. Interference may also arise on tooth surfaces that support retentive clasps when the retentive area is unacceptably high on the abutment tooth or the undercut is excessively severe. These areas of severe or high convexity must be regarded as interference areas and should be diminished in accordance with that. On the diagnostic cast, these areas are also marked for reduction during mouth preparation.

Esthetics

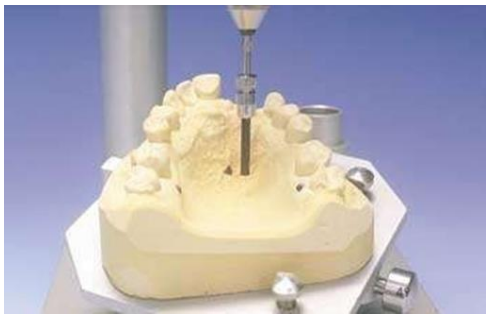
The route of placement so defined must still be taken into account from an aesthetics point of view, both for the placement of clasps and the configuration of artificial teeth. For each given course of placement, clasp designs that will provide sufficient aesthetics can typically be chosen. Certain situations require for the employment of bar clasp arms that are positioned gingivally, while other situations call for cervically positioned circumferential clasp arms. This is particularly relevant when retention may be primarily supported by other abutment teeth that are positioned more posteriorly. In other cases, it may be more aesthetically pleasing to position a cast clasp arm than a tapering wrought-wire retentive clasp arm. In most cases, the positioning of clasp arms does not warrant changing the course of implantation.. The location of clasp arms for esthetic reasons does not ordinarily justify altering the path of placement at the expense of mechanical factors.

It should be taken into account along with other variables, and if a choice between two equally valid paths of insertion allows for a more aesthetically pleasing positioning of clasp arms via one path than by the other, that path should be used. For the previously mentioned reasons, the choice of route is restricted to a more vertical one when anterior replacements are included. Even if it means changing the placement's path and forcing all other aspects to fit, aesthetics must be given first priority in this particular case. This aspect should be kept in mind when the other three criteria are taken into account so that compromises can be made when other considerations are taken into account.

TRIPODING

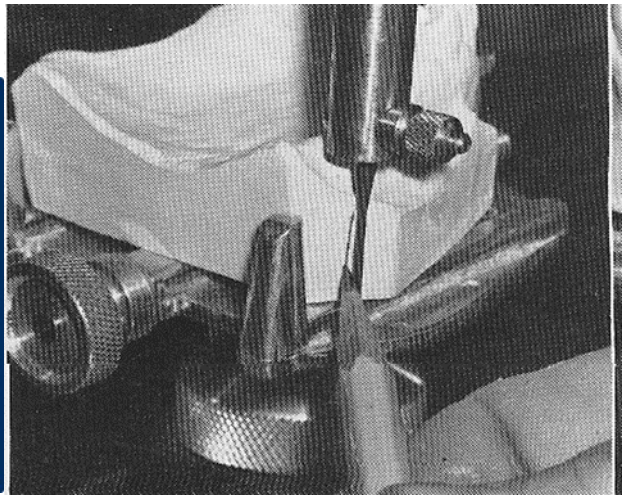
FIRST METHOD :

By placing widely spaced dots on the tissue surface of the cast using the tip of the carbon marker, with the vertical arm of the surveyor in a locked position.



SECOND METHOD

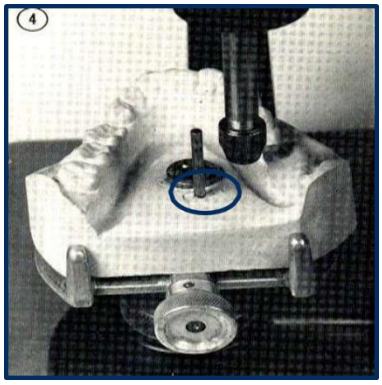
- Score two sides and dorsal aspect of the base of the cast with a sharp instrument held against the surveyor blade.
- By tilting the cast until all three lines are again parallel to the surveyor blade, the original position can be reestablished.
- Fortunately the scratch lines will be reproduced in duplication, there by permitting any duplicate cast to be related to the surveyor in a similar manner.



THIRD METHOD

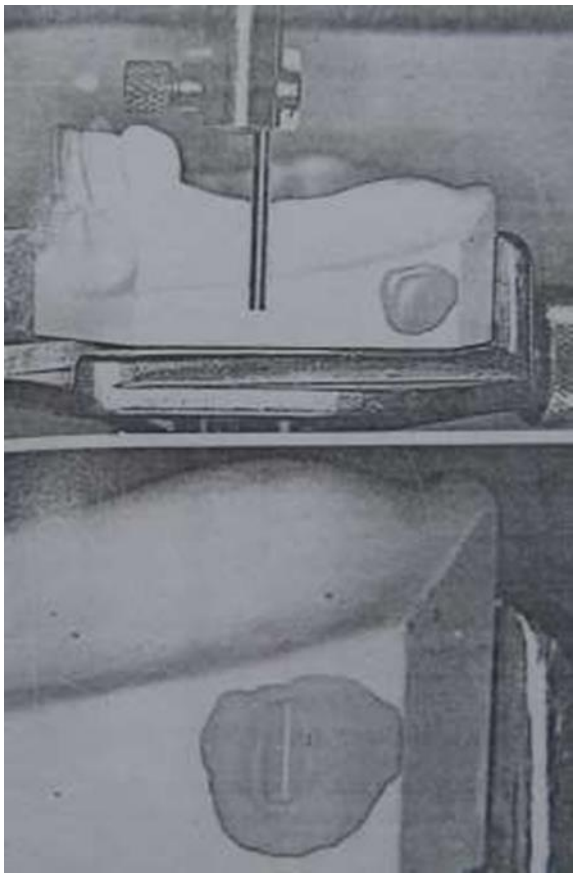
The third method of locating cast is using thin retentive pins.

The pins are placed in the desirable place to re-orient the cast in the surveyor.



FOURTH METHOD

- Wax deposited on side of cast at 3 widely separated points.
- Analyzing rod are used to create imprints of wax.
- This can be transferred by duplication.



FINAL PATH OF PLACEMENT

The final path of placement will be the anteroposterior and lateral position of the cast, in relation to the vertical arm of the surveyor that best satisfies all four factors: guiding planes, retention, interference, and esthetics.

With the exception of restorations that need to be completed, all suggested mouth alterations should be noted in red pencil on the diagnostic cast. If wanted, these could also be shown in a chart that goes with it. Surgery and extractions are prioritized to give the tissue time to heal. The remaining red marks on the teeth show the real adjustments that still need to be made, such as proximal surface preparation, buccal and lingual surface reduction, and preparation of rest seats. The preparation of rest seats should always be postponed until all other mouth preparations have been finished, with the exception of when they are set in the wax pattern for a cast restoration. The actual location of rests will be determined by the proposed design of the denture framework.

Therefore, after choosing the path of placement, the preliminary design should be sketched in pencil on the diagnostic cast. This is done in order to not only find rest places but also to graphically document the treatment plan prior to mouth preparation. In the intervening time between patient visits, other partial denture restorations may have been considered.

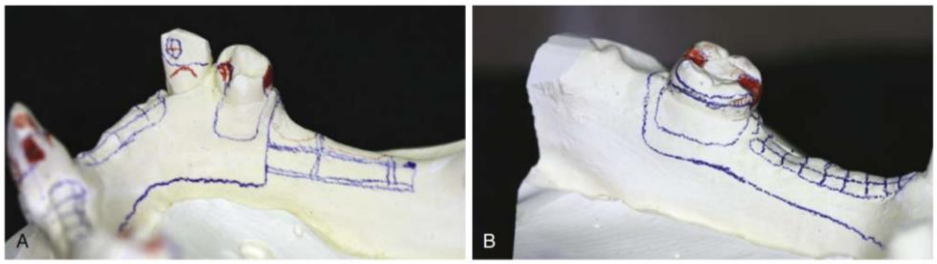
The dentist should have the plan of treatment readily available at each succeeding appointment to avoid confusion and to be a reminder about what is to be done and the sequence that will be required. The plan for treatment should include
(1) the diagnostic cast with the mouth preparation and the denture design marked on it;
(2) a chart showing the proposed design and the planned treatment for each abutment;
(3) a working chart showing the total treatment involved that will permit a quick review and a check-off of each step as the work progresses and
(4) a record of the fee quoted for each phase of treatment that can be checked off as it is recorded on the patient's permanent record.

Red pencil marks on the diagnostic cast are used to indicate the location of areas to be modified and the location of rests. Although it is not necessary that rest areas be prepared on the

diagnostic cast, it is advisable for the beginning student to have done so before proceeding to alter the abutment teeth. This applies equally to crown and inlay preparations on abutment teeth. It is advisable however, for even the most experienced dentist to have trimmed the stone teeth with the surveyor blade wherever tooth reduction is to be done. This identifies not only the amount to be removed in a given area but also the plane in which the tooth is to be prepared.

For example, a proximal surface may need to be recontoured in only the upper third or the middle third to establish a guiding plane that will be parallel to the path of placement. This is not usually parallel to the long axis of the tooth, and if the rotary instrument is laid against the side of the tooth, the existing surface angle will be maintained, rather than having to establish a new plane that is parallel to the path of placement.

The surveyor blade, representing the path of placement, may be used to advantage to trim the surface of the abutment tooth whenever a red mark appears. The resulting surface represents the amount of tooth to be removed in the mouth and indicates the angle at which the handpiece must be held. The cut surface on the stone tooth is not marked with red pencil again, but it is outlined in red pencil to positively locate the area that is to be prepared.



Diagnostic casts can serve as a visual guide for tooth preparation. A, Surveyed cast shows areas requiring tooth reduction in red (mesio-occlusal rest and distal guide plane #28, cingulum rest #27), as well as path of insertion tripod marks. B, This mesially tipped molar has been diagnosed to have a ring clasp. Red markings show the necessary mesio-occlusal and disto-occlusal rests required, as well as the mesial guide plane.

RECORDING RELATION OF CAST TO SURVEYOR

RECORDING RELATION OF CAST TO SURVEYOR

Some method of recording the relation of the cast to the vertical arm of the surveyor must be used so that it may be returned to the surveyor for future reference, especially during mouth preparation. The same applies to the need for returning any working cast to the surveyor for shaping wax patterns, trimming blockout on the master cast, or locating clasp arms in relation to undercut areas.

Obviously the trimmed base will vary with each cast; therefore recording the position of the surveyor table is of no value. If it were, calibrations could be incorporated on the surveyor table that would allow the reestablishment of the same position. Instead, the position of each cast must be established separately, and any positional record applies only to that cast. Of several methods, two seem to be the most convenient and accurate. One method is to place three widely divergent dots on the tissue surface of the cast using the tip of a carbon marker, with the vertical arm of the surveyor in a locked position. Preferably, these dots should not be placed on areas of the cast involved in the framework design. The dots should be encircled with a colored pencil for easy identification.

Tripoding

Tissue surface indexing

Art surface indexing

Relocation devices

REPRODUCTION OF TILT OF A CAST ON A SURVEYOR[13].

TECHNIQUE

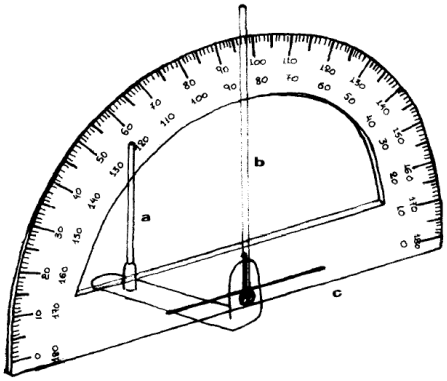
1.Position the cast on the surveyor table, and determine the desired path of insertion.

2. Place the protractor instrument on the surveyor in place of the analyzer rod .

3.Determine three divergent anatomic points on the occlusal surfaces of the teeth or on the edentulous alveolar ridges. One point should be on the midline or near it. These three points

determine a plane. The inclination of which is measured by the protractor in the anteroposterior and transverse axises

4. List the anatomic points and angles on the patient's card



The upright (a) fits into the surveyor rod holder. The protractor (c) can pivot about the upright rod (b).

A METHOD TO RECORD THE PATH OF INSERTION OF A REMOVABLE PARTIAL DENTURE.[19]

METHOD

1. Determine the position of the cast on the surveyor to provide the desired path of insertion for the removable partial denture, and tighten the lock nut of the working table.

2. Lubricate the occlusal surfaces of the teeth and/or ridge of the cast to be used for the recording with a separating media.

3. Place soft modeling plastic at each end of the position-recorder device so that it adheres to the plastic and flows through the holes provided for retention.

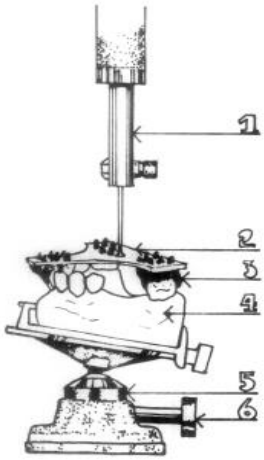
4. Secure the position-recorder device into the vertical arm of the surveyor.

5. Lower the vertical arm of the surveyor until the horizontal plane of the device contacts the occlusal surface of the teeth and/or ridge. Be certain there is intimate contact between the modeling plastic and the occlusal surfaces of the teeth. Cool the modeling plastic with cold water until hard.

6. Record the chosen tilt of the working table . Inscribe the identification of the teeth or region of the ridge used for the record on the dorsal surface of the position-recorder device. The position recorder device, the master cast, and a laboratory work authorization may now be sent to the dental technician.

7. To reposition the cast on the surveyor base, fit the device onto the occlusal surfaces of the chosen teeth and/or ridge area with the lock nut of the working table left open. Maintain pressure with two fingers on the position-recorder device, fit the mandrel to the vertical arm of the surveyor, and tighten the mandrel. Tighten the lock nut of the working table. The angulation of the cast now reproduces the original path of insertion chosen.

Position-recorder device parts description: (1) vertical arm of surveyor,(2) vertical arm lock nut (3) handpiece mandrel, (4) plastic plate, (5) marking area, (6) retention holes, and (7) screw.Chosen tilt as recorded by device: (I) vertical arm of surveyor, (2) position-recorder device, (31 modeling plastic-compound, (41 plaster dental cast, (5) surveyor's working table, and (6) lock nut of working table.



A NEW METHOD FOR RECORDING AND REPRODUCING CAST ORIENTATION ON A SURVEY TABLE. [24]

TECHNIQUE

The cast angle tool (CAT) consists of an inclinometer mounted on the center of a 3.5 × 3.5-inch metal plate with a spring-loaded swivel mechanism

The inclinometer rotates about the center of the metal plate to 2 terminal positions that are perpendicular to each other. Metal stops limit the rotation of the inclinometer to these 2 terminal positions. The inclinometer provides tilt measurements in 1-degree increments. The metal plate has elevated index markers on its undersurface arranged in an arch configuration that allow indexing of the device to the occlusal surface of a cast.

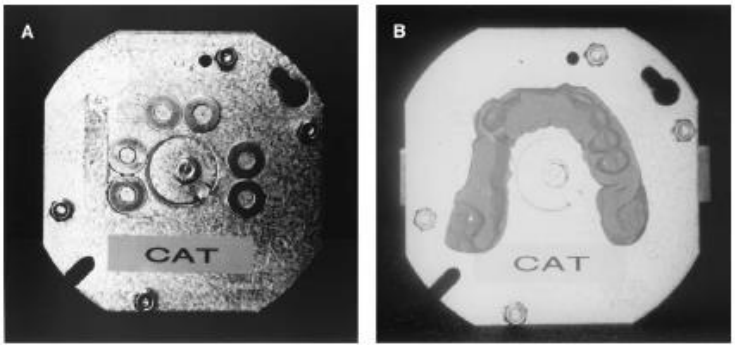
Procedure for recording cast orientation

1. Index the CAT to the cast by applying vinyl polysiloxane (VPS) occlusal registration material to its undersurface and seat the occlusal aspect of the cast into the VPS. After the VPS index has set, remove the device from the cast.
2. Secure the cast on a survey table, and use a surveyor to adjust the tilt until the desired path of insertion is obtained.
3. Replace the CAT on the cast by use of the VPS index, and record the angle of the cast in the frontal plane. Designate the measurement as (_) or (+) to describe the position of the gauge needle relative to zero degrees
4. Rotate the inclinometer counter clockwise to its terminal position, and record the angle of the cast in the sagittal plane. Designate the measurement as (-) or (+)
5. Remove the VPS index from the CAT, and store it with the patient's casts. The VPS index can be easily replaced on the device for subsequent cast reorientation. Record the measurements for cast orientation in the frontal and sagittal planes in the patient's chart as a permanent record of the planned path of insertion.

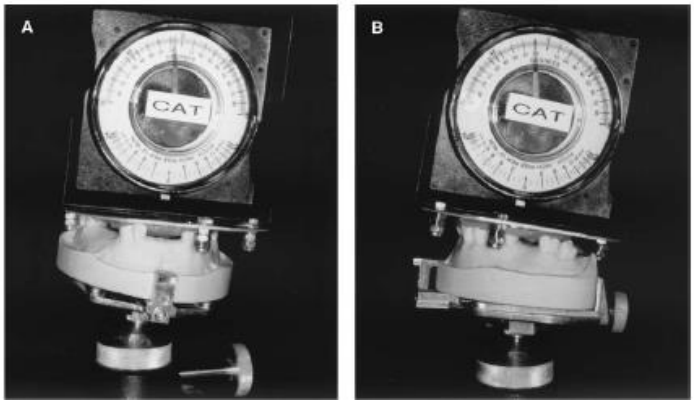
Cast reorientation

1. To reorient a cast to the planned path of insertion, secure the cast on the survey table, and loosen the locking screw that holds the table in position.
2. Attach the VPS index to the undersurface of the CAT, and place it in the appropriate position on the cast.

3. With the inclinometer in the frontal position, tilt the survey table laterally until the predetermined frontal plane orientation is obtained. Lightly tighten the locking screw of the survey table.
4. Rotate the inclinometer counterclockwise to its terminal position, loosen the locking screw, and carefully tilt the survey table anteroposteriorly to the predetermined sagittal plane position. Lightly tighten the locking screw.
5. Rotate the inclinometer clockwise to its terminal position, and verify that the frontal plane angulation has not been altered. Tighten the locking screw after frontal and sagittal plane orientations have been verified



A. *Indexing markers on undersurface of metal plate.* ***B.*** *VPS occlusion registration material used to index occlusal surfaces of cast to CAT.*



Measurement of cast orientation ***A,*** *Frontal plane.* ***B,*** *Sagittal plane.*

On returning the cast to the surveyor, it may be tilted until the tip of the surveyor blade or diagnostic stylus again contacts the three dots in the same plane. This will produce the original

position of the cast and therefore the original path of placement. This is known as *tripoding* the cast.

Some dentists prefer to make tiny pits in the cast at the location of the tripoding dots to preserve the orientation of the cast and to transfer this relationship to the refractory cast. A second method is to score two sides and the dorsal aspect of the base of the cast with a sharp instrument held against the surveyor blade. By tilting the cast until all three lines are again parallel to the surveyor blade, the original cast position can be reestablished.
Fortunately, the scratch lines will be reproduced in any duplication, thereby permitting any duplicate cast to be related to the surveyor in a similar manner. Whereas a diagnostic cast and a master cast cannot be made interchangeable, a refractory cast, being a duplicate of the master cast, can be repositioned on the surveyor at any time. The technician must be cautioned not to trim the sides of the cast on the cast trimmer and thereby lose the reference marks for repositioning.

It must be remembered that repositioning a cast on a surveyor at any time can involve a certain amount of human error. It has been estimated that an error of 0. 2 mm can be anticipated in reorienting a cast with three reference points on its base. This reorientation error can influence the placement of appropriate blockout wax and may result in ineffective placement of direct retainers into prescribed undercuts and improper contacts of minor connectors to guiding planes. Therefore reorientation of the cast to surveyor by any method must be done with great care.

SURVEYING THE MASTER CAST

SURVEYING THE MASTER CAST

The master cast must be surveyed as a new cast, but the prepared proximal guiding plane surfaces will indicate the correct anteroposterior tilt. Some compromises may be necessary, but the amount of guiding plane surface remaining after blockout should be the maximum for each tooth.

Areas above the point of contact with the surveyor blade are not considered to be part of the guiding plane area and neither are gingival undercut areas, which will be blocked out. The lateral tilt will be the position that provides equal retentive areas on all principal abutments in relation to the planned clasp design.

Factors of flexibility, including the need for extra flexibility on distal extension abutments, must be considered in deciding what will provide equal retention on all abutment teeth. For example, cast circumferential or cast bar retention on the tooth-supported side of a Class II design should be balanced against the 18-gauge wrought-wire retention on a distal abutment only if the more rigid cast clasp engages a lesser undercut than the wrought-wire clasp arm. Therefore the degree of undercut alone does not ensure relatively equal retention unless clasp arms of equal length, diameter, form, and material are used.

Gross interference will have been eliminated during mouth preparation. Thus for a given path of placement providing guiding planes and balanced retention, any remaining interference must be eliminated with blockout. If mouth preparation has been adequately planned and executed, the undercuts remaining to be blocked out should be minimal. The base of the cast is now scored, or the cast is tripoded as described previously.

The surveyor blade or diagnostic stylus then may be replaced with a carbon marker, and the height of convexity of each abutment tooth and soft tissue contours may be delineated. Similarly, any areas of interference to the rigid parts of the framework during seating and removal should be indicated with the carbon marker to locate areas to be blocked out or relieved.

Carbon markers that become the slightest bit worn from use should be discarded. A worn (tapered) carbon marker will indicate heights of contour more occlusally located than they actually exist. The carbon marker must be parallel to the vertical spindle of the surveyor. The diagnostic stylus should always be checked to be sure that it is not bent or distorted.

A worn carbon marker (left) should be discarded because it will invariably misleadingly mark the height of contour for a given orientation of the cast to the vertical spindle of the surveyor. Unworn carbon (right) with an angled end is preferable for marking heights of contour on abutment teeth and performing surveys of soft tissue areas

MEASURING RETENTION

The surveyor is used with the master cast for two purposes:
(1) to delineate the height of contour of the abutment teeth both to locate clasp arms and to identify the location and magnitude of retentive undercuts and
(2) to trim blockout of any remaining interference to placement and removal of the denture.

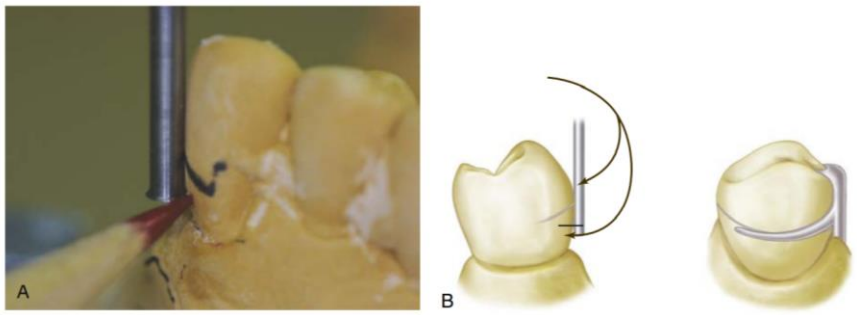
The areas involved are those that will be crossed by rigid parts of the denture framework. The exact undercut that retentive clasp terminals will occupy must be measured and marked on the master cast. Undercuts may be measured with an undercut gauge, such as those provided with the Ney and Jelenko surveyors.

The amount of undercut is measured in hundredths of an inch, with the gauges allowing measurements up to 0. 03 inch. Theoretically the amount of undercut used may vary with the clasp to be used up to a full 0. 03 inch. However, undercuts of 0. 01 inch are often adequate for retention by cast retainers. Tapered wrought-wire retention may safely use up to 0. 02 inch without inducing undesirable torque on the abutment tooth, provided the wire retentive arm is long enough (at least 8 mm). The use of 0. 03 inch is rarely, if ever, justified with any clasp. When greater retention is required, such as when abutment teeth remain on only one side of the arch, multiple abutments should be used rather than increasing the retention on any one tooth.

When a source of light is directed toward the tooth being surveyed, a triangle of light is visible. This triangle is bounded by the surface of the abutment tooth on one side and the blade of the surveyor on the other, the apex being the point of contact at the height of convexity and the base of the triangle being the gingival tissue . Retention will be determined by
(1) the magnitude of the angle of cervical convergence below the point of convexity
(2) the depth at which the clasp terminal is placed in the angle and
(3) the flexibility of the clasp arm.

The intelligent application of various clasp designs and their relative flexibility are of greater importance than the ability to measure an undercut with precise accuracy.

The final design may now be drawn on the master cast with a fine crayon pencil, preferably one that will not come off during duplication. Graphite is usually lifted in duplication, but some crayon pencil marks will withstand duplication without blurring or transfer. * Sizing or spraying the master cast to protect such pencil marks is usually not advisable unless done with extreme care to avoid obliterating the surface detail.



A, Undercut gauge measures the depth of undercut below the height of contour. B, Specific measurement of the undercut gingiva to the height of contour may be ascertained with the use of an undercut gauge attached to the surveyor.

BLOCKING OUT THE MASTER CAST

After the establishment of the path of placement and the location of undercut areas on the master cast, any undercut areas that will be crossed by rigid parts of the denture (which is every part of the denture framework but the retentive clasp terminals) must be eliminated by blockout.

In the broader sense of the term, blockout includes not only the areas crossed by the denture framework during seating and removal but also
(1) those areas not involved that are blocked out for convenience;
(2) ledges on which clasp patterns are to be placed
(3) relief beneath connectors to prevent tissue impingement and
(4) relief to provide for attachment of the denture base to the framework.

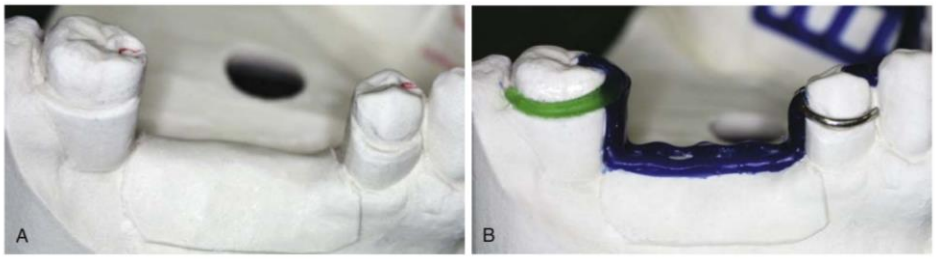
Ledges or shelves (shaped blockout) for locating clasp patterns may or may not be used. However, this should not be confused with the actual blocking out of undercut areas that would offer interference to the placement of the denture framework. Only the latter is made on the surveyor, with the surveyor blade or diagnostic stylus being used as a paralleling device.

Hard inlay wax may be used satisfactorily as a blockout material. It is easily applied and is easily trimmed with the surveyor blade. Trimming is facilitated by slightly warming the surveyor blade with an alcohol torch. Whereas it is true that any wax will melt more readily than a wax-clay mixture if the temperature of the duplicating material is too high, it should be presumed that the duplicating material will not be used at such an elevated temperature. If the temperature of the duplicating material is high enough to damage a wax blockout, other distortions resulting in an inaccurate duplication will likely occur. Parallel blockout is necessary for areas that are cervical to guiding plane surfaces and over all undercut areas that will be crossed by majoror minor connectors.

Other areas that are to be blocked out for convenience and to avoid difficulties in duplication should be blocked out with hard baseplate wax or oil-base modeling clay (artist's modeling clay). Such areas are the labial surfaces and labial undercuts not involved in the denture design and the sublingual and distolingual areas beyond the limits of the denture design. These are

blocked out arbitrarily with hard baseplate wax or clay, but because they have no relation to the path of placement, they do not require the use of the surveyor. Modeling clay that is water-soluble should not be used when duplication procedures are involved. Areas to be crossed by rigid connectors, on the other hand, should be trimmed with the surveyor blade or some other surveyor tool parallel to the path of placement .

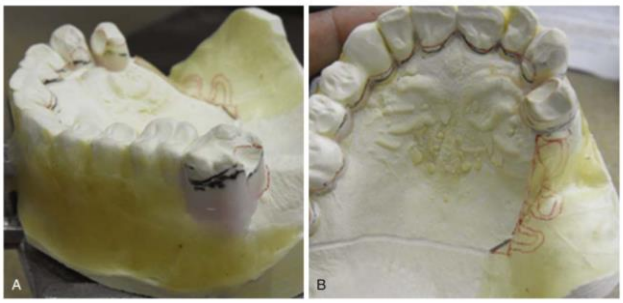
This imposes a considerable responsibility on the technician. If the blockout is not sufficiently trimmed to expose guiding plane surfaces, the effect of these guiding planes, which were carefully established by the dentist, will be nullified. If, on the other hand, the technician is overzealous in paralleling the blockout, the stone cast may be abraded by heavy contact with the surveyor blade. Although the resulting cast framework would seat back onto the master cast without interference, interference to placement in the mouth would result. This would necessitate relieving the casting at the chair, which is not only an embarrassing and time-consuming operation but also one that may have the effect of obliterating guiding plane surfaces.



The wax ledge on the buccal surface of the molar abutment will be duplicated in a refractory cast for exact placement of the clasp pattern.

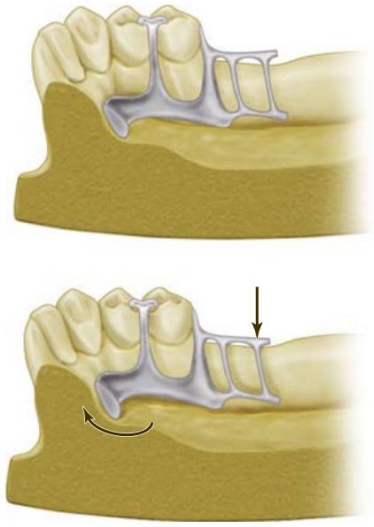
RELIEVING THE MASTER CAST

Tissue undercuts that must be blocked out are paralleled in much the same manner as tooth undercuts. The difference between blockout and relief must be clearly understood.



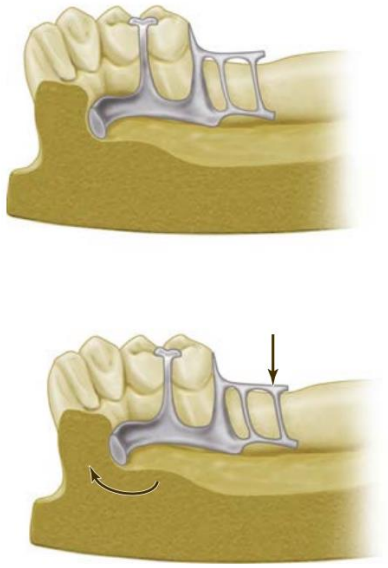
Parallel blockout (A, labial surfaces of all teeth and gingivae to the retentive clasp on tooth #2) and relief (B, marginal gingivae of palatal surfaces of teeth and at distal minor connector) in preparation for framework casting.

For example, tissue undercuts that would offer interference to the seating of a lingual bar connector are blocked out with blockout wax and trimmed parallel to the path of placement. This does not in itself necessarily afford relief to prevent tissue impingement. In addition to such blockout, a relief of varying thickness must sometimes be used—depending on the location of the connector, the relative slope of the alveolar ridge, and the predictable effect of denture rotation. It must be assumed that indirect retainers, as such, or indirect retention is provided in the design of the denture to prevent rotation of the lingual bar inferiorly. A vertical downward rotation of the denture bases around posterior abutments places the bar increasingly farther from the lingual aspect of the alveolar ridge when this surface slopes inferiorly and posteriorly.



The lingual alveolar ridge slopes inferiorly and posteriorly (upper figure). When the force is directed to displace the denture base downward, the lingual bar rotates forward and upward but does not impinge on the soft tissue of the alveolar ridge (lower figure).

Adequate relief of soft tissues adjacent to the lingual bar is obtained by the initial finishing and polishing of the framework in these instances. However, excessive upward vertical rotation of a lingual bar will impinge on lingual tissues if the alveolar ridge is nearly vertical or undercut to the path of placement .



An undercut alveolar ridge was blocked out parallel to the path of placement in fabricating the lingual bar (upper figure). Application of vertical force to cause rotation of the lingual bar upward can cause impingement of lingual tissue on the alveolar ridge (lower figure).

The region of the cast involving the proposed placement of the lingual bar should, in this situation, be first relieved by parallel blockout and then by a 32-gauge wax strip. Low-fusing casting wax, such as Kerr's green casting wax, should not be used because it is too easily thinned during adaptation and may be affected by the temperature of the duplicating material. Pink casting wax should be used, even though it is difficult to adapt uniformly.

A pressure-sensitive, adhesive-coated casting wax is preferred because it adapts readily and adheres to the cast surface. Any wax, even the adhesive type, should be sealed all around its borders with a hot spatula to prevent its lifting when the cast is moistened before or during duplication. Horizontal rotational tendencies of mandibular distal extension removable partial dentures account for many of the tissue irritations seen adjacent to a lingual mandibular major connector. These irritations can usually be avoided by blocking out all undercuts adjacent to the bar parallel to the path of placement and then including adequate stabilizing components in the design of the framework to resist horizontal rotation.

Judicious relief of the tissue side of the lingual bar with rubber wheels at the site of the irritation will most often correct the discrepancy. Under no circumstances should grinding any

portion jeopardize the rigidity of the major connector. Still other areas requiring relief are the areas where component parts cross the gingiva and gingival crevices. All gingival areas bridged by the denture framework should be protected from possible impingement resulting from rotation of the denture framework. Hard inlay wax may be used to block out gingival crevices.

Parallel blocking, shaped blocking, arbitrary blocking and relief

After the establishment of the path of placement and the location of the undercut areas on the master cast, any undercut areas that will be crossed by rigid parts of the denture (which is every part of the denture framework but the retentive clasp terminals) must be eliminated by block out.

In the broader sense the term blockout includes not only the areas crossed by the denture framework during seating and removal, but also those areas not involved that are blocked out for convenience.

Ledges on which clasp patterns are to be placed.

Relief beneath connectors to avoid tissue impingement, and Relief to provide for later attachment of the denture base to the framework.

Ledges or shelves (shaped block out) for locating the clasp patterns may or may not be used. However, this should not be confused with the actual blocking out of undercut area that would offer interference to the placement of the denture framework. Only the latter is made on the surveyor, with the surveyor blade or the diagnostic stylus being used as a paralleling device.

Block out material may be purchased, or it may be made according to the following formula:

Melt and mix together:

4 ½ sheets of base plate wax

4 ½ sticks of temporary gutta-percha stopping

3 sticks of sticky wax

½ tsp Kaolin

Add ½ tube lipstick for color.

PARALLEL BLOCK OUT, SHAPED BLOCK OUT, ARBITARY BLOCK OUT AND RELIEF

The differences between paralleled block out, shaped block out, arbitrary block out, and relief are given below in a tabular form. The same factors apply to both the maxillary and mandibular arches, except that relief is ordinarily not used beneath palatal major connectors, as it is with mandibular lingual bar connectors, except when maxillary tori cannot be circumvented or when resistive median palatal raphes are encountered.

Parallel blockout

SITE	MATERIAL	THICKNESS
Proximal tooth surfaces to be used as guiding planes	Hard base plate wax or block out material	Only undercut remaining gingival to contact of surveyor blade with tooth surface
Beneath all minor connectors	Hard base plate wax or block out material	Only undercut remaining gingival to contact of surveyor blade with tooth surface
Tissue undercuts to be crossed by rigid connectors	Hard base plate wax or block out material	Only undercut remaining gingival to contact of surveyor blade with surface of cast
Tissue undercuts to be crossed by origin of bar clasps	Hard base plate wax or block out material	Only undercut remaining gingival to contact of surveyor blade with surface of cast
Deep interproximal surfaces to be covered by minor connectors or linguoplates	Hard base plate wax or block out material	Only undercut remaining gingival to contact of surveyor blade with surface of cast
Beneath bar clasp arms to gingival crevice	Hard base plate wax or block out material	Only undercut area involved in attachment of clasp arm to minor connector

Shaped blockout

SITE	MATERIAL	THICKNESS
On buccal and lingual surfaces to locate plastic or wax patterns for clasp arms	**Hard base plate wax**	**Ledges for location of reciprocal clasp arms to follow height of convexity so that they may be placed as cervical as possible without becoming retentive**
		Ledges for location of retentive clasp arms to be placed as cervical as tooth contour permits; point of origin of clasp to be occlusal or incisal to height of convexity, crossing survey line at terminal fourth, and to include under cut area previously selected in keeping with flexibility of clasp type being used

Arbitrary blockout

SITE	MATERIAL	THICKNESS
All gingival crevices	Hard base plate wax	Enough to just eliminate gingival crevice
Gross tissue undercuts situated below areas involved in design of denture framework	Hard base plate wax or oil-base clay	Leveled arbitrary with wax spatula
Tissue undercuts distal to cast framework	Hard base plate wax or oil-base clay	Smoothed arbitrary with wax spatula
Labial and buccal tooth and tissue undercuts not involved in denture design	Hard base plate wax or oil-base clay	Filled and tapered with spatula to within upper third of crown

Relief areas

SITE	MATERIAL	THICKNESS
Beneath lingual bar connectors or the bar portion of linguoplates when indicated	Adhesive wax sealed to cast; should be wider than major connector to be placed on it	32-gauge wax if slope of lingual alveolar ridge is parallel to path of placement 32-gauge wax after parallel block out of undercuts if slope of lingual alveolar ridge is undercut to path of placement
Areas in which major connectors will contact thin tissue, such as hard areas so frequently found on lingual of mandibular ridges and elevated median palatal raphes	Hard base plate wax	Thin layer flowed on with hot wax spatula; however, if maxillary torus must be covered, the thickness of the relief must represent the difference in the degree of displacement of the tissues covering the torus and the tissues covering the residual ridges
Beneath framework extensions onto ridge areas for attachment of resin bases	Adhesive wax, well adapted and sealed to cast beyond involved area	20-gauge wax

CONCLUSION

CONCLUSION

The turning point in the change of partial denture constructions from guesswork based on clinical experience to scientifically based procedure was the appearance of the dental surveyor in 1918. Many advances made in the field of removable partial dentures have made the practice from accurate, but the one piece of equipment out the modern clinical practice of removable partial prosthodontics would not be possible in the surveyor.

The surveyor is essentially a parallelometer, an instrument used to determine the relative parallelism of surfaces of teeth or other areas on a cast of the jaws. The best and most accurate removable partial denture can be constructed only through the use of a dental surveyor.

It should be remembered that when a laboratory technician receives a cast from a dentist on which he is to construct a removable partial denture, there is nothing the technician can do but accept that cast as its is. He cannot alter the shape of the stone teeth to improve the position of the height of contour so that a retentive clasp may be located in the gingival third of the tooth for better esthetics and mechanical advantages. He cannot cut away a bony exostosis on the edentulous ridge to permit greater ridge coverage by the denture base.

Thus it is essential that the dentist use the surveyor before planning the reference for the patient.

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