2

System oriented planning and design – model measurement

The planning and construction of partial dentures according to this methodology improves and facilitates the procedures and can be applied equally for analogue and digital work steps.

Digital design – Varseo 3D printing system

Basics of model surveying

While the dentist uses diagnostic measurement to check design options, the dental technician is responsible for implementing the dentist's design specifications. In case no diagnostic measurement has been made, the first step is to check the retention capacity of the intended clasp teeth. The importance of the diagnostic measurement becomes clear here. The final direction of insertion can only be determined when the retention capacity of the denture is ensured by determining all undercut points. Afterwards, the prosthetic equator is marked. The positioning of the clasps is based on it.

Definition of terms for the surveying of partial dentures

Anatomic equator

Designation for the largest horizontal circumference of the clinical crown in a perpendicular alignment to the crown axis of the individual tooth.
Note: The anatomic equator does not play any role in the model surveying

Prosthodontic equator

Synonyms: height of contour, clasp guide line or equator line
The prosthodontic equator is defined on the basis of the path of insertion and/or position of the model on the tilt-top surveying table. The path of insertion is determined beforehand in the surveying unit and the prosthodontic equator is marked with the carbon marker. It indicates the largest crown circumference based on the path of insertion. The passive clasp parts are located above the prosthodontic equator, all active clasp parts (lower clasp arm/direct retainer) are located below the prosthodontic equator. Since the clasp line primarily depends on the prosthodontic equator, the latter is also designated as the clasp guide line.

Crown axis

This axis runs vertically from the apex of the root to the middle of the incisal edge. In the case of multirooted teeth, it is the line between the bifurcation (bisection) of the roots to the middle of the masticating surface. The vertically applied masticatory pressure corresponds to a purely axial load. A uniform transmission of force takes place on the entire root circumference!

Retention field

Synonyms: undercut, infrabulge
In the area below the prosthodontic equator, the end of the clasp arm will find its retention. The retention capacity of the clasp is determined with the undercut gauge or an undercut depth measuring device.

Auxiliary line for clasp length mark

As a vertical pencil line, it shows to what extent the clasp should encompass the tooth. The undercut point is measured on this auxiliary line. The clasp reaches its deepest point on the auxiliary line.

Undercut point (point of termination of the active arm)

It results from the undercut value necessary for the retention of the denture and is determined with the undercut gauge or needle of the undercut depth measuring unit. The end of the clasp reaches its maximum undercut value at the undercut point in the retention field.

Undercut angle (angle of cervical convergence, degree of undercut, angle of contact)

The angle of cervical convergence of the clasp results from the inclination of the tooth surface in the retention field. A tooth that is only moderately inclined towards the prosthodontic equator leads to an angle of cervical convergence in which the clasp can run over a longer distance in the retentive zone.

Zero position

This designates the initial position of the master model for surveying on the tilt-top surveying table. It runs perpendicularly to the analyzing rod and generally corresponds to the occlusal plane. Surveying of the model in the zero position is intended to enable the patient to insert the denture under masticatory pressure. For aesthetic or functional reasons, measurement in the zero position is often not possible.

Occlusal plane (bite plane)

This plane is determined on the dentulous jaw by the height of the lower central incisors (incisor point) and of the disto-buccal cusps of the lower central molars. To avoid an inclined position of the master model, the maxillary tuberosity and/or retromolar trigone (pad) cannot be used as reference points in the case of free-end saddles. The height of the lost teeth can only be roughly estimated.

Clasp line

It is defined after measurement of the undercut point and the drawing of the equator on the clasp tooth. The drawn-in line corresponds to the center of the clasp line.

Active clasp arm (direct retainer, lower clasp arm, retention)

This part of the clasp, which is located below the prosthodontic equator, anchors the denture in the retention field and thus secures it against tensile forces.

Passive clasp arm (upper clasp arm, bracing)

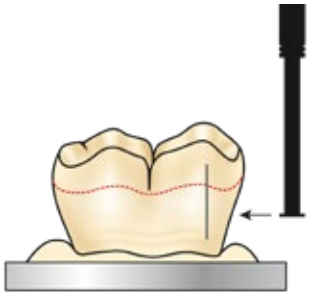
The part of the clasp on or above the prosthodontic equator. These solidly and broadly designed areas enable distribution of horizontally applied forces and act as a guiding plane for insertion and removal.

Rest (support, dental or occlusal rest)
The clasp rest primarily serves to transmit the masticatory pressure forces and additionally compensates for horizontal forces to a slight degree. Ideally the rest is placed in a (occlusal, incisal, cingulum) rest seat prepared on the clasp tooth.

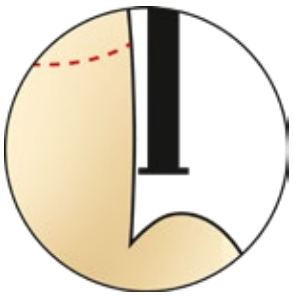
Guiding surfaces (for clasp shoulder, passive clasp arm)
Designation for plane support surfaces which have contact with the passive clasp arm, clasp shoulder or occlusal third of the minor connector. Vertical guide surfaces corresponding at both halves of the jaw and positioned at the same height define the path of insertion and help to avoid harmful shear stress at the abutment teeth.

Work steps for model surveying

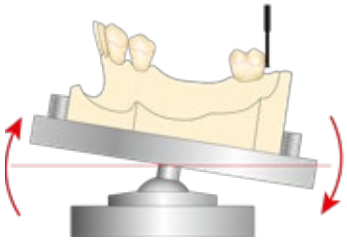
- Mark support points, take into account specifications and/or prepared rest seats
- Set zero position in the measuring unit with the tilt-top surveying table (provisional path of insertion)
- Use analyzing rod to check and select the abutment teeth
- Define retention fields (model analysis)
- Check retention capacity (undercut depth)
- Check contact surfaces of rigid clasp elements for undercuts (corresponding guide surfaces)
- Define type of clasp (see laboratory order)
- Mark clasp length by means of vertical auxiliary line (draw with pencil along analyzing rod)
- Use undercut gauge according to Ney or undercut depth measuring device
- Measure desired undercut (use vertical auxiliary line)
- If necessary, tilt model table slightly (preferably anterior - posterior)
- Draw in undercut point on vertical auxiliary lines
- Do not change model position anymore! (mark final path of insertion with vertical lines on the model base)
- Insert carbon marker and sheath (bevel carbon marker on one side for interdental spaces!)
- Mark prosthodontic equator with carbon marker (do not use worn carbon marker!)
- Drawn clasp line (different color from prosthodontic equator)
  - Active clasp arm: Take into account angle of cervical convergence of the clasp! (25 - 30° to the path of insertion)
  - Passive clasp arm: Mark undercuts to be blocked out



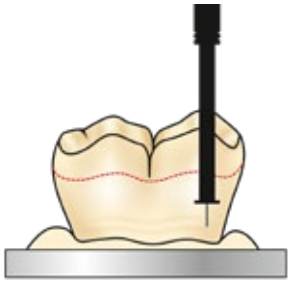
Move the Ney undercut gauge towards the auxiliary line



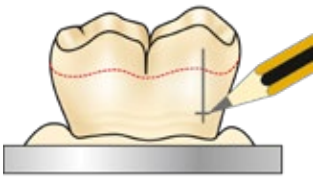
The shaft of the undercut gauge has no contact with the tooth surface



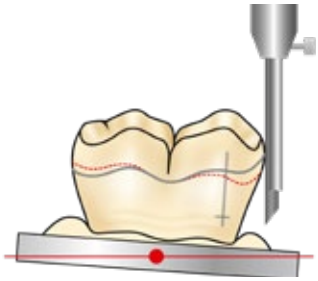
Tilt the model tabel slightly



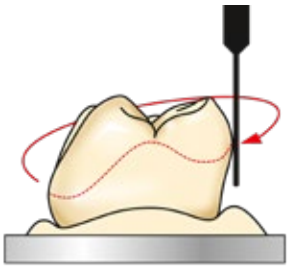
Shaft of the undercut gauge has to connect with all auxiliary lines



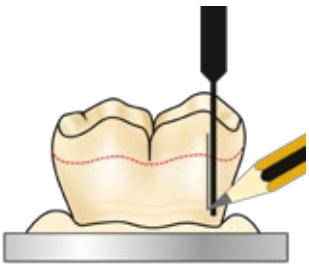
Horizontal line marks the clasp tip



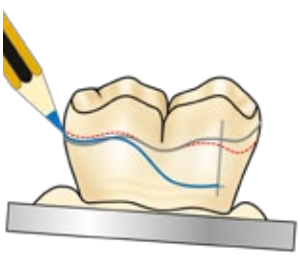
Guide the carbon marker with low pressure around the tooth to mark the prosthodontic equator



Check the retention capacity with help of an analyzing rod



Vertical line marks the end of the clasp



Mark the clasp line – one third is below the prosthodontic equator

The ring clasp will later be positioned centrally on the drawn line

Determination of the path of insertion

For the purpose of surveying, the master model is securely clamped in the model holder of the tilt-top surveying table. The provisional position of the master model corresponds to the zero position (occlusal plane) as far as possible. It may change in the course of the surveying for structural or aesthetic reasons. The model table is tilted in the anterior (mesial tilt) or posterior (distal tilt) direction accordingly. Ideally the master model is to be aligned such that the prosthodontic equator is positioned as low as possible in the visible area. Every perceptible clasp element, no matter how delicately designed, impairs the overall aesthetic appearance. Often minor changes in the position are enough to improve the result. The position of the master model on the tilt-top surveying table is especially important since it defines the path of insertion of the denture.

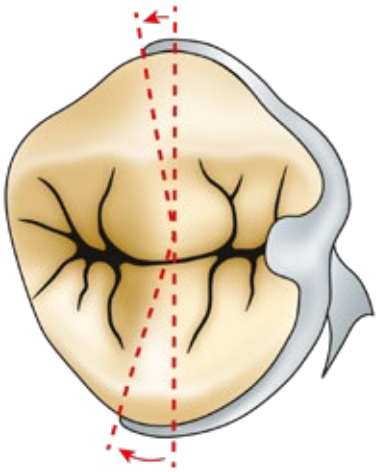
Note: The vertical crown axes of the specified abutment teeth should run parallel to the selected path of insertion as far as possible. A structurally necessary path of insertion that is, however, unfavorable for inserting the denture may lead to horizontal shear stress on the clasped teeth. In extreme cases, permanent clasp deformation or overloading of the periodontium of the clasp teeth occurs when the denture is inserted under masticatory pressure. The periodontal apparatus, in particular the Sharpey‘s fibers, is primarily oriented to the compensation of vertical forces (masticatory pressure forces) for physiological capacity in the case of axial application of force because the Sharpey‘s fibers can be subjected to maximum tension.

Horizontal shear and withdrawal forces can only be compensated to a limited extent. Consequently, one should avoid horizontal shear load, such as that which occurs due to great deviation from the zero position. There is a risk that not only vertical, but also horizontal stress is applied in the transmission of the masticatory forces from the denture to the periodontia of the teeth. As a result of this, changes in the zero position that suggest themselves for aesthetic reasons must be considered carefully. If clasp teeth already have a considerably diverging position, the inclination of the teeth important for denture anchoring must not be additionally reinforced through the selected model position. There are situations in which a great deviation from the zero position may provide functional advantages. This applies, for example, to dentures with very long bounded saddles on which strong tensile forces act, especially when glutinous food is chewed. With an appropriate path of insertion the denture is pressed against the remaining anterior number of teeth, instead of detaching itself. The force that is redirected in this way holds the denture in its position during the masticatory process.

Defining the clasp length

The tooth surfaces earmarked as the retention zone are defined with the analyzing rod, which is moved from mesial to distal. In mandibular predominantly lingual and in the maxillary buccal retention areas are available. If the arrangement of the existing natural teeth allows, the undercuts are located exclusively either buccal or palatal/lingual. The undercuts are evenly distributed among the clasp teeth capable of bearing loads. No tooth may be overloaded here! In the ideal case, the retention force and/ or withdrawal force is roughly equal on both halves of the jaw. Tilting of the denture during removal is extensively avoided in this way.

The retentive areas become apparent below the contact point from the analyzing rod to the tooth. The end of the clasp could find its undercut here. The entire specified clasp line is traced with the analyzing rod. Special attention must be paid to how big the undercut angle or angle of cervical convergence is in the retentive field. Angles of inclination that are too big or too small are compensated for on the tilt-top surveying table by changing the model position. The clasp length is defined by drawing a vertical line on the respective tooth surface. A sharp pencil (medium hardness) is moved along the analyzing rod for this purpose. The clasp tooth must have a sufficient retentive zone in the area around the vertical auxiliary line. When the auxiliary line is positioned, aesthetic aspects should be taken into account. A longer clasp is less visible since it can be placed deeper in the undercut area. The clasp tip must not be put too near to the replacement or neighboring tooth. When positioning the auxiliary line or the clasp drawing, it must be kept in mind that the tooth is adequately held later. Encompassing the clasp tooth by somewhat more than 180° is generally adequate to avoid a change in position (movement).



Provide sufficient clasp enclosure

However, a distinction must be made whether the tooth is a clasp tooth standing alone, a tooth in a closed row of teeth or a gaplimiting or terminal tooth.
The mark for the end of the clasp (auxiliary line) should not be placed in the interdental space since the self-cleaning process could be impaired here by the clasp tip. A retention niche results. In the case of terminal molars, the auxiliary line is put somewhat in the distobuccal region. In this way, the risk of injuring the cheek mucous membrane with the clasps that are open on the dorsal side is lower when the denture is inserted. Only when the respective clasp length has been defined through an auxiliary line at all clasp teeth, is the undercut value measured.

Arrangement of fields of retention

The retention fields acting against withdrawal forces have to be evenly distributed among the clasp teeth and ideally placed in a corresponding position. If the clasp tooth has two equally large or deep retention fields, as far as possible, an E clasp is indicated, for example. If only a single undercut exists, a passive clasp arm that serves as an embracement is necessary (e.g. G clasp). This has the advantage that the clasp scarcely deviates from the specified insertion and removal direction.
The natural tooth is exposed to a slight horizontal shear load at the most. A major functional disruption occurs if the rigid guide arms prematurely lose their contact to the tooth. If clasps are not arranged opposite of each other (correspondingly) in this case, the denture tilts and searches for the easiest path. In places where clasp arms must bend up or move excessively, this leads to physiologically unwanted shear stress on the clasp tooth.

Therefore, ring and back-action clasps arranged one-sidedly must be viewed very critically since both have extremely long clasp arms and deep undercuts. Retention fields positioned opposite each other or in a line have to be used as an embracement for this reason. Only if the force of withdrawal is distributed evenly, can the denture be removed from the patient‘s mouth without tilting.

In the selection of the undercuts, therefore, the focus must be placed on the requirement for corresponding retention fields. The undercut is positioned accordingly in both halves of the jaw either buccally or lingually. In the case of a diagonal clasp retention line, it can be placed in a labial as well as disto-buccal position.

Specifying the undercut point

Measuring and drawing the undercut point (point of termination of the active clasp arm) are the next steps in model surveying. The retention capacity of the denture and the clasp length are defined through the undercut point. The clasp should guarantee a secure physical hold of the natural tooth and be restricted to the absolutely necessary size to avoid extensive tooth coverage. Its function determines its design. If, for example, a low tensile load is expected (small tooth-bounded saddle, 2 clasps), a short arm and a small undercut are adequate. The requirement for a secure physical hold of the tooth often leads to overdesign (overdesigned structures). When weighing up the advantages and disadvantages of a longer clasp arm, aesthetic and hygienic aspects should also be taken into consideration. Small approximal embracements are often sufficient here as a clasp substitute and represent the better solution.

The analyzing rod is replaced by the appropriate undercut gauge or an undercut depth measuring unit. The standard undercut gauge from the Ney system is marked with rings on the shaft.

Ney instruments

The tooth surfaces below the prosthodontic equator are available for anchoring the partial denture. The clasp teeth specified for measurement have a different curvature. In the case of a pronounced curvature, the undercut gauge finds the rest point only a slight distance away from the prosthodontic equator. This has the advantage that the clasp tip later runs with an adequate spacing to the marginal gingiva. The prosthodontic retention is significantly better with greatly curved tooth surfaces where the clasp can snap into place. Moderately inclined retention fields have the advantage that the clasp tip can be integrated gently. A disadvantage is that it can easily detach itself from its position under tensile load. This is why retention fields with greater curvature are advantageous for denture anchoring in the case of free-end saddles, which are greatly subjected to tensile stress according to experience.

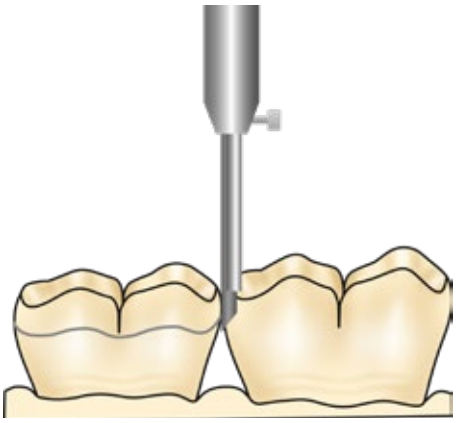
Note: Measuring begins at the clasp teeth with the highest value.
Vital clasp teeth with load capacity must be classified higher than already root-treated or diverging teeth or teeth tilted towards the path of insertion. In the measuring process, the undercut gauge is moved on the auxiliary line downward until the gauge edge and the shaft are positioned at the clasp tooth. If no undercut, too little undercut or too great undercut is shown when positioning the undercut gauge, the model is tilted slightly in the mesial (anterior) or distal (posterior) direction. The lateral tilt makes even insertion difficult and must be avoided as far as possible. If the desired undercut depth cannot be achieved even with barely acceptable model tilting, the largest possible value is used. An additional clasp or an arm reinforced in its cross-section can improve the retentive force of the denture.

Since the clasp reaches its lowest point at the auxiliaryline, a minimum spacing of 1.0 – 1.5 mm from the clasp edge to the marginal gingiva has to be maintained. The pencil drawing (auxiliary line) is interrupted by a slight scraping with the undercut gauge at the contact point of the undercut gauge to the plaster tooth in order to define the undercut point.

Drawing the height of contour (prosthodontic equator)

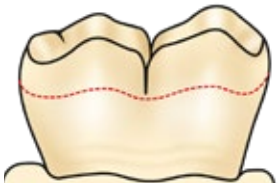
The undercut gauge is replaced by a carbon marker and the reinforcement rail from the surveying set, which secures it against breakage. Used carbon markers should be replaced promptly. To draw in the clasp shoulder, the complete course of the prosthodontic equator (survey line) must be known. In the case of an unchanged model position, the carbon marker is moved around the clasp tooth with slight pressure.

Hint: The small interdental spaces cannot be recorded with wide carbon markers. It is therefore suggested that the carbon markers be beveled on one side with a sharp blade. In this way they can also be used in the approximal areas.



Beveled carbon marker reaches critical areas

The carbon marker marks the prosthodontic equator at the largest extension of the tooth, based on the path of insertion. Since the clasp line results primarily from this marking line, the prosthodontic equator is also called the height of contour. The prosthodontic equator results from the respective position of the model table (path of insertion). It is not identical to the anatomic equator, which runs parallel to the tooth axis.



Anatomic equator

Prosthodontic equator, also named constructive equator

Drawing the clasp line

To draw in the clasps, the model is taken out of the model holder (tilt-top surveying table). If the tooth surfaces are normally inclined towards the path of insertion, a third of the clasp runs below the prosthodontic equator. This is where the denture finds its support (active part of the clasp). The passive part of the clasp arm runs on or above the prosthetic equator. It compensates for shear forces and in this way prevents lateral movement of the denture. If undercut areas are located only in a buccal position, for example, the palatal clasp arms run consistently on or above the prosthodontic equator.

The clasp drawing is not carried out to the full width, but exclusively centrically. The clasp tip is extended approx. 1 mm beyond the previously defined undercut point and the vertical auxiliary line. The minor connector leading to the clasp is touching accurately to the tooth only in the upper occlusal third. Below the prosthodontic equator it runs without contact. This is the only way to ensure smooth insertion and removal of the denture.

Note: Surveying the master model is directly connected with selection of the type of clasp. Here it is shown whether the desired clasp is actually suitable from a functional and aesthetic point of view.