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FRAMEWORK DESIGN

FOR METAL-CERAMIC RESTORATIONS

Manual

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The fabrication of aesthetic and functional metal-supported ceramic restorations requires both comprehensive knowledge and high skills. Restorations are often assessed solely on the basis of their aesthetic appearance. However, this is not quite sufficient for a functional, durable restoration. This Manual on "Framework design for metal-ceramic restorations" discusses the physical properties and materials science aspects of the two material types used, i.e. alloys and veneering ceramic, in order to outline the complex context.

In addition to the theoretical basics, the fabrication of two different framework constructions in dependence of the alloy properties will be explained step by step.

To further explain the interplay between the framework material and the veneering ceramic, all the veneers have been reduced on one side (see cover picture).

The objective of this Manual is to support you even better in your daily work.

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Framework statics (stability)

During mastication, compressive, flexural, shear, and tensile stresses are exerted on the alloy framework. The ceramic veneering material tolerates torsional movements of the metal framework only to a certain extent.
In connector areas between bridge pontics and abutment teeth, the framework material must demonstrate adequate thickness. **The framework construction must be able to withstand the mentioned forces.**

In order not to compromise the optical and functional aspects (hygiene ability), the framework reinforcements are positioned in the less obvious areas.

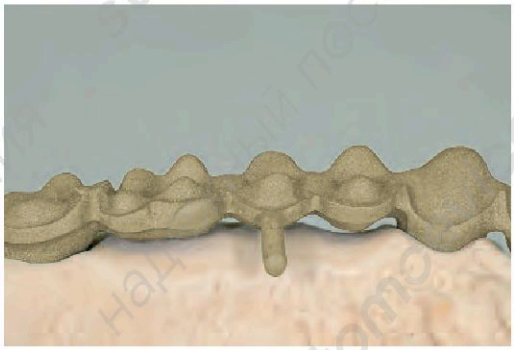
During oxidation and the subsequent ceramic firings, alloy frameworks are exposed to considerable thermal stress. If the framework design is incorrect and the wall thicknesses are insufficient, the heat treatment may cause distortion of the framework alloy and, eventually, inaccuracy of fit. The ceramic exerts compressive stress on the framework during sintering and the subsequent cooling phase. Only an appropriate design of the framework protects from deformation.



Heat treatment may result in deformation of too thin and too delicate framework constructions. This may lead to considerable problems affecting the marginal integrity during firing and during the cooling phase due to residual thermal stress caused by the difference between the CTE of the alloy and that of the ceramic material.

Only if the framework is stable enough, is the fabrication of a full ceramic veneer possible. If not enough space is available, the stress-bearing areas of the veneered bridge are fabricated of metal (with a fully anatomic design).



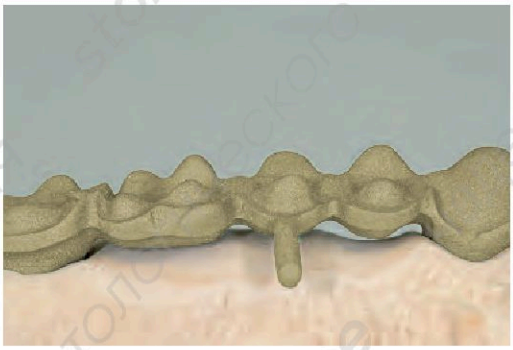


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Strength of bridge frameworks

The alloys and the working technique have to be selected in such a way that the fabrication of a stable framework for ceramic veneering material is possible.

The strength of the alloy framework is influenced by the preparation, abutment teeth, contour of the abutment teeth, type of alloy, and the design of the framework.



Bridge reconstruction made of a high-gold alloy



Bridge reconstruction made of a palladium-based alloy

Important

It is important to know the properties of the alloy, particularly the modulus of elasticity and the 0.2 % proof stress.
The lower the modulus of elasticity and the 0.2 % proof stress, the more stable the framework walls and connector areas of the bridge framework have to be designed.

If the alloy features a high modulus of elasticity and proof stress, a high amount of force is required to deform the alloy framework.





Base metal alloys with a higher modulus of elasticity and a higher proof stress may be used for more delicate framework designs.

Since base metal alloys oxidize more easily and intensively and show a darker oxide on their surface, they have to be appropriately masked with a thicker opaquer layer.

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Connector areas of bridge frameworks

Since a metal-ceramic bridge is also planned with aesthetic considerations in mind, special requirements are placed on the connector areas of a bridge framework. The objective is to design the connector areas in such a way that they are both stable and satisfy the aesthetic demands.

The functional requirements of a metal-ceramic restoration must always take precedence over the aesthetic considerations.

Connector variants:
- Single-piece casting
- Attachment connections
- Joining technique
  - Solder connections before and after firing (see Soldering Manual)
  - Laser arc and impulse welding connections







Single-piece casting is the most commonly used method to achieve the best possible strength of the bridge framework. **The cast structure must be homogeneous.**

TIP
If divergences exist between the abutment teeth, they are evened out by means of attachment connections.

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Connector areas / material dynamics

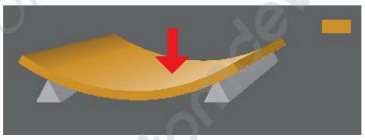
The geometry and size of the cross-section influence the strength of the bridge restoration. For dental alloys, longish and round cross-sections are selected, since the tensile and compressive strengths are basically equal to each other.

Note

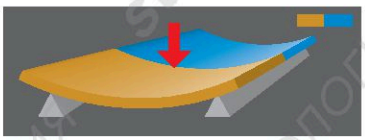
- The deflection of a bridge that rests on two abutments depends on the geometry of the connector cross-section
- The deflection of a bridge may lead to extreme stress exerted on the abutments

The larger the span width between the abutment teeth, the higher the risk of deformation for the bridge reconstruction.

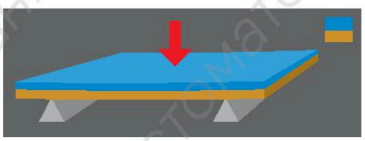
The dimensions of the framework cross-section must be large enough, especially in the direction of loading. For the posterior area, an adequate height of the connectors is important, while a horizontal reinforcement in the lingual direction should be provided in the anterior area.



Single width of the connector
= Single stability



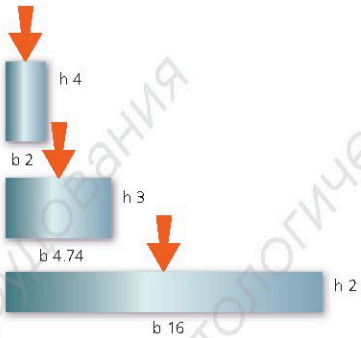
Double width of the connector
= Double stability



Double height of the connector with single width
= Eightfold stability

Note

- The height of the connector cross-section counteracts the degree of deformation
- By doubling the height, the degree of deformation is reduced by a factor of 8
- By doubling the span, the degree of deformation is increased by a factor of 8

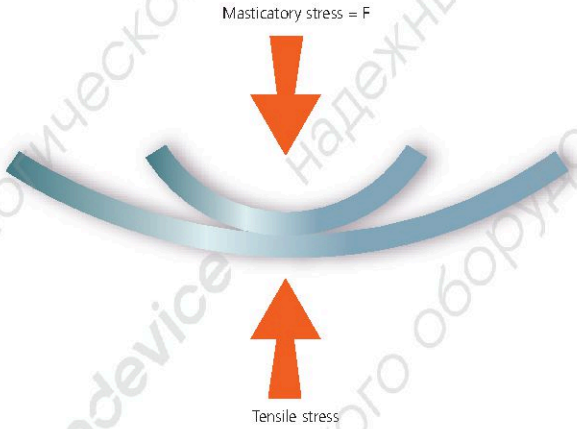


The flexural resistance is equal for all three test samples.

Important: From a clinical standpoint the height can scarcely be replaced by width.

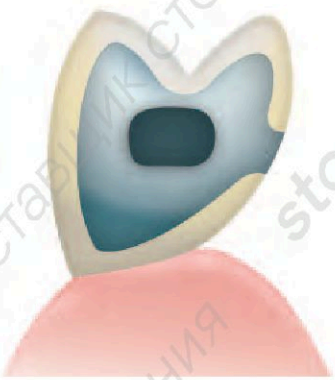
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In bridge restorations with a shorter span width, the connector cross-section must comply with the minimum requirements. If the same deformation load is applied to two beams, one of which is half the length of the other, the curvature of the shorter one will be four times more pronounced than that of the longer one. The maximum tensile strength not only depends on the absolute deflection value, but also on the corresponding curvature.



An increased curvature of the beam and/or a thicker ceramic layer at the underside of the restoration increases the tensile stress.

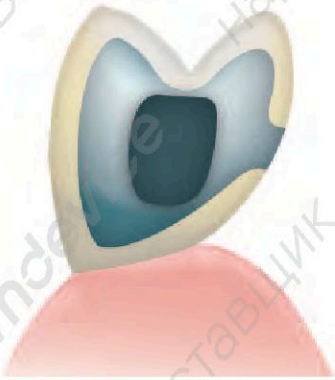
The cross-section of the interdental connector area decisively influences both the strength of the restoration during the dental-lab procedures and the clinical long-term success after cementation. Therefore, the cross-section of the interdental connector must be adequately dimensioned in accordance with the alloy used (particularly with high-gold alloys). The thermal behaviour of the selected alloy during the working procedure in the dental laboratory has to be considered for the connector design.



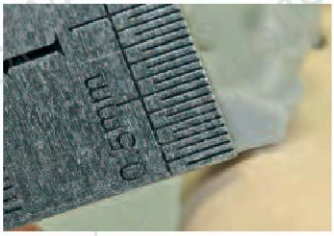
Single width of the connector
= Single stability

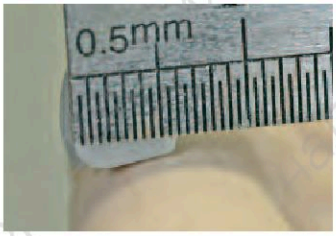


Double width of the connector
= Double stability



Double height of the connector with single width
= Eightfold stability



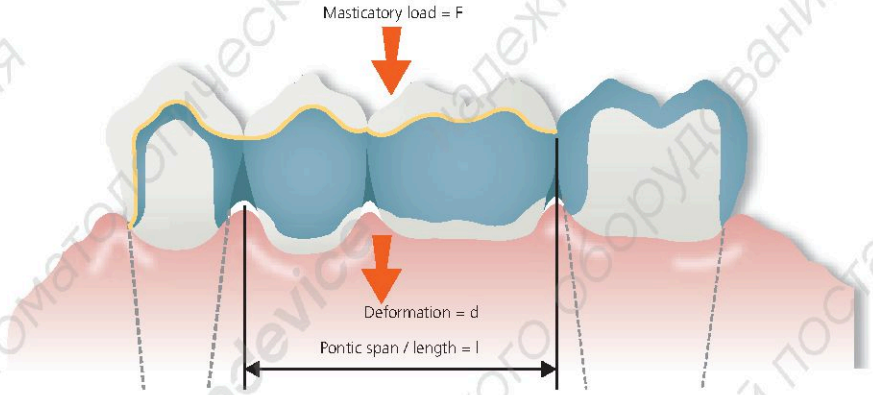




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Connector cross-sections

Materials have a limit of elastic deformation – i.e. the elastic limit. The elasticity of a material is quantified by the modulus of elasticity. The modulus of elasticity describes the resistance against elastic deformation.
For reasons of easier measurability, the 0.2 % proof stress is used as an alternative technical elastic limit.
It is actually beyond the true elastic limit, since at this load, an alloy will undergo 0.2 % permanent, i.e. plastic deformation in tensile tests.
The connector cross-sections in dental restorations must be designed in such a way that the 0.2 % proof stress is not reached under the usual masticatory forces.

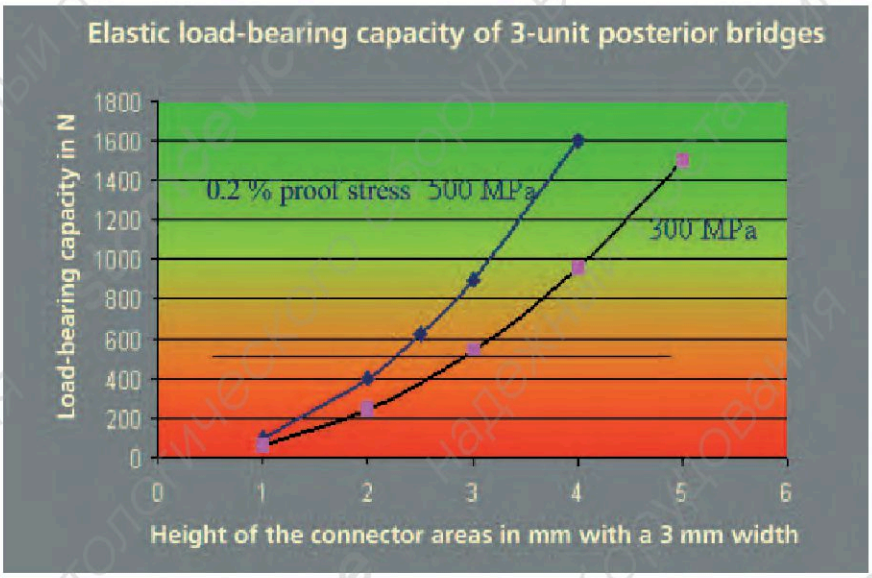


The connector cross-sections listed in the table have been defined taking the physical data of the alloys and veneering ceramic into account.
These connector dimensions are to be considered minimum requirements. They include a double safety margin as regards the specified minimum requirements.

	3-unit metal-ceramic restoration		4-unit metal-ceramic restoration	
Alloy: 0.2 % proof stress	Masticatory load = **F** Pontic span length = **l 10 mm**		Masticatory load = **F** Pontic span length = **l 20 mm**	
Load-bearing capacity in N Restoration Connector cross-sections in mm	**1000 N Premolars, molars**	**600 N Anterior**	**1000 N Premolars, molars**	**600 N Anterior**
270 MPa	3 / 5	4 / 3	3 / 6	5 / 3
360 MPa	3 / 4	3 / 3	3 / 5.5	4 / 3
500 MPa	3 / 3.2	3 / 2.5	3 / 4.5	3.5 / 3
700 MPa	2.5 / 3	2.5 / 2.5	3 / 3.8	3 / 3

The dimensions of the connector cross-sections depend on the physical properties of the materials.
Since the vertical masticatory load in the posterior region differs from the vertical/horizontal load in the anterior region, the connector cross-sections may also show some differences.

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Schematic diagram of the connector areas of two alloys with a different 0.2 % proof stress in MPa, in dependence of the masticatory load in N.

In addition to the 0.2 % proof stress, a number of other factors also influence the connector cross-sections:

- Modulus of elasticity - the higher the modulus of elasticity, the lower is the elastic deformation
- Span of the metal-ceramic restoration
- Layer thickness of the veneering ceramic – the thicker the layer of the veneering ceramic, the higher is the tensile stress (especially in the basal area)

Fracture of a metal-ceramic posterior bridge



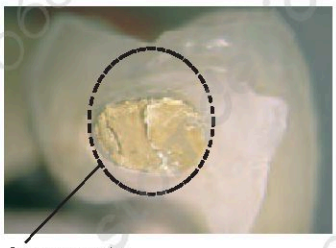


Example of a restoration that fractured as a result of an inadequately dimensioned connector cross-section



Incorrect cross-section of the metal-framework of 1.5 x 2.5 mm = 3.75 mm² – vertical dimension only 1.5 mm in the bending direction!

The connector dimensions are way below the required minimum values.



Correct cross-section

Only the correct dimensioning of the connector cross-section results in appropriate stability for a fully functional restoration.

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The following aspects have to be observed in the fabrication of metal-ceramic restorations in the dental laboratory:

- Only if there is enough space between the alveolar process and the antagonist, may the alloy framework be veneered on all sides.
- If space is limited, attempts should be made to compensate the missing height by increasing the width. However, this is most often not possible without substantially compromising the conditions for self-cleaning and oral hygiene. If the height of the alloy framework has to be reduced, the required strength can be achieved by leaving certain surfaces non-veneered.
- Scallops in invisible areas of the restoration increase its strength.
- If additional strength is necessary, the palatal surface in maxillary restorations and/or the lingual surface in mandibular restorations may be left non-veneered.
- If space is extremely limited, yet another outer surface of the restoration must remain non-veneered. This may either be the vestibular or occlusal surface in the mandible, while it is always the occlusal surface in the maxilla.
- If there is only enough space for the minimum metal cross-section, the bridge restoration cannot be veneered.
- The alloy framework must never be designed with weak statics just to fabricate a questionable veneer.
- For bridges with shorter span widths, the same minimum requirements must be observed.
- The aim is to achieve an even ceramic surface.
- If uneven ceramic layer thicknesses cannot be prevented, the thicker layers should always be located in the pressure areas.

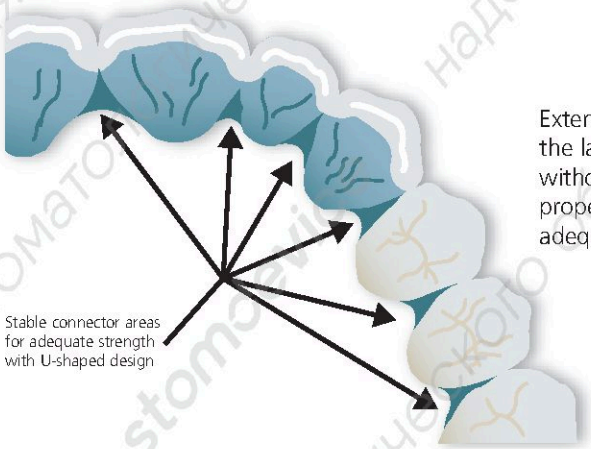


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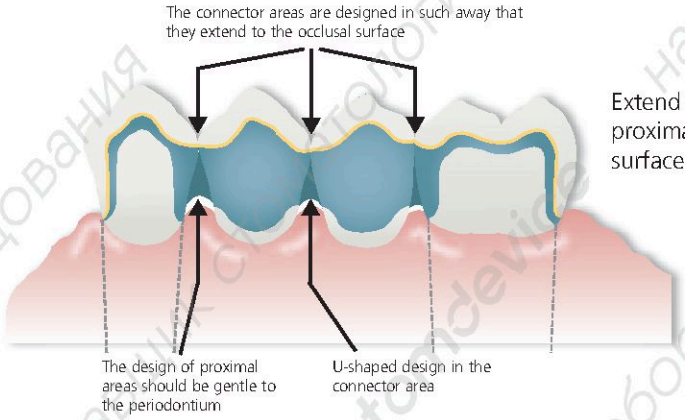
Connector areas / direction of loading

In pure posterior bridges, vertical occlusal forces are the strongest of the occurring forces. In the anterior region, horizontal stress in a sagittal direction caused by protrusive and lateral movements of the mandible during intercuspation are also exerted on bridge reconstruction in addition to the vertical occlusion forces.

Framework connectors between the anterior and the posterior region, therefore, also have to be given an adequately stable design in a horizontal lingual direction, as well as the suitable height.



Extend the connectors as far as possible towards the labial/buccal and occlusal/cervical aspect without overly compromising the aesthetic properties. The connector area must provide adequate strength and stability.



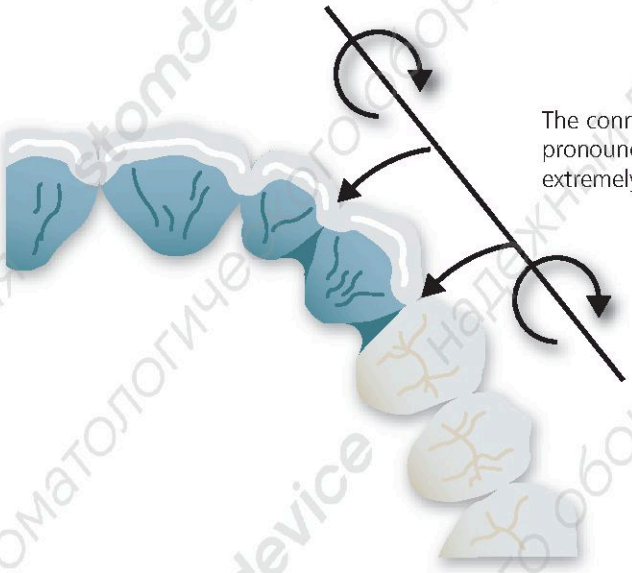
Extend the connector area lingually and proximally as close to the occlusal and labial surface as possible.





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Particularly in the canine area, tensile and torsional stresses are also exerted on the connector areas, in addition to the vertical and horizontal stresses.



The connectors of canines should be particularly pronounced, since they have to withstand extremely high stress.

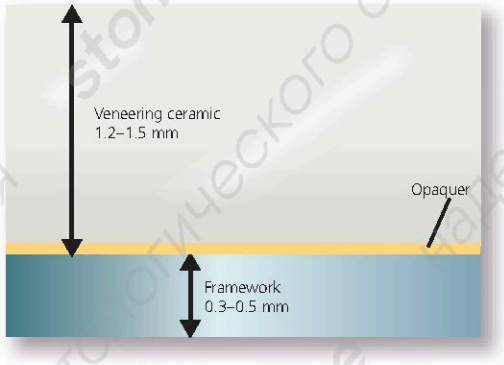


The connector areas must always be designed to ensure adequate stability. The lingual area should have a U-shaped design towards the gingiva.

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Factors for the strength of alloys and metal-ceramics

The average thickness of veneered framework constructions is 1.5–2.0 mm on the labio-buccal side; 1.2–1.5 mm thereof are made up of ceramic material and 0.3–0.5 mm of alloy. The greater part of the occurring forces (e.g. occlusal forces) is borne by the alloy framework.

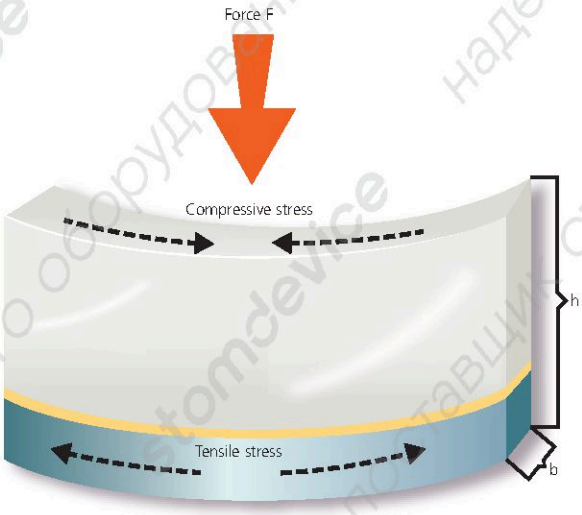


The homogeneous bond between the alloy and the ceramic layers not only increases the strength of ceramic-veneered frameworks, but also substantially reduces the fracture susceptibility of ceramic materials. In fact, it is this sound bond between alloys and veneering ceramics that permits minimum alloy framework thicknesses of 0.3–0.5 mm.

The strength of a metal-ceramic bridge largely depends on the alloy framework, if tensile stress at the ceramic surface is to be expected.



The applied force produces compressive stresses at the upper side of the bridge reconstruction and tensile stresses at its underside. The compressive strength of the ceramic is considerably higher than its tensile strength. If the tensile stress exceeds the tensile strength of the ceramic, cracks may develop which will ultimately result in fracture.



The most important factors determining the strength of the metal-ceramic restoration include the bonding strength at the interfaces, the strength of the framework, and the different coefficients of thermal expansion of the alloy and the ceramic.

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Coefficient of Thermal Expansion (CTE)

The coefficient of thermal expansion is a unit of measure for the dimensional changes of a substance under a defined thermal influence. The CTE is the unit of measure to determine a possible alloy-ceramic combination.

As a rule, the CTE of the veneering ceramic must be lower than the CTE of the alloy. In this way, the veneering ceramic is put under compressive stress.

Ceramic alloys and ceramic veneering materials must have similar coefficients of thermal expansion in the temperature ranges of 25–500 °C or 20–600 °C in order to keep the stresses in the interface areas of both materials to a minimum. Ceramic alloys have a slightly higher coefficient of thermal expansion than ceramic veneering materials. This results in the development of tensile stresses in the alloy during cooling after firing, and of compressive stresses in the veneering ceramic.

Ceramic materials with a CTE value that is approximately 1 mm / m k lower than that of the alloy are selected. This means that for traditional feldspar ceramics, the CTE value should be at least 5 % but a maximum of 10 % below the CTE value of the alloy. Basically, the instructions of the corresponding manufacturers have to be observed.

High CTE of the alloy / low CTE of the ceramic	Select a firing cycle with slow cooling
Low CTE of the alloy / high CTE of the ceramic	Select a firing cycle with quick cooling

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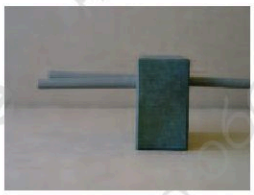
Heat resistance

Heat resistance describes the stability of shape of materials under the influence of heat.

During oxidation and firing of the veneering ceramic, the alloy must demonstrate adequate heat resistance to prevent the alloy framework from sagging (sag resistance). This is particularly important for long-span bridges. Therefore, alloys are usually required to have a solidus temperature that is approximately 100 °C higher than the firing temperature of the veneering ceramic.



Pins before a heat resistance test
Dimensions of the pins: Length 50 mm, diameter 4 mm



Metal pins bent by gravity after a 10-minute heat treatment at 1005 °C, i.e. 50 °C below the solidus point

The heat resistance depends on the following factors:

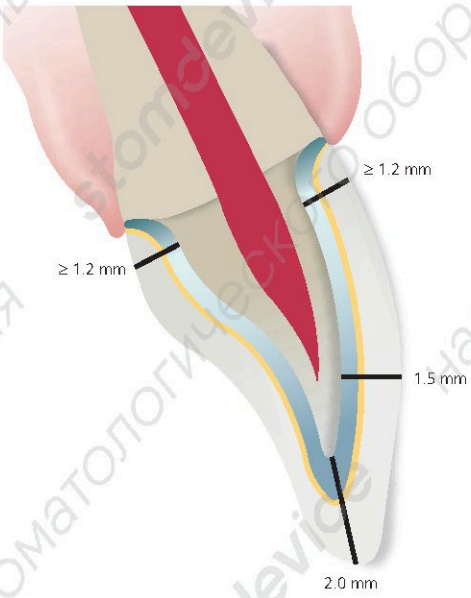
- Composition of the alloy: In general, high-gold alloys that do not contain any metals of the platinum group demonstrate low distortion resistance.
- Framework design: Depending on the alloy type used, the contouring of the framework must be carried out in such a way that adequate support is provided. Large span widths with massive pontics always increase the weight of the restoration and thus require a stable framework.
- Density of the alloy: The higher the density of the alloy, the higher is also its weight.
- Temperature: If possible, the solidus point of the alloy should be as far away from the firing and soldering temperatures as possible.
- Duration of the heat treatment: The longer the duration of the heat treatment, the higher is the risk of distortion.
- Oxide firing: In order to achieve an accurately fitting bridge framework after firing, the framework must always be adequately supported during the firing procedures (starting with oxide firing and continuing with all the subsequent firing cycles). All abutments must be supported using firing pins.
- Furnace calibration: The ceramic furnace must be regularly calibrated to ensure exact temperature control.

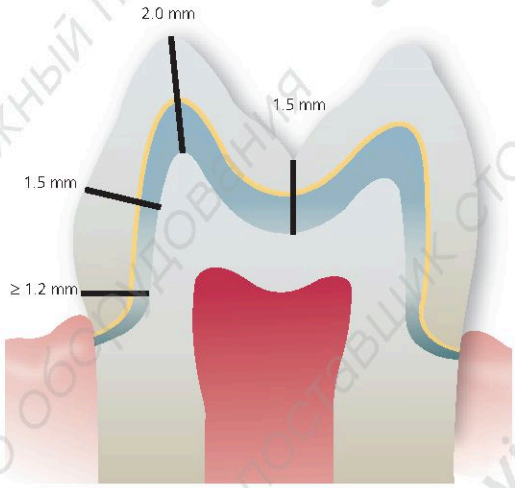
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Basic prerequisites of abutment preparation

An adequately stable and aesthetic metal-ceramic restoration is also achieved by a preparation with ample available space.





The minimum reduction for the preparation is 1.2–1.3 mm in the central area and usually 1.5–1.6 mm in the incisal area.

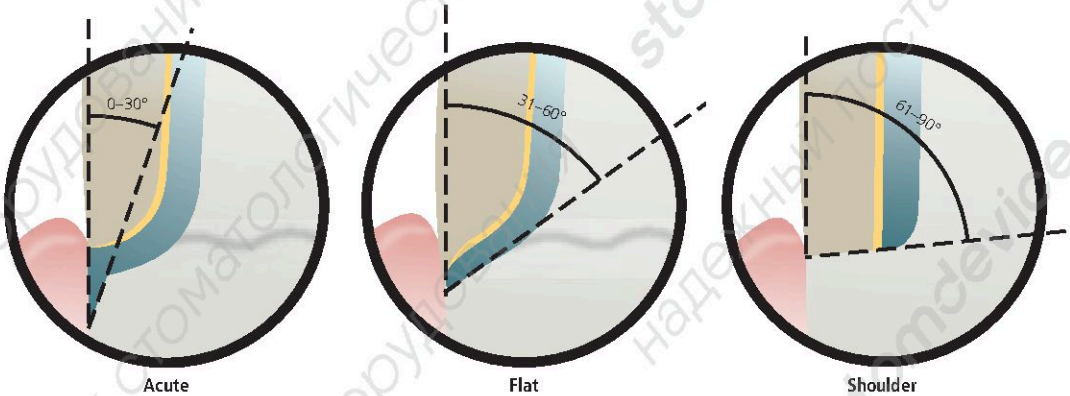
If conventional cementation is to be applied, a minimum height of the prepared stump of 3 mm and a convergence angle of approximately 6° have to be observed.

More space for the metal-ceramic restoration is always considered ideal and should be preferred.

If the minimum space requirements cannot be met because the abutment tooth cannot be adequately reduced (prepared), a metal-ceramic restoration is contraindicated.

Preparation in the marginal area:

The larger the marginal angle, the more ideal are the conditions for creating a ceramic shoulder or for neatly veneering the metal margin with ceramic. With angles smaller than 50°, the metal margin may only be covered with an over-contoured ceramic layer. A visible alloy margin is then almost unavoidable.



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Framework design in the marginal area

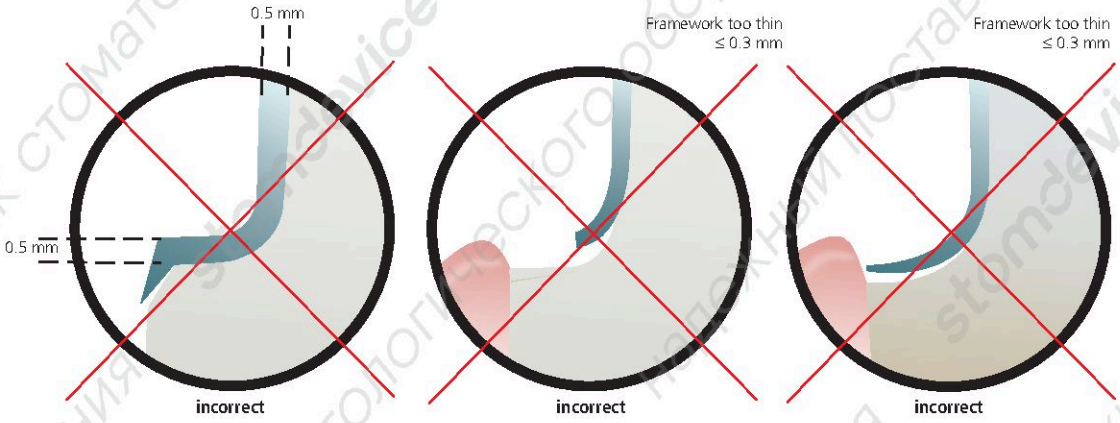
The crown design in the marginal area and the accuracy of fit on the natural tooth stump directly influence the periodontal health.

For ceramic veneers, the materials at the crown margin must demonstrate a minimum thickness in order to achieve ample stability and appropriate shade reproduction.

The accuracy of fit of the alloy framework must be maintained even after several ceramic firings.

Deformation of the alloy, which might occur as a result of the slight difference between the solidus point of the alloy and the firing temperature of the ceramic (approximately 150 °C), must be prevented by designing a stable, robust framework.

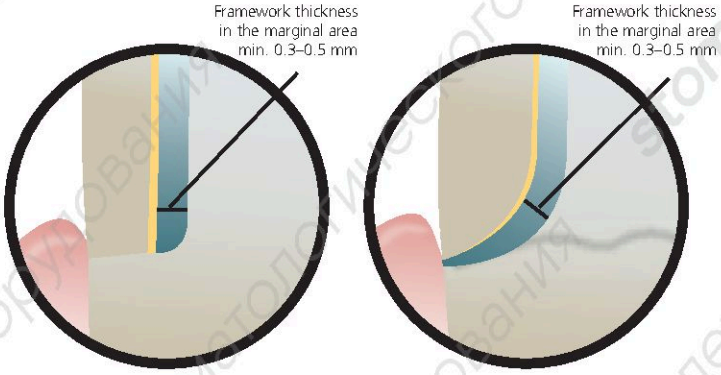
During the ceramic firing cycles, the framework in general and the margin area in particular must not expand.



For the physiological design of the crown margin, the following aspects apply:

The crown margin ...

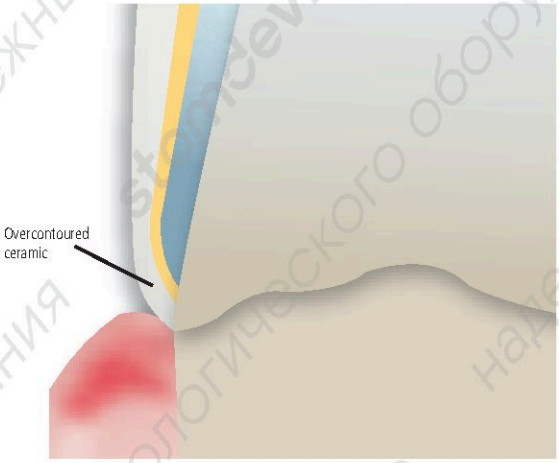
- **... must show sound accuracy of fit with the preparation margin**
- **... must be able to withstand the effects of masticatory stress**
- **... must demonstrate permanent stability of shape**
- **... must produce a smooth, gapless transition to the prepared tooth**
- **... must run in the sulcus gingivae**



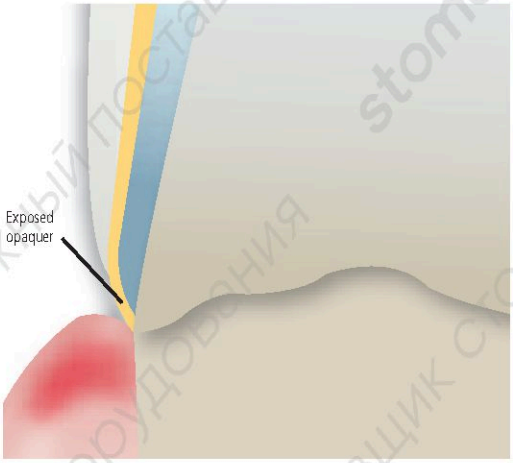
Only the definite end of the margin is tapered.

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Important:
An inadequate crown margin design may lead to (secondary) caries and injury to the marginal periodontium.



The metal framework can only be veneered by overcontouring the ceramic

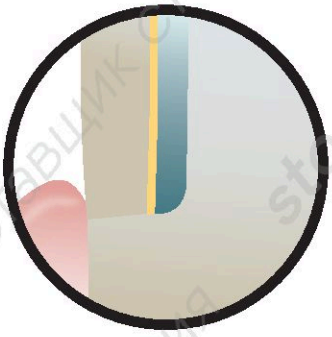


If the overcontoured area is eliminated, the opaquer is exposed

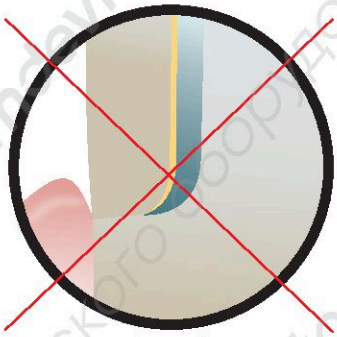
The restorative crown margins should be designed in such a way that the natural tooth contour is continued in the marginal area of the crown and the veneer. Over- or undercontoured crown margins have to be avoided, since they may lead to injury of the marginal periodontium.
A flawless crown margin is indispensable.

Fused-on ceramic shoulder

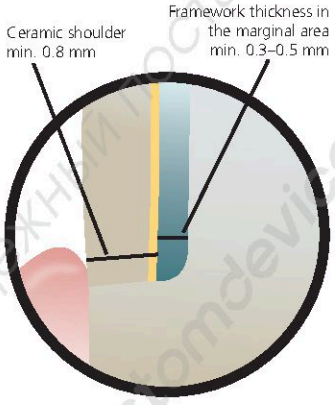
- Shoulder or chamfer preparation
- The entire shoulder area is supplemented with ceramic shoulder material
- Presents optimum possibilities for a precise marginal finish
- A ceramic shoulder produces the least stress in the cervical area
- In aesthetically critical areas, optimum space conditions for the framework and the ceramic should result in excellent aesthetics



correct



incorrect

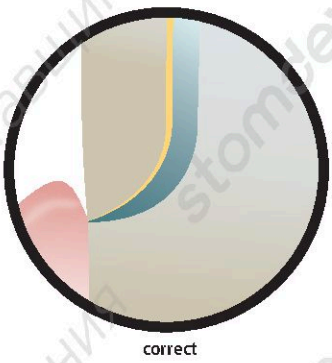


Note
With fused-on ceramic shoulders, it must be made sure that the framework, as well as the veneer is supported by the prepared tooth. Reduce the framework exactly up to the inner edge of the chamfer or shoulder preparation. In this way, functional support of the framework by the preparation is ensured.

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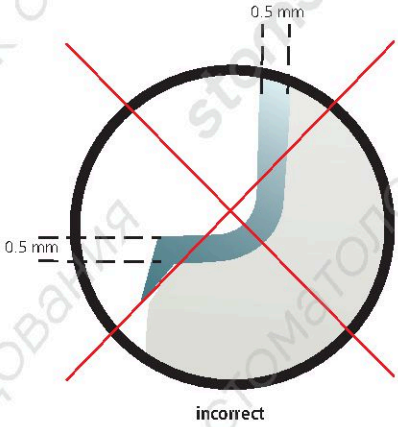
Tapered (non-visible) metal margin

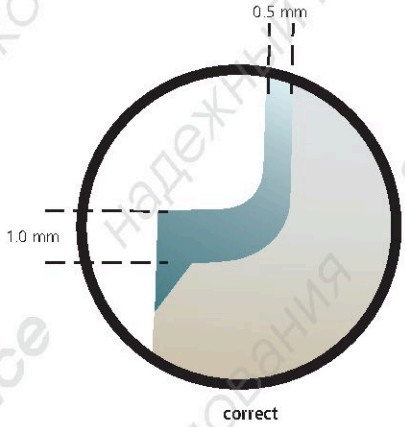
- Shoulder or chamfer preparation
- The metal margin is reduced and thinly tapered and then veneered with ceramic material
- By reinforcing the framework in the shoulder area, the ceramic is prevented from bending up
- Good accuracy of fit is achieved with a shoulder preparation
- Preferably, the crown margin should be placed slightly sub-gingival



Metal margin

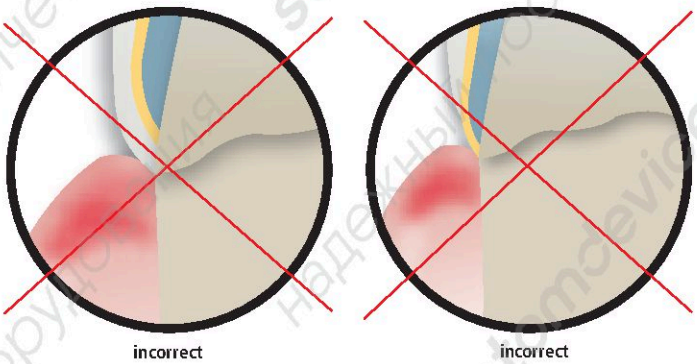
- Bevelled shoulder or chamfer preparation
- Depending on the width of the bevel, the alloy margin will be visible in the marginal area
- A good marginal seal is possible with a bevelled shoulder
- Visible alloy margins in aesthetically non-critical areas
- The tapered margins must be reinforced to counteract the bending up of the margins during ceramic firing
- The opaquer layer of at least 0.25 mm must be covered with ceramic material, even in the marginal area. Exposed, coarse-grained opaquer material will lead to irritation of the gingiva and plaque accumulation





Tangential margin

- Is ground like a tapered margin and, in ideal cases, describes the root cross-section and the crown margin demarcation line
- Easy to prepare and features the least loss in tooth structure
- The preparation margin is barely visible in the oral cavity and on the working die
- An exact crown margin is difficult to achieve and rather left to chance
- Can be used for young teeth with a large pulp chamber
- Overcontouring in the marginal area must be prevented
- Exposure of the opaquer must be prevented (irritation of the gingiva, plaque accumulation)



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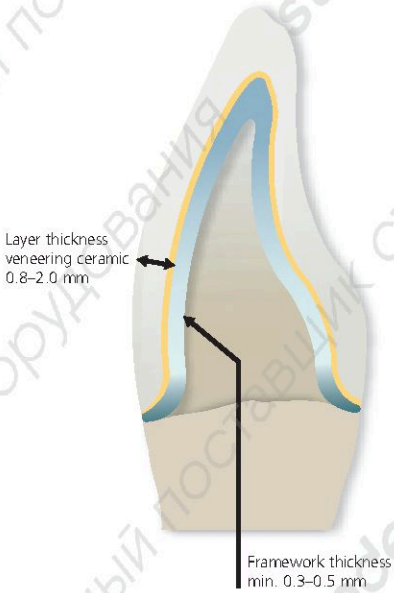
Functional framework design for the veneering ceramic

The design of the alloy framework for the veneering ceramic is of utmost importance. The functional and structural balance of the framework construction is decisive for the success or failure of the metal-ceramic restoration.

The contoured crown and bridge frameworks should always allow an even layer thickness of the veneering ceramic. In order to achieve an even shade of the veneer, the layering thickness of the ceramic veneer should not fall below 0.8 mm or exceed 2.0 mm.
If this layer thickness is not possible in the marginal area of the crown due to the risk of over-contouring, the opaquer must at least be covered with a ceramic layer of 0.25 mm.

The minimum thickness of the framework **after finishing** has to be at least 0.3 mm for single crowns and at least 0.5 mm for abutment crowns in bridge frameworks.

The reduced dimensions of the prepared abutment teeth are always evened out by the wax-up of the framework.





Varying layer thicknesses of the veneering material result in undesired shade differences and uncontrollable shrinkage of the ceramic material coupled with tensile stress.

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TIP
If no situation model is available, a full wax-up of the intended restoration should always be fabricated. The wax-up is then evenly and proportionally reduced for the ceramic veneer (1–1.5 mm; reduced contours). The thus produced reduced tooth shape then serves as the statically supporting framework for the veneering ceramic.

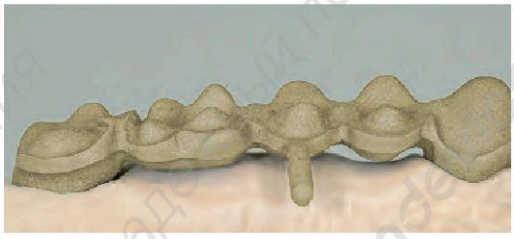




Alloy frameworks for ceramic veneers must meet the following requirements:

- Wax-up of the suitable framework construction
- Use of a suitable alloy
- A compatible alloy-ceramic combination must be used
- Stress exerted on the ceramic must be absorbed by the framework construction
- The cross-sections of the framework connectors must be dimensioned in such a way that they provide ample stability
- Scallops reinforce the framework and enable even cooling
- The pontics should be fabricated in such a way that they support the veneering ceramic and enable more even cooling, e.g. by creating scallops
- The transition areas between the metal and the ceramic must never be located in contact or gliding areas
- At the ceramic-alloy interface, the framework should be perpendicular to the ceramic (in this way, stress concentration at the ceramic-alloy interface is reduced and exposure of the ceramic opaquer at the bonding interface is prevented)
- The framework should be given a design that enables an even layer thickness of the veneering ceramic
- To achieve a true-to-nature shade effect of the veneering ceramic, a minimum layer thickness of 0.8 mm is required
- The surface of the framework construction must not show any sharp angles or edges – it must always be smooth and rounded
- Cast frameworks must not show any defects, such as porosity or bubbles
- Framework constructions must demonstrate sufficient firing stability, particularly in the marginal area
- The stress-bearing framework must be designed as stable as possible





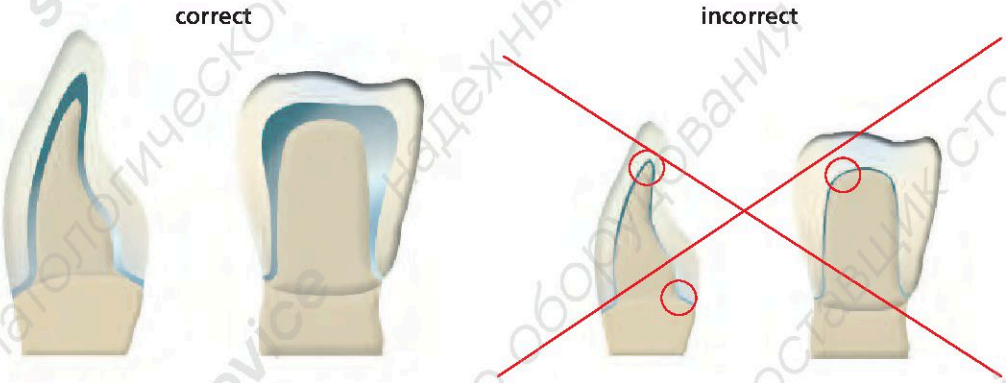
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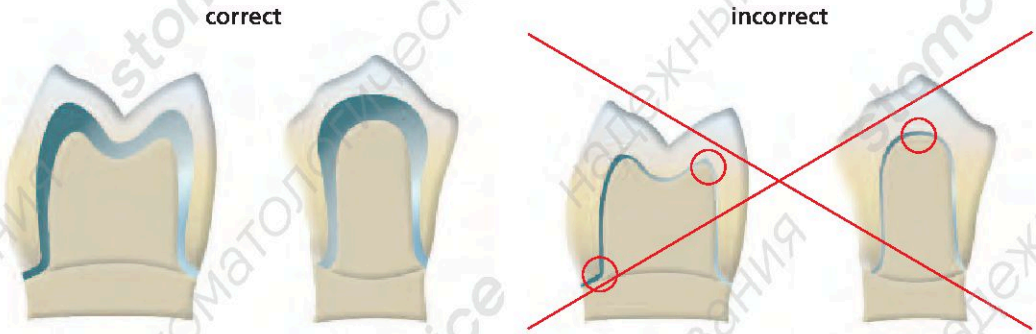
Functional support of the veneering ceramic

The framework reflects the reduced tooth shape. It must be contoured in such a way that it provides incisal and occlusal support. An even, proportional layer thickness should be achieved in the incisal area, as well as in the cusp and fissure areas. In this way, the forces that are applied during static and functional masticatory loading are mainly transmitted to the framework and not to the veneering ceramic alone.

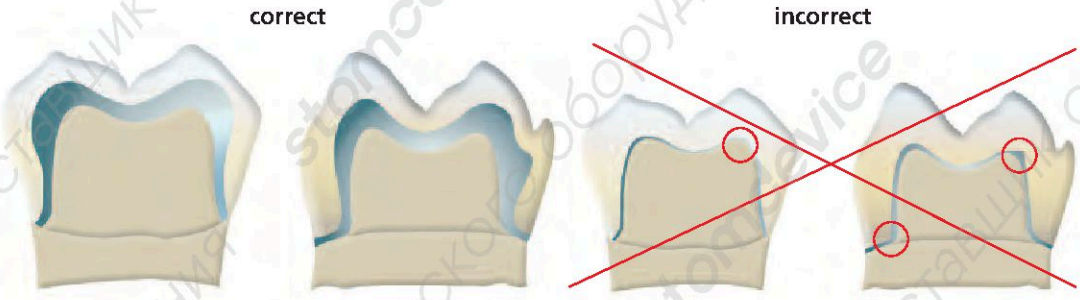
Anterior crowns



Premolar crowns



Molar crowns



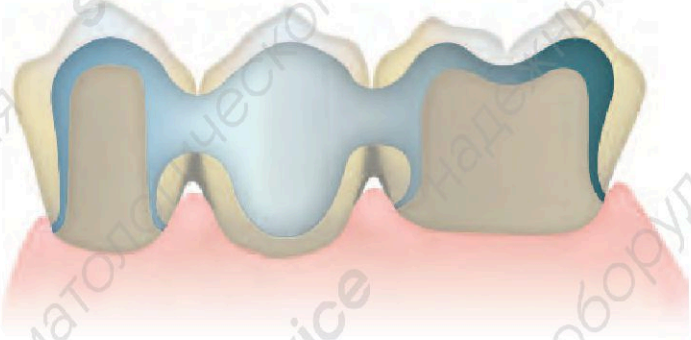
The main load of the forces that are applied, e.g. occlusal forces and stress in a labio-lingual direction, is absorbed by the alloy framework.

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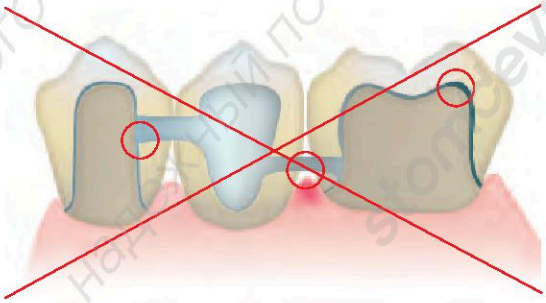
Framework design for bridge frameworks

On frameworks veneered with ceramic, thermal stress is exerted during firing and functional masticatory stress after cementation. These forces must be transmitted to the framework rather than to the ceramic veneer. In bridge frameworks, the stability in the connector areas between the bridge abutments and bridge pontic in particular must be ensured by the framework design and adequate framework thickness.

correct



incorrect



correct







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Transition from the alloy to the veneering ceramic

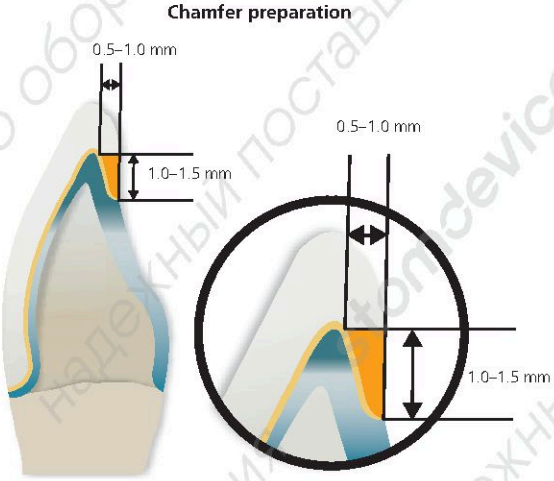
The transition from the alloy framework to the veneering ceramic must be clearly defined. The interfaces to the ceramic material must not demonstrate any sharp edges, grooves, angles, hollow spaces, or undercuts.



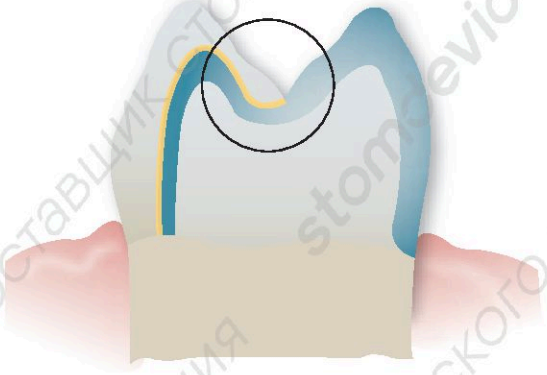


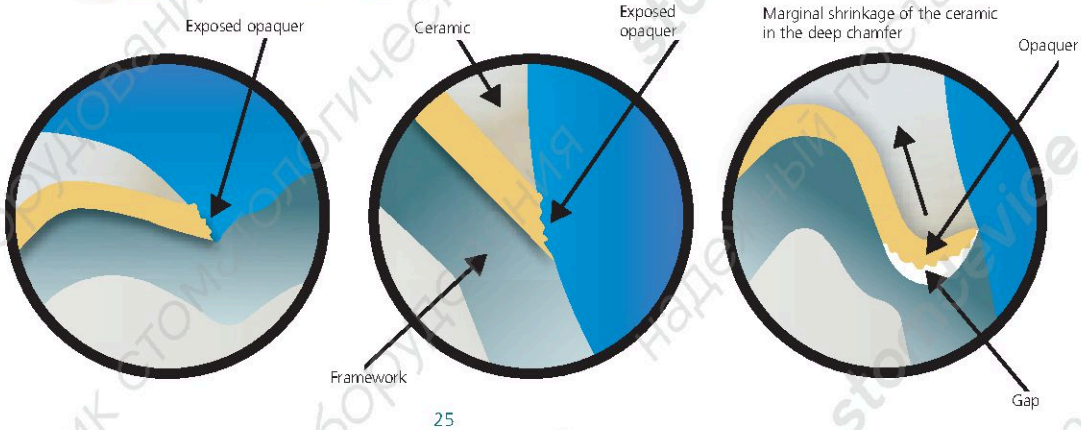
Requirements for the transition area

- An adequate layer thickness in the transition area must be ensured
- The opaquer layer should not be exposed (plaque accumulation on coarse-grained, porous opaquer material, irritation of the gingiva)
- The external angle between the framework and the veneering ceramic should be 90°
- The transition areas should be given convex contours
- A smooth transition area ensures an optimum surface and supports polishing and cleaning



Transition area between alloy and ceramic – correct





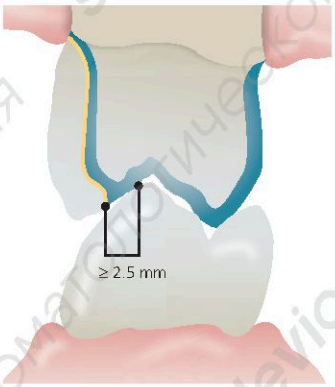
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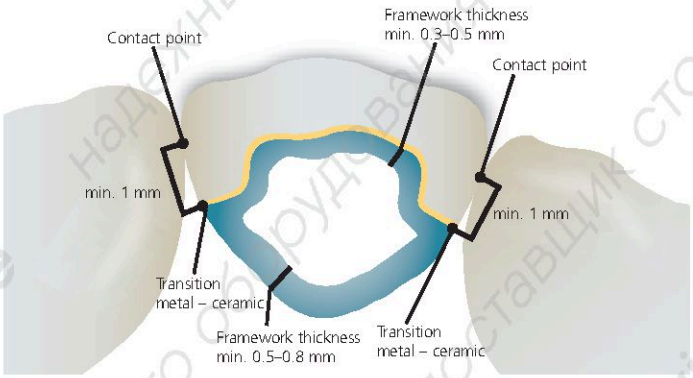
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Occlusal and proximal contacts or contacts established by excursive movements must consist of either metal alone or ceramic alone.

Occlusal and proximal contacts

– Transition areas between metal and ceramic must be at least 2.5 mm away from any contact points in the occlusal area and at least 1 mm in the proximal area.



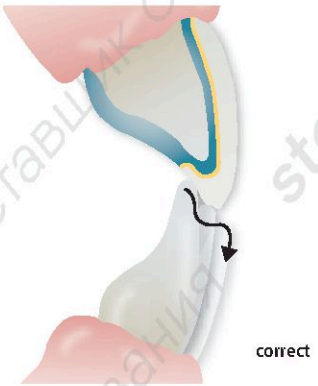


Contact point with adjacent gliding surface

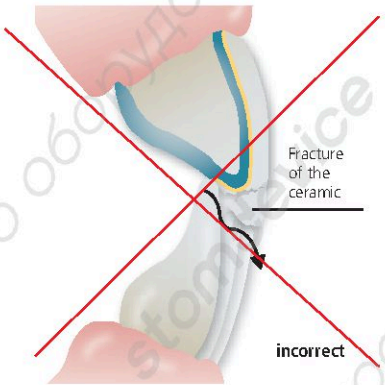
During excursive movements of the mandible – guided by the palatal surface of the maxillary canine – the interface between the framework and the veneer must not be located on this gliding path.

The interface between metal and ceramic must never be located on a gliding surface or a contact point. The gliding surface of the maxillary teeth, particularly the canines, must be designed of metal alone or ceramic alone. The palatal surface is designed in accordance with the depth of the overbite.

Occlusion at the incisal edge
Gliding surface entirely on the ceramic material

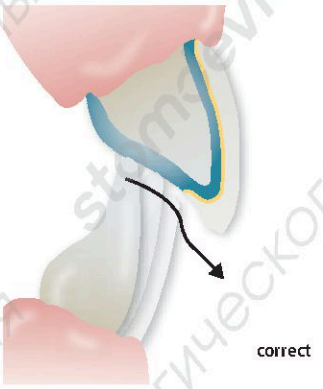


Occlusion at the interface between metal and ceramic
Gliding surface on metal and ceramic



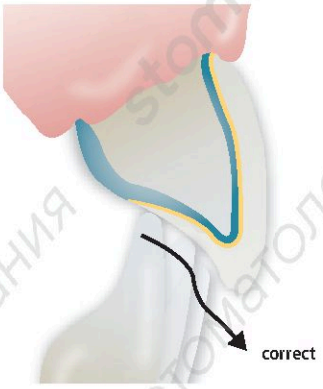
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Occlusion in the cervical area
Gliding surface entirely on the metal framework



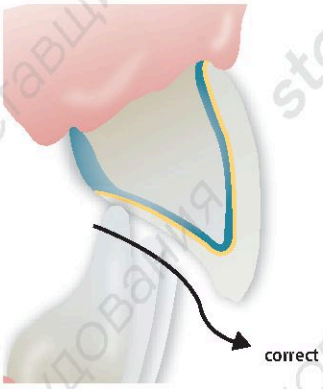


Occlusion in the central area
Gliding surface entirely on the ceramic





Occlusion in the cervical area
Gliding surface entirely on the ceramic



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Design of bridge pontics

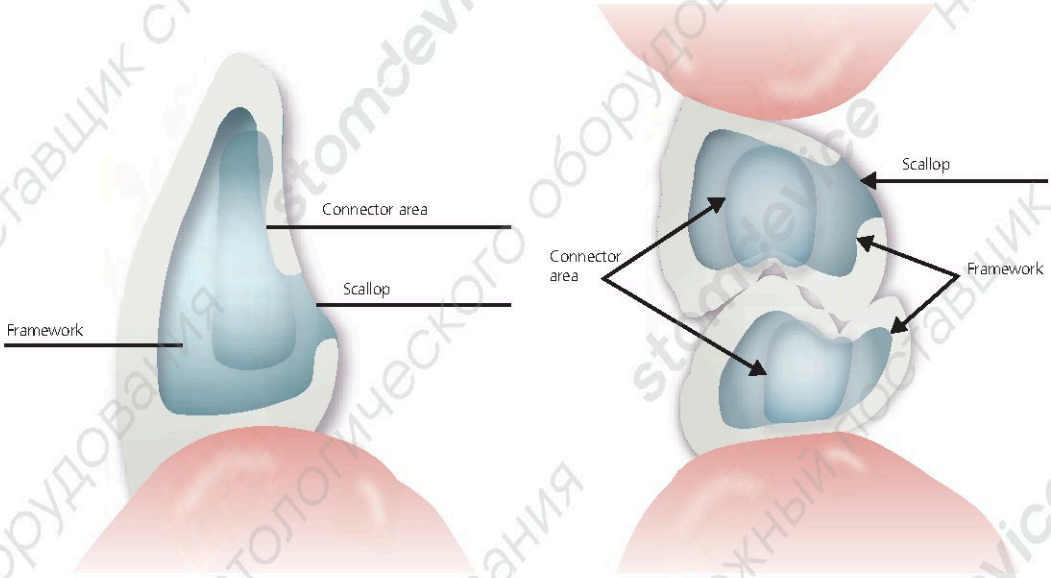
The bridge pontics represent a reduction of the original shape of the natural tooth to be replaced. During fabrication, hygienic, functional, and aesthetic aspects are taken into account. Adequate personal oral hygiene and an individualized preventive treatment regime are the basic prerequisites for long-term success.



Functional requirements for bridge pontics

Basically, bridge pontics are fabricated in the same way as abutment frameworks. They represent the load-bearing framework for the veneering ceramic. Therefore, the same basic prerequisites apply:

- The bridge pontic replaces the missing tooth and carries the veneering ceramic
- The connector areas between the bridge pontic and the bridge abutment have to be given a stable design
- Lingual reinforcement of the bridge pontics by contoured scallops is indicated for certain alloy types
- Massive bridge pontics are evenly and thus better cooled if they have a scalloped design
- When including scallops, the bridge pontics must already be given a convex design during the fabrication of the wax-up



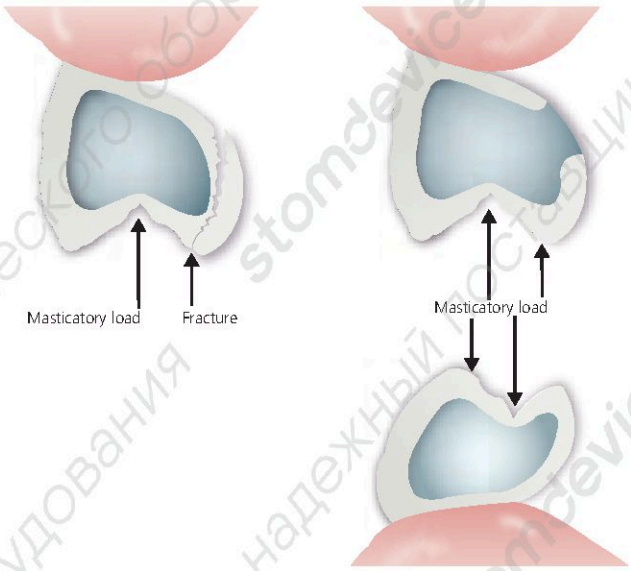
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Bridge pontics 22, 12, 14–16

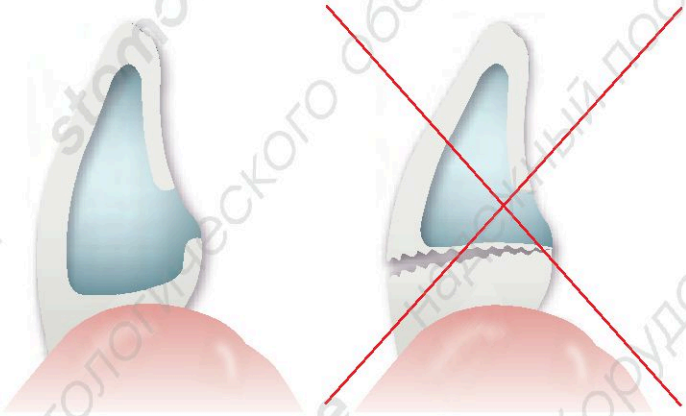


– Because of the cusp-fossa intercuspation, the palatal cusps in the maxilla are under higher masticatory stress than the lingual cusps in the mandible (normal bite). Providing adequate support is especially important for the stress-bearing palatal cusps in the maxilla.



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– The bridge pontic must support the veneering ceramic at the basal surface towards the gingiva. Too large a distance between the framework and the gingiva at the basal surface has to be prevented. Sharp edges and angles have to be rounded out and an even layer thickness of the veneering ceramic has to be ensured.



correct incorrect





– In cantilevered bridges, the dimensions of the bridge pontics have to be reduced. The cantilevered pontic has to be supported by at least two abutment teeth. Even cooling of the massive bridge pontic should be ensured by way of a scalloped design.

The lower the modulus of elasticity and the 0.2 % proof stress of an alloy, the more a scalloped design of the bridge pontics is recommended. In massive bridge pontics, a scalloped design provides a cooling area which minimizes the stresses occurring within the ceramic.

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Rest area of the bridge pontics on the gingiva

– **Sanitary bridges**
Indicated for regions in the oral cavity, in which neither aesthetic considerations, nor phonetic functions play an important role.



– **Spot-type, drop-shaped bridge pontic rest**
The bridge pontic rests only on certain points on the gingiva and demonstrates a convex shape. In such restorations, the morphology and the phonetic functions are limited.



– **Reduced bridge pontic rest**
Labial and buccal similar to a natural tooth. The lingual, convex shape of the bridge pontic is extended to the center of the alveolar ridge. High aesthetic quality. Self-cleaning is ensured by the convex shape of the bridge pontic.

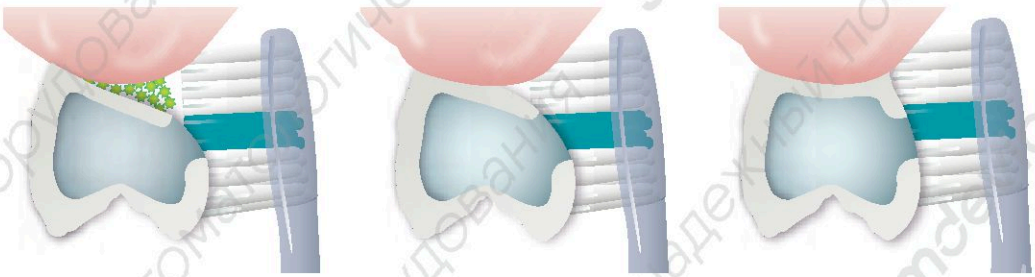


– **Saddle rest of the bridge pontic**
The bridge pontic follows the natural shape of the tooth. High aesthetic quality, since the bridge pontic fills the entire gap between the teeth. A pleasant feeling for the tongue.



The basal surface of the bridge pontic should be made of ceramic, since it comes into direct contact with the gingiva. Glazed ceramics demonstrate the highest biocompatibility. The critical transition areas between metal and ceramic should not come into contact with the soft oral tissues.

Cleaning capabilities of bridge pontics

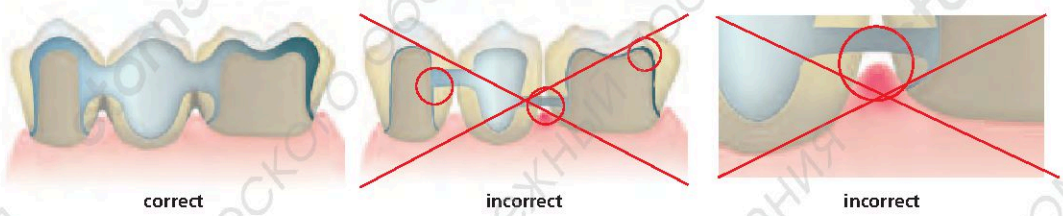


Spot-type, drop shaped rest | Reduced rest | Saddle rest

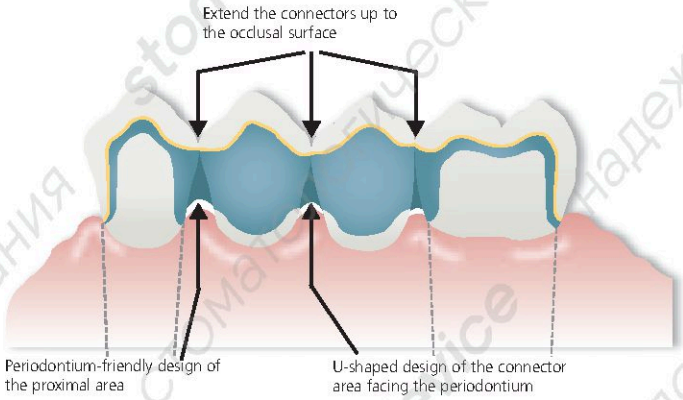
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Design of the proximal area

Once the clinically required strength of a bridge restoration has been achieved, the proximal areas must also be given a clinically sound design. The framework and its thickness must also meet the optical and functional requirements. Moreover, the aspects of periodontal hygiene must be given particular attention.



- The framework connectors in the posterior region should be extended up to the occlusal surface.
- This type of framework design also enables a suitable design of the proximal area towards the periodontium
- The connector area facing the periodontium should always be given a U-shaped, rather than a V-shaped design
- The periodontium must not be affected or even displaced by an overly pronounced design of the proximal area
- The convex shape of the bridge pontics guide the hygiene aids into the interdental spaces





The proximal areas must enable adequate oral hygiene and individualized preventive treatment regimes. During framework design, an adequate opening of the interdental area must be taken into consideration so that oral hygiene with interdental brushes and dental floss can be performed. No black triangles should be created.

Cleaning capabilities with interdental brushes





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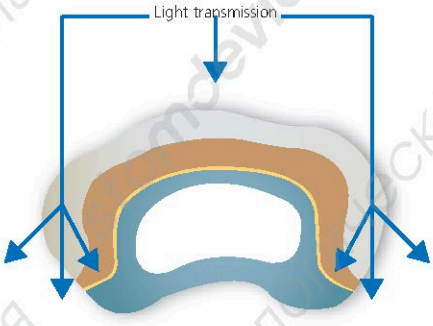
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Framework design from an aesthetic point of view

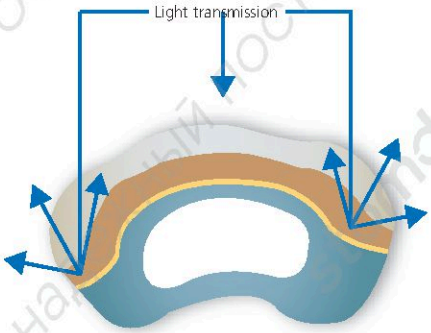
During the fabrication of the framework, the light transmission (passage of light) of the veneering ceramic must also be taken into account. Aesthetic considerations for veneered restorations are directly related to the layer thickness of the veneering material.



In order to achieve relatively high translucency in the mesial and distal proximal areas, as well as in the incisal area of the veneering ceramic, a statically correctly reduced framework construction should be achieved.

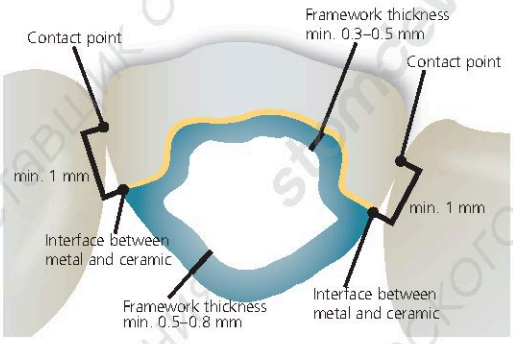


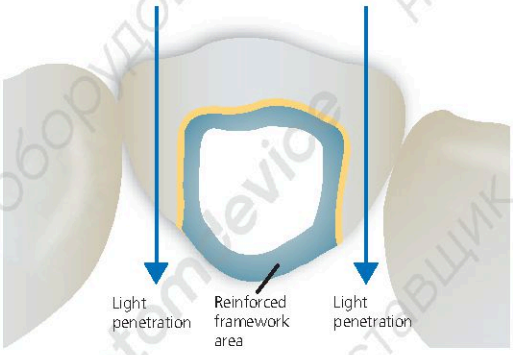
Adequate framework reduction favours the light transmission in the interdental and incisal area

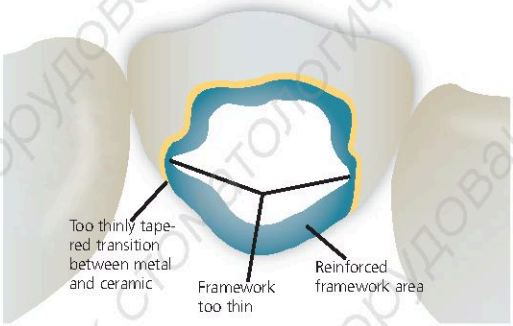


Without framework reduction, light transmission is prevented

The balance between a statically sound and aesthetic framework construction is necessary for a metal-ceramic restoration.







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In order to meet the static and aesthetic requirements, the framework reinforcements are placed in the non-visible, lingual area.





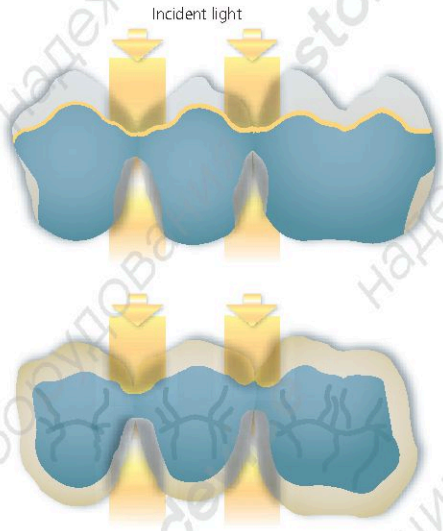
TIP

To achieve adequate light transmission, certain basic requirements must be fulfilled:

- **Chamfer or shoulder of 1–1.2 mm**
- **Minimum space requirement for the veneering ceramic of 0.8 mm**
- **Thickness of the ceramic veneer in the occlusal area of at least 1.5 mm**
- **Framework thickness of at least 0.3–0.5 mm depending on the alloy type and design of the framework**
- **Optimally reduced, but adequately stable framework construction**

If the framework construction reaches too far into the proximal or occlusal area, clear shadows will be visible.

Correct framework reduction prevents the creation of shadows in the veneering ceramic in the proximal and occlusal areas.



In order to achieve light transmission, the framework construction is reduced in a targeted fashion.

Important!

- **The framework reduction must not result in unacceptable weakening of the framework**
- **The available space in the proximal and occlusal areas, as well as the alloy type used, must be taken into consideration in this context**



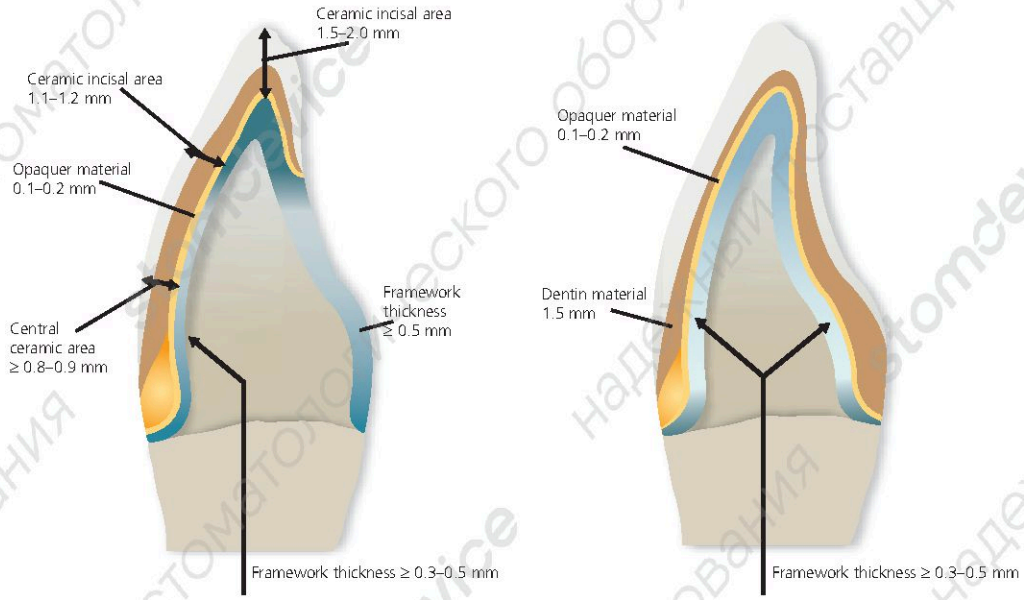
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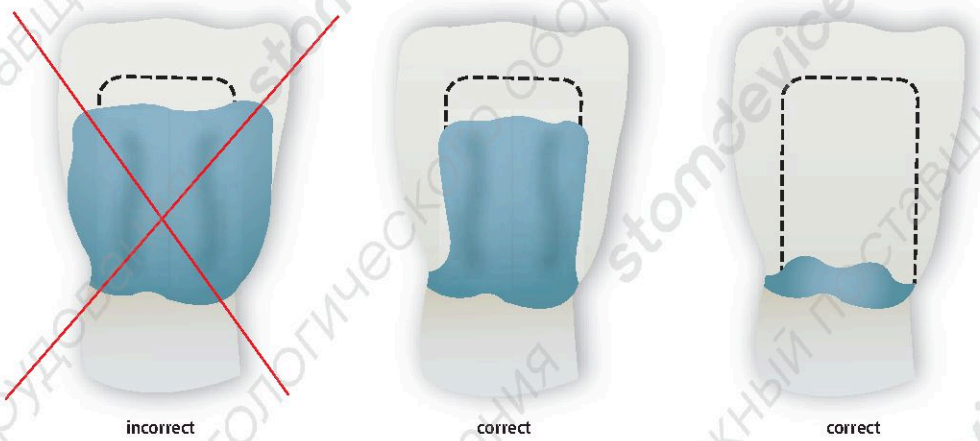
In order to fabricate an aesthetic restoration, the framework should be contoured in such a way that it does not extend too far into the incisal area lingually.



The framework construction must support the veneering ceramic. However, it is reduced in a statically sensible manner to allow the fabrication of aesthetic restorations.



Framework and ceramic layer thicknesses for aesthetic restorations



Palatal and lingual framework design

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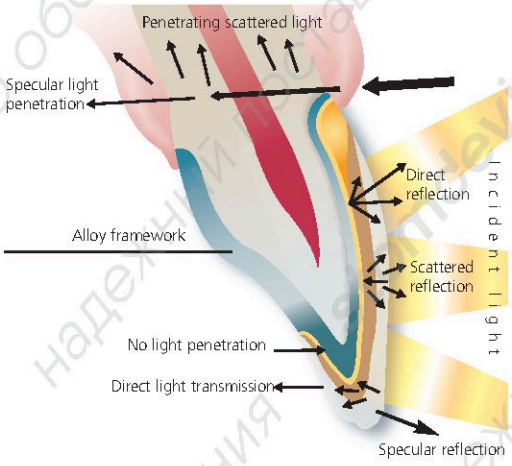
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To achieve a good aesthetic appearance, the vertical dimensions of the alloy margin should not be excessively increased.
In the visible areas of the restoration, an alloy margin should not be fabricated for aesthetic reasons. A chamfer with an invisible metal edge or, even better, a ceramic shoulder are solutions that meet the aesthetic requirements. In the less visible posterior region, a subgingival alloy margin is often possible and helps support the veneering ceramic.

- **A true-to-nature in-depth effect is achieved if light can penetrate deeply into the veneering ceramic = translucency.**
- **In restorations with low translucency, light is more strongly refracted. The light rays are more strongly reflected instead of penetrating the veneering ceramic.**

The framework construction is instrumental in fabricating translucent restorations. In metal-ceramic veneers, the transition areas at the proximo-incisal and lingual surfaces have to be taken into consideration. The interfaces should be moved to the lingual area to as large an extent as possible. In this way, a darkening of the veneering ceramic by incident light of a certain angle can be prevented.

In metal-ceramic restorations, incident light is reflected by the opaquer layer and, ultimately, by the metal framework. Depending on the incident angle, shadows are created at the proximal surfaces. These shadows, however, may be minimized by an optimized reduction of the framework construction. With an optimum framework construction, the light is reflected to a higher or lesser degree, depending on the incident angle.



Reflection and penetration of incident light



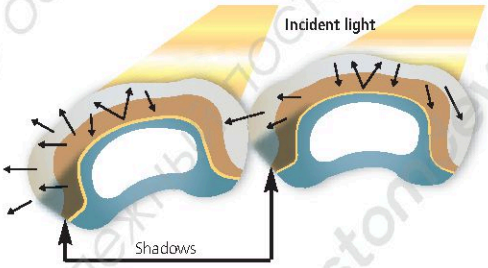
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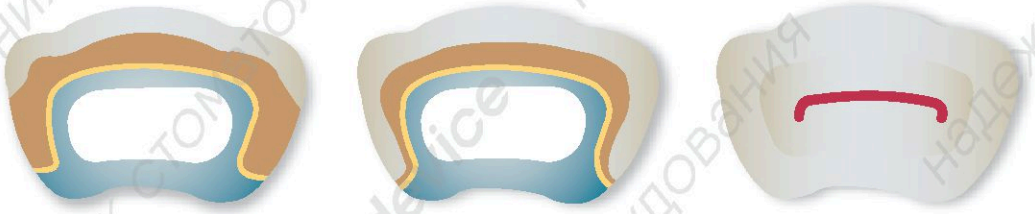
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Scattering of light – reflection or refraction occur in a transparent substance if the light falls on another substance that has a different refractive index.

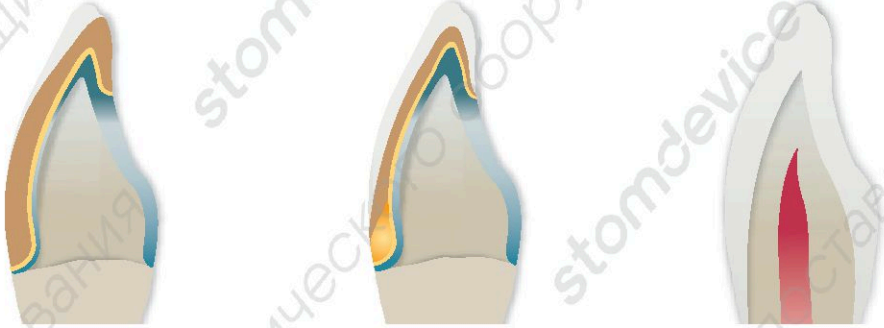


Incident light is directly reflected by the opaquer material layer and the reflected light is scattered. Light penetration occurs in the incisal and proximal areas of the veneering ceramic.





Conventional ceramic layering | Ideal ceramic layering | Natural tooth



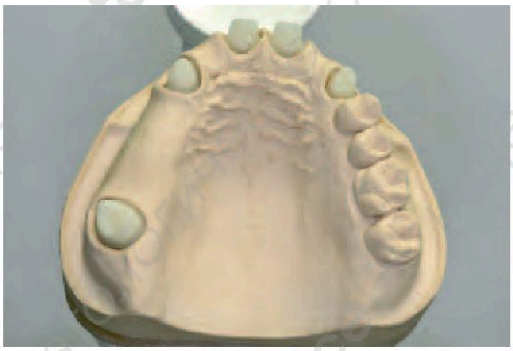
Wrap-around effect in metal-ceramic restorations

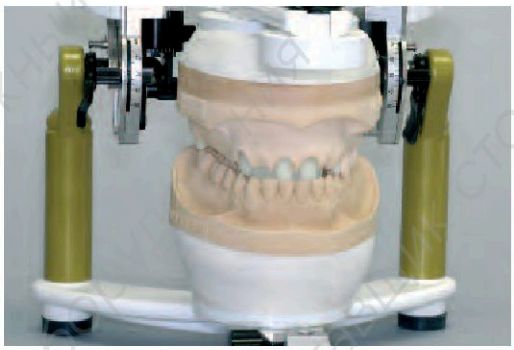
Translucency with an in-depth effect is achieved with a sufficiently thick layer of (translucent) ceramic material. Sufficiently thick in this instance means that the material sufficiently reduces the direct reflection of the opaquer layer.

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Step-by-step instructions

Starting situation of the metal-ceramic restoration
A master model or model with detachable segments based on the impression is fabricated as a working model. The preparation is carefully exposed and marked. A sealer layer is applied to harden the stone die. However, the sealer must not result in any dimensional changes. After that, a spacer may be applied.





Fabrication of a master model or model with detachable segments and model oriented in the Stratos 300 according to average values





Dies with applied sealer and spacer

The following pages will describe two ways of fabricating an alloy framework for metal-ceramic restorations.

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Framework fabrication

Full wax-up

The framework reflects the reduced anatomical tooth shape (tooth shape-supporting contouring). In this way, the veneering ceramic may be applied as an even layer and is adequately supported. Basically, a full wax-up and the fabrication of a silicone key to check the space conditions are recommended.





Fully anatomical contouring of the tooth shape from occlusal, labial …





…buccal, and palatal

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Contouring / reduction

During contouring, it has to be made sure that the frameworks for single crowns demonstrate a minimum thickness of 0.3 mm and those for bridge abutments 0.5 mm after finishing. These thicknesses are a prerequisite for the stability of the alloy framework.





Fabrication of a silicone key to check the reduced wax pattern for the alloy framework





Controlled step-by-step reduction of the contoured anteriors, ...





... premolars ...





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... and molars.





Completely contoured wax framework



Wax framework sprued for conventional bar casting



Cast homogeneous alloy framework

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Finishing the alloy frameworks

The cast alloy frameworks are carefully divested, sandblasted or pickled, and their fit checked on the model. After separation, the alloy frameworks are finished using tungsten carbide metal burs and/or ceramic-bonded grinding instruments. A scalloped design is used to reinforce alloy frameworks with lower physical values. It also permits even cooling.

Framework fabrication for palladium-based and base metal alloys	Supported framework fabrication for high-gold and gold-reduced alloys
	
Fitting and inspection on the master model	
	
Finishing with tungsten carbide metal burs and/or ceramic-bonded grinding instruments	
	
Checking the space conditions with the silicone key …	
	
…..to ensure even layer thickness of the veneering ceramic	

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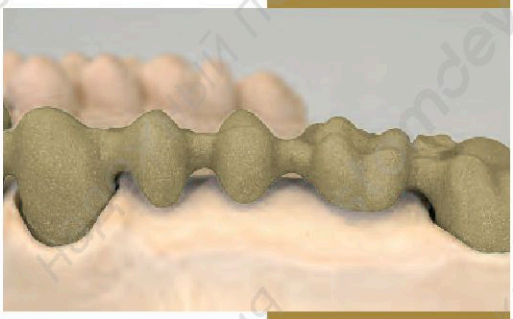
After finishing, the alloy framework is carefully blasted with Al_2O_3 aluminium oxide. The required pressure depends on the alloy type. Therefore, the instructions of the alloy manufacturer have to be observed. Use only pure, disposable jet medium.





Carefully blasted alloy framework after finishing from labial, ...





... buccal ...



... and palatal.



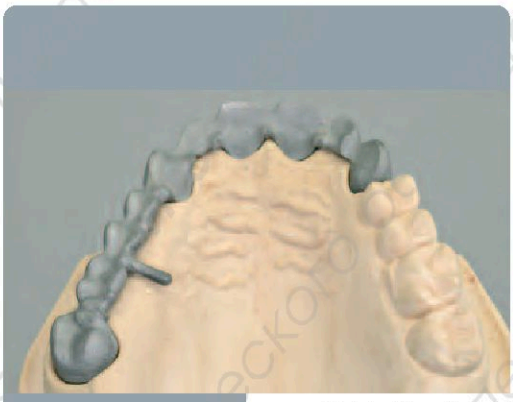
Alloy framework ...





... with a reinforcing scalloped design

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Finished and thoroughly cleaned alloy framework ready for oxidation





Alloy framework with all the abutment teeth firmly supported on the firing tray. Oxidation according to the instructions of the alloy manufacturer

Processing and layering of the veneering ceramic according to the corresponding Instructions for Use.

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Opaquer firing



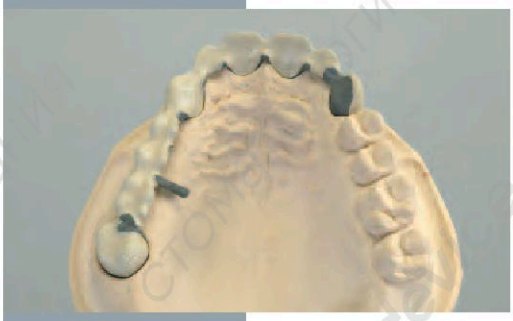


The first opaquer layer (wash) is thinly applied using a brush





The second opaquer layer covers the entire framework





Completely opaquerized alloy frameworks

After the application of shoulder materials and Dentin, Incisal, and Impulse layers, the ceramic firings are completed with a glaze firing cycle. The visible alloy areas are finished and/or pickled and subsequently polished using commercial rubber polishers and polishing pastes.

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Completed metal-ceramic restoration













Metal-ceramic restoration from palatal. ...





... with and without supporting scallops



The alloy framework is invisible from buccal



Alloy framework with palatal reinforcements

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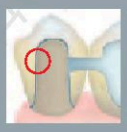
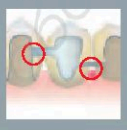






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Trouble shooting chart

TYPE OF DEFECT	POSSIBLE CAUSES	SOLUTIONS
Frog eyes 	■ Residue from grinding instruments ■ Grinding pressure too high ■ Overlaps ■ Jet medium ■ Porous casting ■ Flux on the alloy surface	■ Use only recommended grinding instruments ■ Observe recommended speed ■ Use grinding instruments in one direction only ■ Use only clean, disposable jet medium ■ Veneer only homogeneous, clean casting objects ■ Thoroughly clean the alloy surface after soldering
Fracture and cracks in the ceramic 	■ Not adequately dimensioned framework ■ Coefficients of thermal expansion (CTE) of the alloy and ceramic are not coordinated ■ Use of non-coordinated solders ■ Incorrect framework design ■ Uneven ceramic layer on the metal framework ■ Inappropriate cooling (thermal shock) ■ Sharp edges and angles on the framework	■ Observe framework thickness of 0.3–0.5 mm ■ Check the coefficients of thermal expansion (CTE) of the alloy and the ceramic for compatibility (standard, short-term, or long-term cooling) ■ Use only a coordinated alloy / solder combination ■ Always fabricate a wax-up and a silicone key ■ Design the framework in such a way that it supports the ceramic, which then allows the application of an even ceramic layer ■ Observe the correct firing parameters ■ Round out sharp edges and angles on the framework
Incorrect framework design 	■ No support for the veneering ceramic ■ Framework too thin ■ No supporting scallops	■ Evenly support the veneering ceramic with a correctly dimensioned framework ■ Stable framework design of 0.3–0.5 mm ■ A scalloped design supports the framework during firing and contributes to even cooling
Framework is lifted off, distortion 	■ No correct, stable framework design ■ Connector areas too weak ■ No supporting scallops	■ Observe framework thickness of 0.3–0.5 mm ■ Create adequately large connectors; the vertical dimension is particularly important ■ A scalloped design supports the framework construction
Incorrect pontic and connector design for periodontal hygiene 	■ No cleaning capabilities because the interdental spaces are closed ■ Connectors too close to the gingiva and V-shaped ■ Incorrectly located transition area between metal and ceramic	■ Fabricate a wax-up in order to design a restoration that allows the best possible periodontal hygiene ■ Provide the connectors with a hygiene-friendly, U-shaped design ■ The interfaces between metal and ceramic must not be located in the area of the gingiva

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TYPE OF DEFECT	POSSIBLE CAUSES	SOLUTIONS
Inaccurate transition area between the metal and the ceramic 	■ Transition between metal and ceramic not at a right angle ■ Exposed opaquer ■ Porous interface between metal and ceramic ■ Interface between metal and ceramic in the area of the gingiva ■ Interface between metal and ceramic in the contact area with the antagonist	■ Design the interface between the metal and ceramic with a right angle ■ The opaquer must be covered with fired ceramic ■ Design flawless interfaces between the metal and ceramic ■ The interface between the metal and ceramic must not be located in the area of the gingiva ■ The interface between the metal and ceramic must not be located in the contact areas to the antagonist (at least 2.5 mm distance in the occlusal area and 1 mm in the proximal area)
Connector areas not correct 	■ Connector area not adequately stable ■ Connector not high enough ■ Connector with a V-shaped design in the interdental area ■ Not enough space for a metal-ceramic restoration	■ Contour large enough connector areas in the wax-up ■ A lack in height of the connector area can rarely be compensated by increasing the width (wider alloy surfaces) ■ Always give the connector a U-shaped design in the interdental area ■ Depending on the available space, the framework may be veneered with ceramic – if space is limited, certain surfaces must be contoured in metal to provide adequate support
Fractures of metal-ceramic restorations 	■ Connectors too thin ■ Alloy type contraindicated for long-span bridges ■ Inhomogeneous, porous casting object	■ Adequate connector design for the selected alloy type ■ Use an alloy type suitable for long-span bridges (observe the corresponding indications) ■ Use only clean, homogeneous casting objects
Delamination of ceramic material 	■ Incorrectly dimensioned framework design ■ Failure to observe the cooling behaviour ■ Heat accumulation in massive bridge pontics	■ Contour a wax-up, fabricate a correctly dimensioned framework, which allows even ceramic layering ■ Long-term cooling may be required for certain alloy types, CTE values, and sizes of restorations ■ Massive bridge pontics should be given a scalloped design to facilitate cooling

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