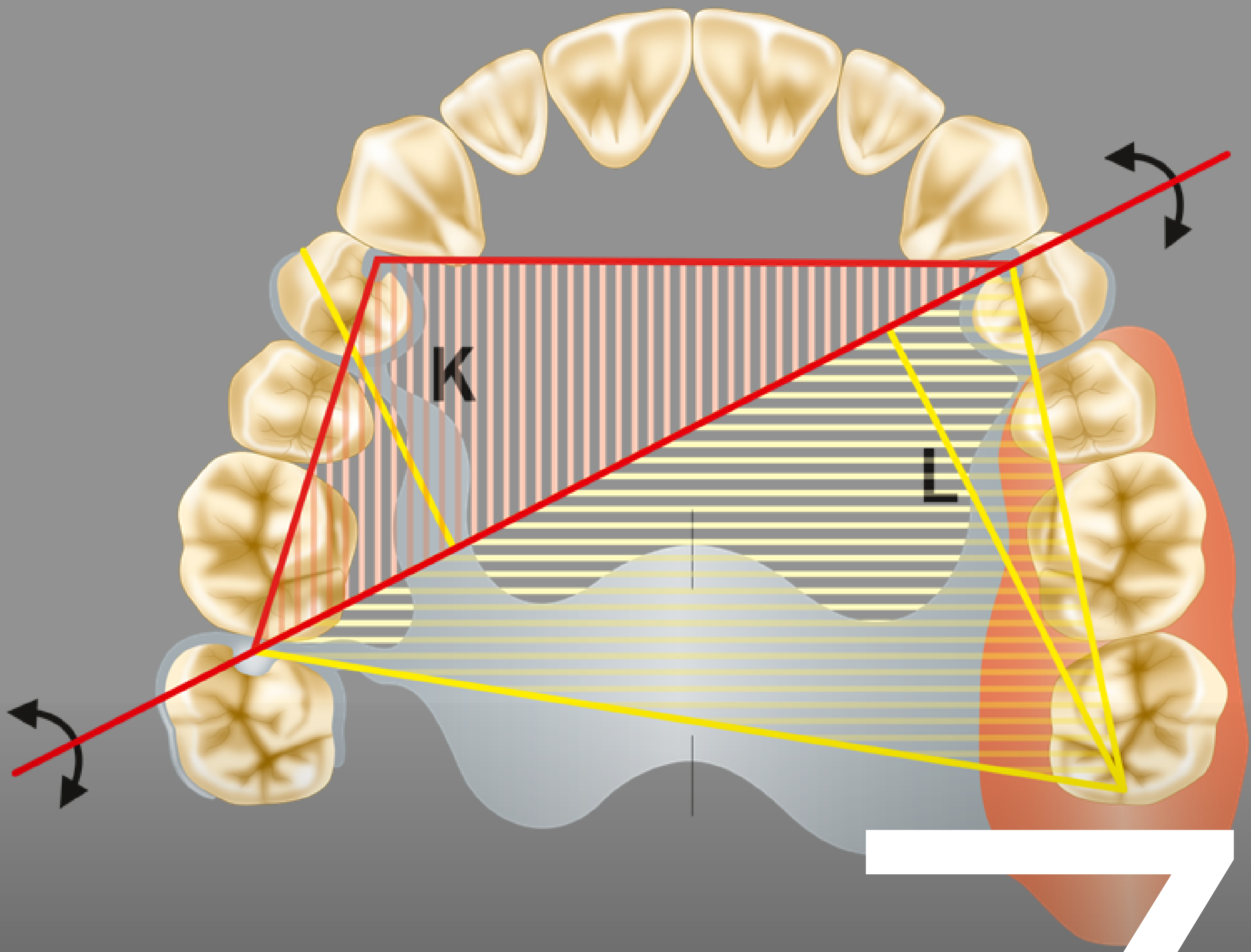


7

Denture kinematics and support

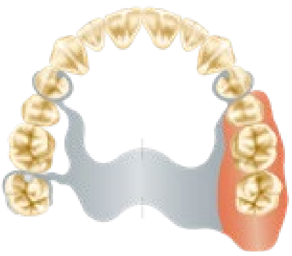
Constructive aspects

In the case of tooth loss, the static structure of the dental arch changes. Forces that were originally harmoniously distributed to the complete dental arch are concentrated on the remaining teeth. Production of the denture must take into account the processes of saddle dynamics. This is the prerequisite for flawless masticatory function and protection of the oral structure against further damage. Indication of a partial denture frame exists in particular, if a reduced dental arch stands in the way integration of a purely periodontally supported denture (e.g. bridge) for static reasons. The partial denture closes the gaps.

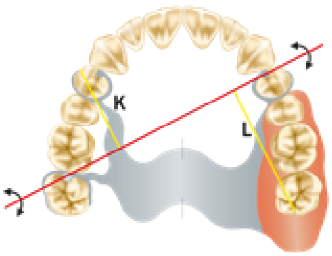
Note: The fewer the teeth are available as abutments, the more the mucous membrane and/or jaw bone must be utilized as a force-transmitting surface.

Stable WIRONIUM®-made denture with large base

The topography of the partially edentulous arch has a great influence on the denture dynamics. Under masticatory pressure part of the forces is transmitted via the occlusal rests and/or periodontia of the clasp teeth. The remaining portion of the forces is transmitted via the denture saddles to the toothless jaw sections. The share of the periodontal and gingival transmission of forces varies depending on the number and distribution of the teeth directly or indirectly included in the construction. Compression of the tissue and movement against the tissue or possibly tilting of the denture occurs in the areas borne by the mucous membrane. As a result of this, permanent denture rotation may develop because complete support on natural teeth is no longer possible.



Unilaterally shortened dental arch



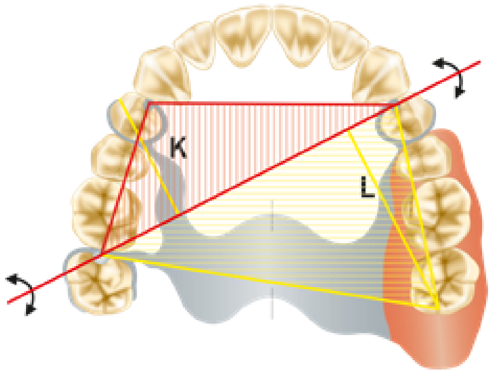
Denture rotation via fulcrum line under saddle load

Rigid clasp arms can slightly restrict the inherent mobility of the denture. Clasp tips always have extensive support in the retention field and not in a retention groove, such as an anchor. Therefore, it is hardly possible to achieve a secure hold and the extensively rotation-free support with a clasp as a retaining element.

Definition of terms for denture kinematics/ saddle dynamics

Gingival loading field
It is defined by the number and distribution of existing teeth and cannot be changed primarily. In the gingival (mucosal) loading field the denture (base and saddle zones) is given its support on the mucous membrane. The fewer teeth exist, the fewer the periodontal support options, the more the denture base must be extended.

Periodontal loading field
The periodontal loading field results from the number of teeth that may be used for support. Its size is defined by the individual selection of support points.



Gingival loading field – crosshatched in yellow
Parodontal loading field – crosshatched in red

Area of support
The area of support is the geometric field which results when the support points actually used are linked to each other (see periodontal loading field). Denture parts placed within this area are securely supported. Replacement teeth located outside the support lines may damage the mucous membrane under load due to settling (tilting) of the denture. Ideally, the area of support is just as large or larger than the gingival loading field.

Clasp retention line
The clasp retention line connects the retention fields of opposite clasps. It begins in the middle of the retention field and runs preferably diagonally through the denture body as far as possible.

Line of support (thrust line)

The support lines result from connection of the support points. They should run peripheral to the gingival loading field, on the margin of the denture body, as far as possible. Ideally the support lines on the two jaw halves are equally long (e.g. Kennedy class III). In the case of a unilateral free-end situation, the length of the support line approximately corresponds to the length of the row of replacement teeth.

- Support line = 2 rests
- Area of support (support polygon) = from 3 rests and up

Axis of rotation or fulcrum line

This line connects the support points (rests), via which the free-end extension rotates under saddle load, to each other. With one exception (Kennedy class I) it always runs through the support points (rests). Only in a bilateral free-end situation does a maxillary tuberosity /retromolar pad assume the function of the support point. The line of rotation runs diagonal! Consequently, from the tuber on the non-loaded side to the terminal tooth of the free-end saddle loaded in each case.

Lever arm of a force (lever)

It counteracts the pressure and tensile forces. In design drawings, the force arm runs from the line of rotation at a right angle to the clasp tip furthest away. If the saddle rises under tensile load, the rest and rigid clasp arm act as an embracement or compensating element. If the saddle settles under pressure load, the clasp tip counteracts the lifting of the denture at the outer end of the force arm. A long force arm improves the secure seating of the denture in all load variants.

Load or load application arm (resistor)

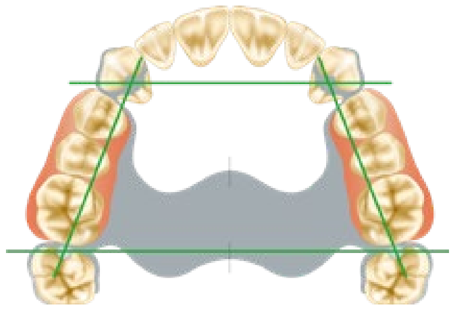
The load arm transmits leverage forces from the loading point to the line of rotation. In a design drawing it runs from the axis of rotation at a right angle to the distal end of the terminal replacement tooth subjected to load (e.g. Kennedy classes I and II). In the case of a frontal edentulous space, it runs from the line of rotation to the outer, i.e. front, margin of the anterior arch. The relationship of the load arm with the force arm is improved by shortening the load arm.

Compensating elements (indirect retainers)

Clasp or base parts can act as compensating elements for tensile and pressure forces. During planning and design, it is necessary to compensate for pressure, tensile and shear forces through clasp or base parts. Retaining and supporting elements or the minor and major connectors can serve to compensate for these forces depending on the denture dynamics and position of the lines of rotation. Example: A tensile force applied to the free-end saddle leads to a situation on the opposite side of the jaw in which the clasp (rest) is pressed against the tooth. In addition to the rest, a broad-based, rigid clasp arm as well as a second rest can act as compensating elements. This reduces the denture dynamics since the compensating elements restrict the lifting of the free-end saddle. Additional compensating elements not necessary for denture anchoring (indirect retainers) must be avoided. They lead to one-sided leverage.

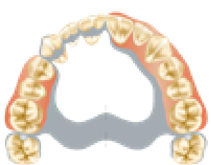
Tooth-supported edentulous areas (interrupted dental arch)

If exclusively tooth-supported gaps/tooth-bounded saddles are closed, the clasp-anchored partial denture has favorable prospects. In the case of periodontally supported saddles, resorption of the alveolar bone takes place more slowly than with periodontal-gingival or purely gingivally supported saddles. The transmission of forces here is reliable because all replacement teeth can be set up along a support line that connects the rests.

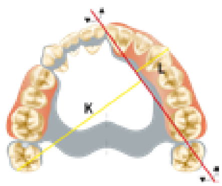


Parodontal support

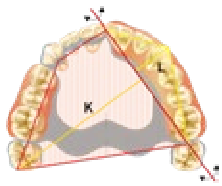
An exception is the extremely long tooth bounded saddle on which the row of replacement teeth runs in a curve. A rotation may occur here under masticatory pressure via the two-sided support at the saddle. The tooth bounded saddle settles in this process (load arm) and at the same time the clasp on the opposite side of the jaw applies a tensile load to the abutment tooth (force arm). Therefore, the load arm must be structurally designed as short as possible and the force arm as long as possible. Because the replacement teeth have to be set up according to aesthetic and functional aspects, only little scope exists to improve the load arm/force arm relationship.



Situation with wide tooth-loaded saddle

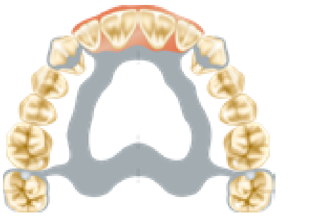


Rotation via the support near the saddle

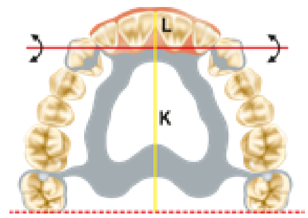


Roatation via the support away from the saddle

Anterior edentulous spaces (Kennedy class IV) should be treated with a fixed anterior bridge, to the extent this is statically feasible. A clasp-supported denture would be a compromise here based exclusively on economic constraints. Under load, the tooth-bounded saddle settles in the front and the denture tilts over the rests bordering the saddle (load arm). At the same time, a strong tensile load is applied to the posterior clasp teeth (force arm). A properly thought-out construction can improve the prognosis: the tooth-bounded saddle in the front is given mesial support and the clasp anchoring is shifted to dorsal as far as possible.



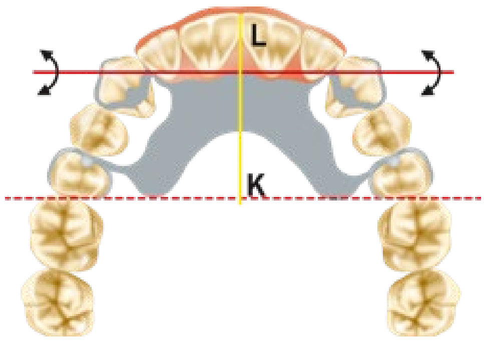
Anterior edentulous space



Dorsal anchor – long force arm

With a suppourt away from the saddle, there is an even and acceptable leverage depth of the saddle during masticatory pressure.

A short load arm and a long force arm are created. With a short force arm, by contrast, the denture lacks secure seating – it easily lifts itself out.



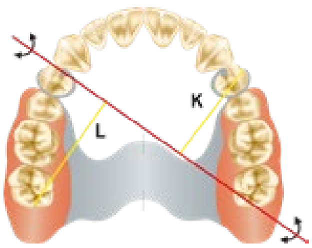
Unfavourable load/force arm relation (faulty design)

Free-end situation (shortened arch)

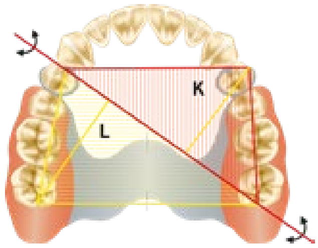
Free-end situation in the upper jaw – WIRONIUM® denture

In the case of partial dentures, the transmission of forces takes place differently to fixed dentures or well connected combination dentures. In the case of a shortened arch and the therefore required free-end saddle, it is consequently necessary to have a well thought-out prosthodontic solution. The mucous membrane must replace the function of the missing teeth in terms of transmission of forces. Even with extensive support via saddle or base parts settling of the free-end denture can hardly be prevented. A thoughtlessly placed rest may enhance harmful leverage forces and thus fester premature loss of the clasp tooth. In the case of bases with a filigree design and narrow saddles, there is increasing settling of the denture because support is provided on the mucous membrane only to a limited degree. Accordingly, the snowshoe principle must be kept in mind in connection with extension of the denture base. The force applied is transmitted over a large rest area through a broadly designed base such that the relieved clasp teeth are available for denture anchoring for a longer time.

With a shortened arch on both sides (Kennedy class I), leverage can not be avoided due to the differences in resilience between abutment teeth and tegument.



Unilaterally saddle load leads to a diagonal course of the fulcrum line



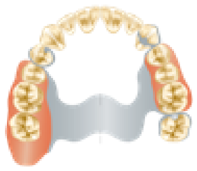
Support away from the saddle widens the paradontal loading area

A denture construction that takes this into account reduces the harmful forces to a minimum. In the planning of a denture a systematic approach, giving consideration to all important aspects, is therefore necessary in order to optimize the denture function:

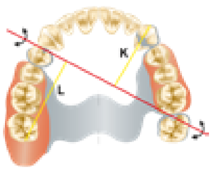
Checklist for planning and designing in the case of free-end situations

- Large extension of saddle zones is targeted
- Take into account anatomic conditions for extension and position of the denture base
- Take advantage of opportunities to reduce leverage effect:
  - Arrangement of supporting elements/indirect retainers (away from saddle)
  - Design of row of replacement teeth (length, number of teeth, occlusal contacts)
  - Extension of denture base
  - Arrangement of compensating elements (as additional clasps, rests, base parts)
  - Take into account expected pressure load depending on individual masticatory function and opposite jaw (natural teeth, fixed or removable denture).

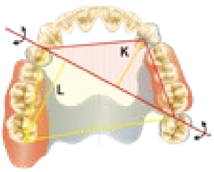
In the case of a unilaterally reduced arch (Kennedy class II), the masticatory process or denture rotation proceeds as follows: the occluding teeth have initial contact at the terminal molars. As the load increases, the denture saddle settles. The denture meets resistance at the nearby rests, one being the mesial support of the terminal premolar towards the saddle and the other the molar support on the opposite side. The line of rotation is formed between these two rests and marks the starting point of the load and force arm. The load arm is created by the masticatory force from the first contact point of the closing teeth (last replacement tooth - opposite jaw); the force arm is formed at the premolar from the clasp tip furthest away.



Unilaterally shortened dental arch



Course of the rotation line when loading the free-end saddle

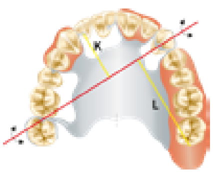


Unfavourable load/ force arm relation

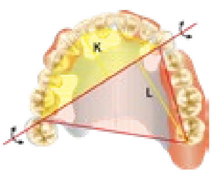
The more the saddle is subjected to masticatory pressure, the greater the tension to which the premolar opposite the saddle is exposed. While the active clasp arm inevitably moves towards the prosthodontic equator (survey line), the abutment tooth may be subject to an enormous tensile force. The extent to which the clasp arm under stress changes its position depends on the leverage conditions, the profile cross-section as well as the mechanical values. In the event of a change in position, the rest may even lift up slightly. With small tooth-supported gaps, it is frequently possible to just use a support instead of a clasp. As such, the abutment tooth is not subjected to harmful traction forces. Avoidance of clasps, however, must not result in a major deterioration in the denture retentive force.

These leverage forces, whose intensity and impact depend on the number, distribution and load capacity of the existing teeth, must be kept within tolerable limits in the structural design of a partial denture.

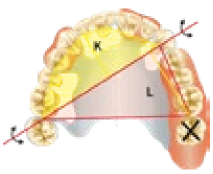
Settling and/or rotation intensify as the length of a free-end saddle and masticatory force increase. For example, marginal loads not only lead to settling of the denture, but also to painful masticatory problems and in worst case to local bone resorption. The contact to natural teeth in the opposite jaw indicates a stronger masticatory force and thus deeper saddle settling. The latter can be mitigated by shortening the artificial number of teeth. In this case, the last molar may possibly not be set up.



Diagonal clasp arrangement



Long free-end saddle, unfavorable load/ force arm relation



Shortened replacement tooth arch improves force/load arm relation

An exception is an emerging elongation of the antagonist. Especially the extensive, primarily tissue-supported saddles should be subjected to load centrally, i.e. on the alveolar ridge. Compression of the mucous membrane is given as a maximum of 1.3 mm in relevant literature. These high resilience values, which are generally measured at specific points, certainly do not correspond to the actual settling depth of an accurately fitting denture base. A compression of the mucosa by 200 – 500 µm (0.2 – 0.5 mm) appears more realistic. Even in the case of large free-end saddles with a long row of replacement teeth, the load remains within physiologically tolerable limits in this way. A large saddle and base extension as well as consistent consideration of the saddle dynamics are important. Static problems arise increasingly if all replacement teeth cannot be set up within the support points for functional or aesthetic reasons.

Note:
In particular, free-end saddles have to be checked for a flawless fit and/or the necessity of relining at short time intervals!

Extremely low number of remaining teeth

The extent to which a suitable dental support can be guaranteed depends on the arrangement of the few existing teeth. The connection of possible support points must not result in a diagonal support line. Even if only two abutment teeth remain, they can be used as clasp teeth in a tangential arrangement of the support line. In view of this aspect, unilaterally arranged groups of remaining teeth must normally also be used for support. When positioning the support points, one must ensure that the support line does not turn into a rotation axis. The latter would be the case if, for example, the denture were supported on a molar and a canine positioned on the opposite side (diagonal support line!).

Positioning of rest seats and denture Support

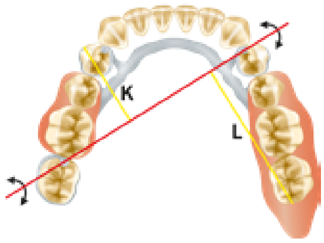
A successful periodontal support distributes the masticatory force to as many of the existing loadbearing natural teeth. However, this goal must not lead to an overdesign.

Rests prevent the settling of the partial denture into the tegument. The vertical masticatory force should be transmitted to the periodontia of the clasp teeth as far as possible via the rests (dental support). The following applies as a guideline: one rest for 1 ½ to 2 replacement teeth. Since sore spots frequently occur in the marginal zone from the base to the saddle, a stable transition (minor connector) is necessary from the rest to the frame. Preparation of rest seats helps to avoid malocclusions, among other things. On premolars a support away from the saddle (namely: mesial rest seat) is preferred in tooth-supported and free-end situations.

WIRONIUM®-denture with support away from the saddle on premolar

Supporting elements located distal to the saddle lead to rotation of the clasp tip on the tooth here because they act as a pivot point. A support near the saddle may be necessary in the case of small tooth-bounded saddles, short clinical crowns as well as frontal edentulous spaces. In the case of terminal molars, the rests are placed near the saddle.

Also with edentolous situation support away from the saddle



Complete periodontal support

There are a great number of studies and publications concerning the kinematics of free-end saddles in connection with occlusal load and on the placement of the rest seats. In the majority of cases, support away from the saddle (mesial rest seat) is advocated in unilateral and bilateral free-end situations in the relevant literature. Support near the saddle is propagated in isolated cases. This requirement is based on clinical studies in which supports away from the saddle resulted in a trend towards greater settling depths at saddle margins. However, the prevailing school of thought continues to advocate support away from the saddle.

Rest seats are prepared as a depression-like cavity, while taking into account saddle dynamics. Appropriately placed preparations make it possible for the rest to rotate slightly in its support because minimal inherent mobility of the denture in connection with masticatory movements cannot be avoided. The preparation must always take into consideration the axial position of the teeth and the path of insertion of the denture. It must also be ensured that sufficient space is available for the clasp connectors. To maintain the integrity of the dentine core, the preparation must only be carried out in the tooth enamel. Otherwise preserving and/or prosthodontic treatment of the defect is absolutely necessary. The horizontal extension (mesial-distal, vestibular-oral) of the rest cavity depends on the anatomy of the tooth. The following recommendations serve as a guideline:

- mesial-distal extension approx. ¼ of the crown width
- vestibular-oral extension approx. ½ of the crown width or half of the distance between the vestibular and oral cusp tips

The maximum horizontal extension of the prepared depressions should never exceed 2.5 mm. The material thickness of the rests, ranging from 0.6 – 1.0 mm, depends on the occlusal space available. The angle of inclination, which results from the position of the rest in relation to the main direction of load, is ideally around 90°. When masticatory pressure commences, slipping of the rest and application of shear load on the clasped tooth as well as damage to the marginal periodontium are avoided in this way. If feasible, rest seats should be provided in existing amalgam fillings or inlays. The preparation of rest seats in non-metallic fillings (composite fillings, ceramic inlays, galvano-inlays) is problematic. The same applies to crowned teeth with an unknown thickness of the crown wall. There is a risk of perforation in connection with preparation of rest seats in existing crowns. This inevitably leads to remaking the crown.

Canine and anterior teeth are frequently unsuitable for mounting supporting elements (direct retainers) due to the inclination of their clinical crown. Rests near greatly inclined oral areas do not ensure transmission of masticatory pressure forces axially to the tooth axis (particularly in the mandible). There is a risk that the tooth will be pressed out of the dental arch in a vestibular direction. This effect could be further reinforced by a vestibular retention arm in a low position. If inclusion of a canine or anterior tooth in the construction cannot be avoided, there are two possible approaches. The first one involves small rests/ embracements that ensure splinting of the tooth. These rests/ embracements require, in some cases, shoulder-shaped preparations tangent to the incisal edge. The cavity must be designed such that the rest completes the anatomic shape of the tooth. Patients often find fault with the aesthetics of this solution because the rest on the incisal edge as well as the vestibular clasp arm are visible. The second approach is to crown the tooth. Support surfaces and secure retentive fields are created in this way.

Crowns made of Wirobond support the WIRONIUM® denture

Supports to be placed on anterior teeth should always be provided in the cervical area as far as possible. This counteracts unfavorable leverage which could press out the tooth in the labial direction.

Loosened or root-treated teeth or teeth with large fillings are not very suitable for the placement of clasps. A second rest is indicated in connection with rotated or greatly tilted teeth in many cases.