PROCEED MC & Zr

Effortless aesthetics

TECHNICAL

MANUAL

GC

PROCEED MC & Zr

Preface

“By taking care of laboratory products for GC in the South-east Asia region my top priorities are to provide products information and tools that exceed dental technicians need and to fulfil a promise to help them to understand the core concept and skills that will prepare them to succeed using GC lab products.

I made this PROCEED MC & Zr Technical Manual as a user’s manual intended to provide an introduction to the range of ceramics and their use, and from the user’s point-of-view, obtaining knowledges, compiling them for interpreting the desired future outcome of their work and executing them.

The goal of this manual is also to give some basic instructions on the optical properties of each type of ceramic powder, and an important broad overview of the main functions of the alloy and zirconia framework design as well as the preparation design of the tooth which both lead to the longevity of the ceramic layers and therefore the restoration.

This technical manual is designed to help readers locate information quickly and easily. Detailed documentation of information and procedures is brought forth by photos, illustrations and tables throughout the manual.
Every effort has been made to ensure that this document is an accurate representation of PROCEED MC & Zr and is suitable for all the necessary knowledge that beginners or new users require as well as highly skilled ceramists.

Finally, I hope this Technical manual will be helpful for the users and the readers and will provide effective learning for building habits that will serve their daily works and encourage strong relationships between dental technicians and dentists.”

Mr. Frederic FURGIER – CDT
Dental ceramist trainer – GC Asia

Contents

I - Introduction

Ceramic materials are connecting the gap between functionality, esthetic and patient good health. Aesthetics and strength are the primary reasons why a metal ceramic and zirconia ceramic restoration would be prescribed.

Ceramic on metal substructure have been available since the 1960s. For 6 decades the metal ceramic restorations have shown quite successful performances since it combines good aesthetic with adequate strength and accurate fit with today a survival rate of 97% after a period of ten years in clinical service. (1)
Besides, the demand for life-like substructure material that copy tooth structure gave rise to the development of new all-ceramic systems. The research for all-ceramic restorative materials that include aesthetic and strength has contributed to the development of zirconia as well as ceramic for zirconia esthetically pleasing and strong.

GC's effort to improve the quality of ceramics from metal-ceramic restorations (PFM: Porcelain Fused to metal) to zirconia substructure ceramics restorations (PFZ: Porcelain Fused to Zirconia) in terms of choice of feldspar minerals, crystal size, optical properties (such as chroma, translucency and opalescence), mechanical performance in flexural strength and fracture toughness brings with PROCEED a remarkable technological evolution to meet the specific requirements and optimal aesthetic of today.

The ultimate goal of PROCEED is achieving adequate strength and toughness, optimal aesthetics and long-life oral performance.
The replication of natural teeth with high esthetic needs represents a challenge, and it's where PROCEED is all about with its "effortless aesthetic" concept.

Finally, ceramic layers are nothing without a good knowledge on tooth preparation and substructure framework design and this manual will also serve as a guide to understanding the importance of good preparation design and framework design to get the most out of the ceramic layers in terms of durability and aesthetics.

- The intended use of PROCEED MC ceramic is to be use on metal substructure, so call PFM restoration (Porcelain Fused to Metal), to mimic the natural tooth shape and visual shade by hand build-up the ceramic powder before firing it in a porcelain furnace to get the final tooth restoration.
- The intended use of PROCEED Zr ceramic is to be use on zirconia substructure to mimic the natural tooth shape and visual shade by hand build-up the ceramic powder before firing it in a porcelain furnace to get the final tooth restoration.

(1) reported by Eliasson et al.

II – Description of PROCEED MC & Zr

The **ENGINEERING** between the ***BRUSH***

and ***AESTHETIC*** !

A - Composition

PROCEED natural feldspathic ceramics are in part based on natural raw materials (feldspar minerals and leucite crystals).

The high purity of the feldspar minerals and leucite crystals offers unique properties and effortless aesthetic

Natural feldspars are a mixtures of potassium feldspar ($K_2Al_2Si_6O_{16}$) and sodium feldspar ($Na_2Al_2Si_6O_{16}$).
Potassium feldspar provides hardness, increased thermal expansion (leucite) and chemical durability.
Potassium feldspar is responsible for the formation of leucite crystals which increase the strength of restoration by absorbing the energy of the propagation of cracks, as a result the propagation of cracks are stopped or slowed down.

Ceramics are composed of 3 major elements:

1. **The glass,** which provide high esthetic (the matrix),
2. **Crystalline particles**, they are the crystals inside the glass increasing the optical and mechanical properties
3. **Filler particles,** it can be pigments, opacifiers that are added to control optical effects as opalescence and fluorescence to mimic natural dentine and enamel.

B - Manufacturing process

The dental ceramics are made from different steps.
The feldspar minerals are blended by ball milling and fused at around 1300°C to form the glass.
After the firing process the glass is quenched in water and fused again at a 750 to 1150°C for several hours to form a controlled nucleation and growth of internal crystals evenly scattered throughout the glass.
This process from forming the glass to a crystalline glass is called ceraming.
A second time the ceramic is quenched and then crushed and reduce to a fine powder.
The growth of crystals, their number and size (also call crystallization or crystal nucleation) are controlled by the time and the temperature of the ceraming heating process.

In terms of temperature, dental porcelains can be classified as 'high' and 'low' fusing porcelains depending the coefficient of thermal expansion of the substructure where the ceramic is applied.

PROCEED MC is a 'high' fusing dental ceramic for metal substructure.
PROCEED Zr is a 'low' fusing dental ceramic for zirconia substructure.

C - Properties of PROCEED MC & Zr

PROCEED is a **Leucite Feldspar-based ceramic**

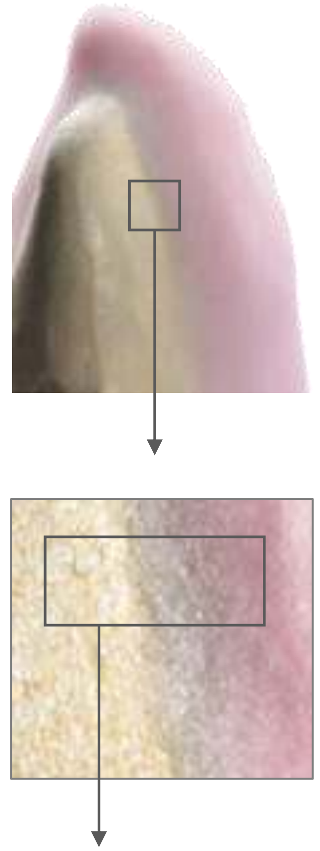
Microstructure of PROCEED

The ceramic has two different phases, it's a Multiphasic ceramic as it contain a dispersed crystalline phase surrounded by a translucent glassy phase (crystals part and glass part).

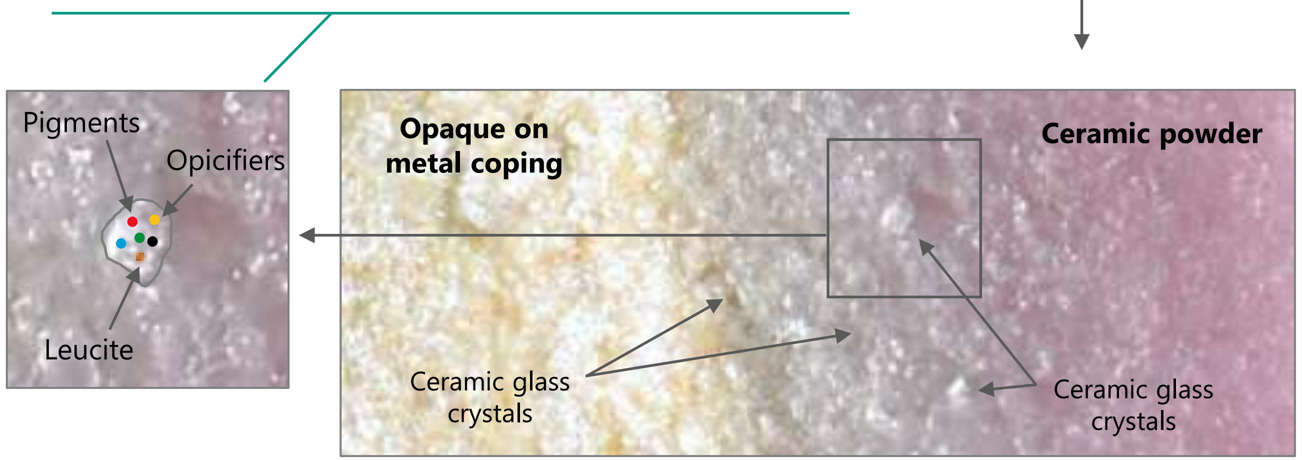
- The glassy phase has the properties of glass such as brittleness, translucency and non-directional fracture pattern (the glassy phase is responsible for the aesthetics) .
- The crystalline phase contributes to the overall strength of the ceramic, makes the material more stable during the firing cycle and more resistant to stresses in the mouth (the crystalline phase is associated with mechanical strength).

PROCEED MC contains between 15 and 25 vol % leucite ($KAlSi_2O_6$) (potassium alumino-silicate) and PROCEED Zr contains between 1 to 2% of Leucite. This incorporation of a proportion of leucite crystals into the feldspathic ceramic composition serves to increase the thermal expansion of the porcelain to bring it closer to that of the metal or zirconia substrate.
Nevertheless, the amount of leucite in the glass matrix is adjusted to get a coefficient of thermal contraction slightly lower than the one of the metal or zirconia in order to bring the ceramic under a slight compression around the substructure during the firing cycle.
The leucite is also associated with the crack propagation strength, more presence of leucite means less propagation of crack which result in less failure.

Crystal content improves light scatter and opacity and aids in the color adaption of the transparent glassy phase to dental hard tissues (enamel and dentin).
Crystals also bring the fluorescence of the restoration as similar as to natural dentition with excellent color stability, even after repeated firings
To finish, the microstructure of PROCEED gives an abrasion values close to those of natural tooth enamel.



The colour pigments and metal oxides are covered with the protective glass. The colouration, translucency and brilliance are retained, even after several firings.
Colour pigments and metal oxides are unprotected in conventional ceramic powders and reduce with every firing which makes the ceramic powders to change in colour intensity and brilliance.



PROCEED MC & Zr

SECURE AND STABLE MATERIAL

- Natural Leucite Feldspar based ceramic
- Fluorescence similar to natural dentition
- Low shrinkage due to the density of the material.
- Abrasion values is close to those of natural teeth enamel
    - Low solubility
    - High wear resistance
    - Antagonist friendly
- Hight strength for its category 90+ MPa (The Norm minimum is at 50 Mpa)
- The CTE (Coefficient of Thermal Expansion) of both PROCEED MC & Zr allows the ceramics to be used with common ceramic alloys and zirconia frameworks

PROCEED MC Properties	Measure	Value	Norm
Dentine Firing	°C	890	
Coefficient of Thermal Expansion (25-500°)	10^{-6} xK^{-1}	13,1	
Glass Transition Temperature	°C	575	
Solubility	µm/cm²	15	Max. 100
Density	g/cm³	2,52	
Flexural Strength	MPa	92	Min. 50
Median Grain Size	D 90%	60	

All tested materials conform to EN ISO 9693-1.

PROCEED Zr Properties	Measure	Value	Norm
Dentine Firing	°C	800	
Coefficient of Thermal Expansion (25-500°)	10^{-6} xK^{-1}	9,5	
Glass Transition Temperature	°C	550	
Solubility	µm/cm²	16	Max. 100
Density	g/cm³	2,43	
Flexural Strength	MPa	90	Min. 50
Median Grain Size	D 90%	60	

All tested materials conform to EN ISO 9693:2000.

PROCEED MC & Zr meets the requirements of the standards:
flexural strength of ≥ 50 MPa, chemical solubility of < 100 µg/cm2 and debonding / crack initiation strength ≥ 25 MPa.

PROCEED Colour Chart

The ***PERFECT*** Match!

D - Colour Chart

IN PERFECT HARMONY TO SIMPLE CROSS-MATCH SHADE

- All the PROCEED shades are harmonized to match together.
- Aesthetics in perfect harmony whether it is PROCEED MC or PROCEED Zr
- Aesthetic cross-match shades between PROCEED MC and Zr when different frame structure are required.
- No need to modify techniques as it is by using a variety of manufacturers for different material support.

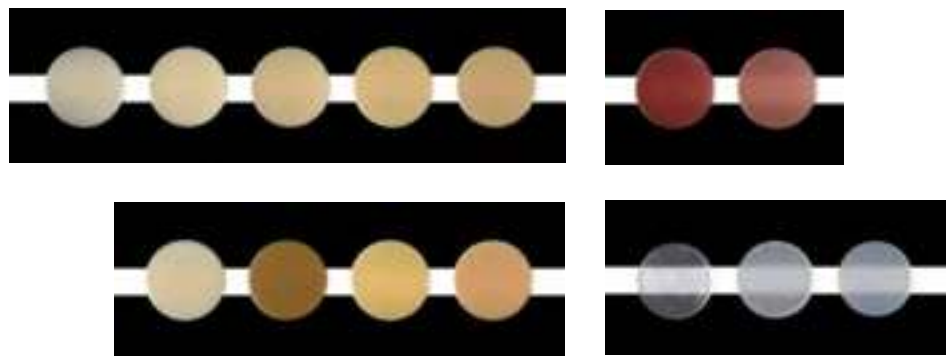
LIFE-LIKE LAYERING SHADES

Unique shades specially developed for PROCEED MC & Zr with:

- deep chroma
- high fluorescence
- Opalescence
- and/or high transparency.

EFFECT SHADES

- To add individual touches to the ceramic restoration a variety of unique effect shades have been developed for internal and external layering.



PROCEED MC & Zr have superb color matching of natural tooth structures even in the thinnest of layers due to the crystal size and specific pigmentation.

TO MASK METAL COPINGS

Opaque

- Excellent masking ability even in very thin layers making it easier to create perfect aesthetics.
- Shades are color matched when applied on any metal/alloy frameworks.
- Available in powder (bottle) and paste (syringe).

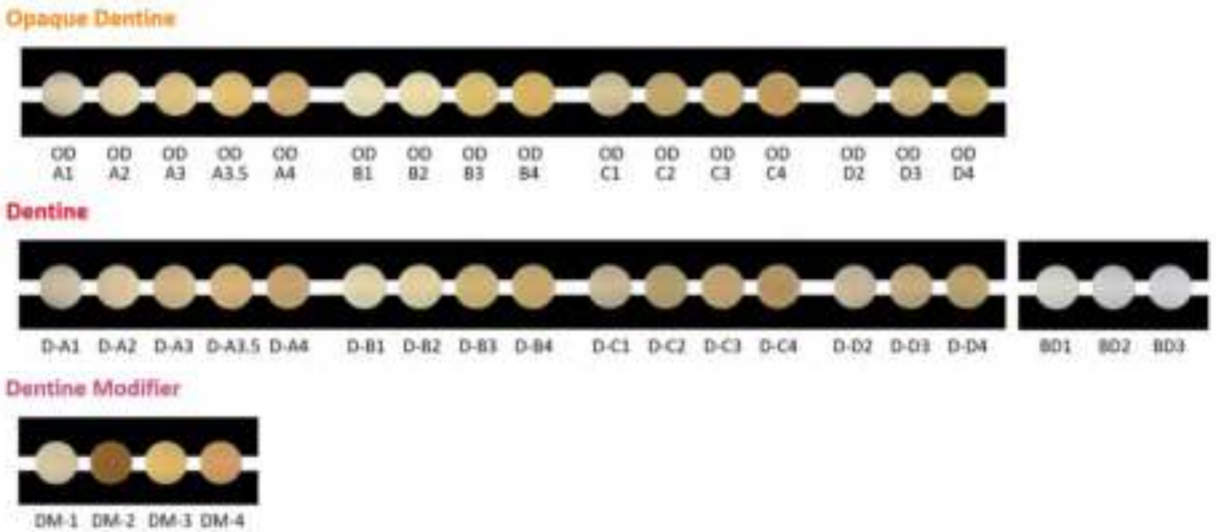
TO MATCH DENTIN

Dentin

Gives life-like chroma to the dentin body and excellent masking even in very thin layers .

Opaque Dentin/Dentin Modifiers

Intensifies chroma and gives life-like shades in very thin layers . Reduces dark, shadow areas and transmitted intra-oral light.



TO MATCH ENAMEL

Enamel / Effect Enamel

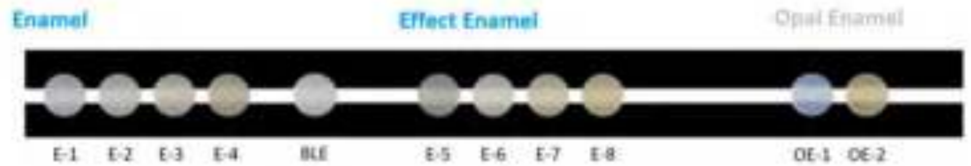
Graduated enamel powders to match natural incisal areas .
Effect Enamel can be mixed with enamel or used directly.

Effect Transparent

Color transparent enamel to create life-like occlusal or labial surfaces in the presence of any slightly colored enamel.

Enamel Opal

Enamel colors with a high level of opalescence in conjunction with high translucency.



FOR EXTRA FLUORESCENCE

Clear Fluorescence

Unique to GC - a highly transparent shade to match the fine line of ‘clear material’ in a natural tooth . Gives life-like transmission and reflection of light as well as deep, realistic color in a very thin layer (max 0 .2mm).

FOR EXTRA TRANSLUCENCY

Transparent

Translucent has two shades: Neutral and for extra opalescence, Opal . Transparent can be mixed or used directly.

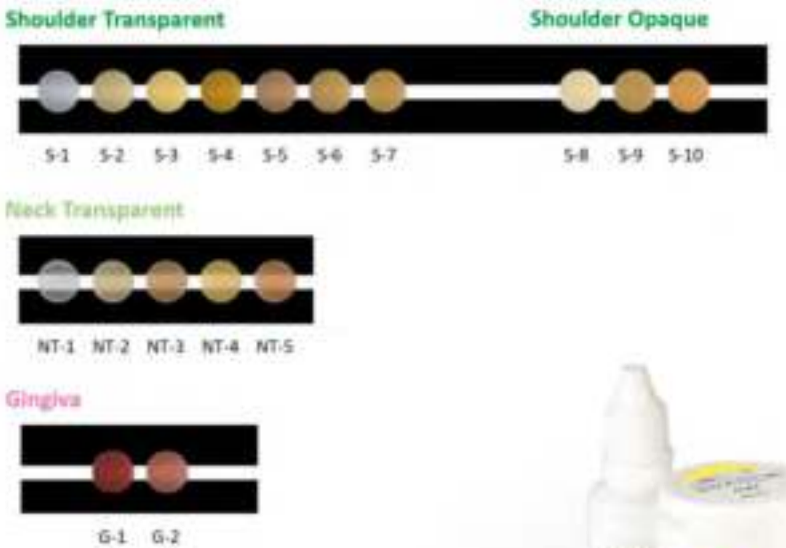
FOR CERAMIC SHOULDERS

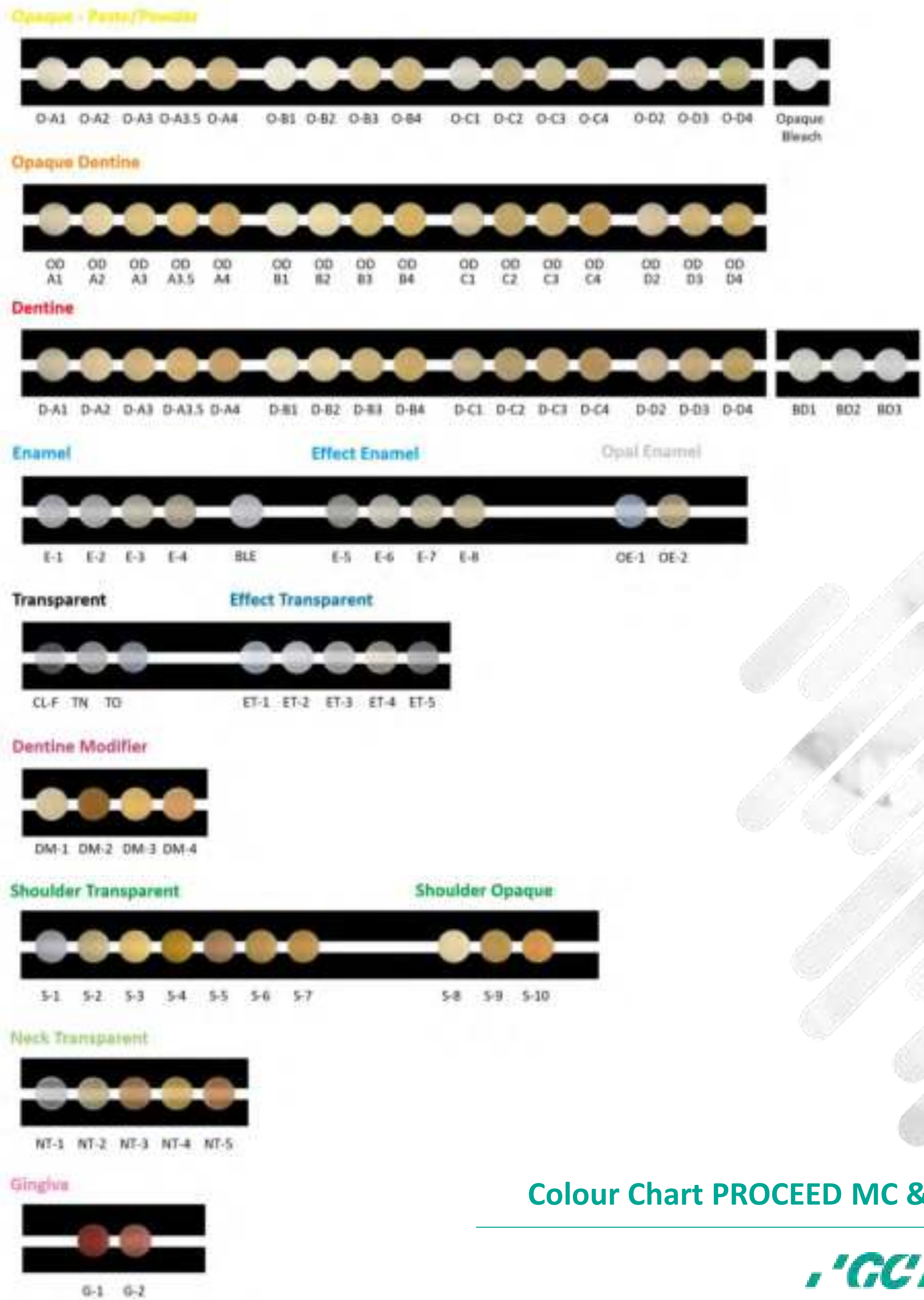
Shoulder Transparent
Transparent, highly fluorescent shades.

Shoulder Opaque
Opacious, highly fluorescent shades

FOR EXTRA CERVICAL TRANSLUCENCY

Neck Transparent
Very translucent, highly fluorescent, deep color shades to add life-like depth to the cervical third.
Can also be used in other parts of the restoration.





Colour Chart PROCEED MC & Zr

E - Assortments of PROCEED ceramic range

GC PROCEED MC Colour Chart																	
V-Shade		A1	A2	A3	A3.5	A4	B1	B2	B3	B4	C1	C2	C3	C4	D2	D3	D4
Paste / Powder Opaque	16	OA1	OA2	OA3	OA3.5	OA4	OB1	OB2	OB3	OB4	OC1	OC2	OC3	OC4	OD2	OD3	OD4
Paste / Powder Opaque	1	Opaque Bleach															
Opaque Dentine	16	ODA1	ODA2	ODA3	AOD3.5	ODA4	ODB1	ODB2	ODB3	ODB4	ODC1	ODC2	ODC3	ODC4	ODD2	ODD3	ODD4
Dentine	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Transparent Clear fluorescent	1	CL-F															
Enamel	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Dentine Bleach	3	BD1	BD2	BD3													
Enamel Bleach	1	BL-E															
Dentine Modifier	4	DM1-Sun	DM2-Terracotta	DM3-Sand	DM4-Flesh												
Transparent	2	TN neutral	TO opal														
Effect Transparent	5	ET1-blue	ET2-white	ET3-rosa	ET4-yellow	ET5-grey											
Effect Enamel	4	E5-grey	E6-yellow soft	E7-orange	E8-yellow												
Opal Enamel	2	OE1	OE2														
Neck Transparent	5	NT1	NT2	NT3	NT4	NT5											
Shoulder Transparent	7	S-1	S-2	S-3	S-4	S-5	S-6	S-7									
Shoulder Opaque	3	S-8	S-9	S-10													
Gingiva	2	G1	G2														
Correction	1	COR															
Glaze	1	GL															

GC PROCEED Zr Colour Chart																	
V-Shade		A1	A2	A3	A3.5	A4	B1	B2	B3	B4	C1	C2	C3	C4	D2	D3	D4
Liner	5	L2	L2	L2	L3	L2	L1	L3	L3	L3	L1	L2	L2	L2	L1	L2	L3
Liner		L4 Bleach	L5 Gingiva														
Dentine	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Transparent Clear fluorescent	1	CL-F															
Enamel	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Dentine Bleach	3	BD1	BD2	BD3													
Enamel Bleach	1	BL-E															
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Opal Enamel	2	OE1	OE2														
Neck Transparent	5	NT1	NT2	NT3	NT4	NT5											
Shoulder Transparent	7	S-1	S-2	S-3	S-4	S-5	S-6	S-7									
Shoulder Opaque	3	S-8	S-9	S-10													
Gingiva	2	G1	G2														
Correction	1	COR															
Glaze	1	GL															

F - Opacity level of PROCEED powders

What is important to understand with the different opacity levels of ceramic powders is their interaction on light scattering.

4 phenomena occur when light is diffused on the ceramic: transmission, reflection, absorption and reflection

- **Light transmission** occurs when light passes through ceramic with transparent substances (low opacity). This transmission can be reduced or even stopped when it encounters molecules of different levels of opacity in different powders. The less opacity level, the more transmission of light, the more opacity level, the less transmission of light.
- **Reflection of light** occurs mostly when the light bounces on the surface of the crown or internally when the light return from the surface of mineral material. The reflection process inverts each wave light back-to-front.
- **Absorption of light** occurs when the light wave is absorbed by powders with a high level of opacity as it propagates through them and will never be released as light again but as a colored. The less opacity level, the less absorption of light and less reduction of the intensity of light. The more opacity level, the more absorption of light and more gradual reduction of the intensity of light
- **Refraction of light** occurs due to the change in speed of light when it enters from one opacity level powder to another one, it also changes the direction of light when travelling at a different speed in different opacity level powders. Refraction occur in low opacity level powders when the light falls on another layer of ceramic that has a different level of opacity, meaning a different refractive index.

PROCEED Ceramics Opacity Levels			
POWDERS		NAME	OPACITY LEVEL %
PO	(PO-A1 to PO-D4 and Bleach)	Paste Opaque	100%
O	(O-A1 to O-D4 and Bleach)	Opaque	100%
G1		Gingiva	85%
G2		Gingiva	80%
OD	(OD-A1 to OD-D4)	Opaque Dentine	80%
BD	(BD-1 to BD-3)	Dentine Bleach	80%
S	(S-8 to S-10)	Shoulder Opaque	80%
DM	(DM-1 to DM-4)	Dentine Modifier	75%
D	(D-A1 to D-D4)	Dentine	75%
COR		Correction	65%
S	(S-1 to S-7)	Shoulder Transparent	60%
BL-E		Enamel Bleach	50%
OE	(OE-1, OE-2)	Opal Enamel	50%
E	(E-5 to E-8)	Effect Enamel	50%
E	(E-1 to E-4)	Enamel	45%
NT	(NT-1 to NT-5)	Neck Transparent	40%
ET	(ET-1 to ET-5)	Effect Transparent	40%
TO		Transparent Opal	40%
TN		Transparent Neutral	35%
CL-F		Transparent Clear	15%

The measurements of the opacity levels are average values. The different color intensities have a big influence on the opacity. Therefore, the indicated values can only be seen as an orientation aid.

*All opacity values refer to samples with a thickness of 1mm and a measuring range of 400-700nm and are based on in-house measurements. The average values are indications for the orientation within the system.

III – Alloy/metal Structural Framework Design

All **KNOWLEDGE** is connected to all others.

The ***FUN*** is in making the connection!

A - Introduction

A good knowledge on framework design can avoid mechanical, functional and aesthetic failure.
The framework design is the most fundamental part that will define the lifetime of the restoration.

Metal-ceramic restorations are prone to compression and tension that lead to failure, a consequence of possible failure is the fracture of the veneering ceramic, the fracture of the metal framework or both.
Failure can compromise aesthetic, function and biologic tissue.

Metal-ceramic restorations undergone thermal stress during the firing process of the ceramic and functional masticatory stresses after cementation.
These forces must be transmitted to the framework rather than to the ceramic layer.

B - Alloy frameworks generality

The physical and chemical properties of both ceramic and metal alloy must be compatible.
Ceramic and metal/alloy expand by a different coefficient amounts upon heating; we call this coefficient the coefficient of thermal expansion (CTE)
The fusion temperature of ceramic, usually between 700 to 1100c, must be lower than the metal casting fusion temperature, which prevents the cast metal substructure from melting during the ceramic firing process.

The shortened form of the Coefficient of Thermal Expansion can be as CTE or COTE and can also be called as Coefficient of Linear Thermal Expansion (CLTE).

The coefficient of thermal expansion of ceramic is usually between 12.5 to 14 x10-6/0C and should be approximately as to 1 x10-6/0C less than the CTE of the casting alloy, which put the ceramic into slight compression (at the ceramo-metal interface) on the metal alloy coping when it cools down.
Ceramics become much stronger under a state of compression than under tension.

Coefficient of thermal expansion (CTE)

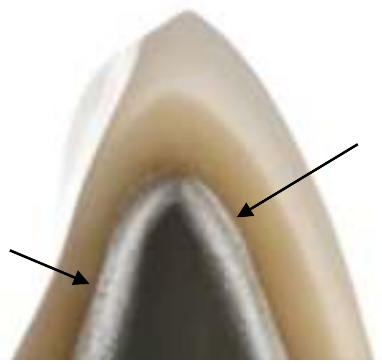


Fig.2 - Using an alloy with the right CTE allows a great bond of the opaque and ceramic on the alloy substructure
(Ceramic and photo Mr. Frederic Furgier - CDT)

Coefficient of Thermal Expansion (CTE) of PROCEED MC:

PROCEED have a Coefficient of Thermal Expansion (25-500°) of **13,0 / 13,1**
Ceramics must have a lower CTE than the CTE of the alloys to shrink on the alloy substructure, this compression also allows a better bonding on the opaque layer.

General information about Precious Metal and Alloy:

Precious metals or non-precious metals with a CTE of **13,8 – 14,9** can be veneered with PROCEED MC.

Note:
here are some recommendations if the metals/alloys CTE is up to 14,5 and if the CTE is down to 14,1:
- CTE > 14,5: Prolonged cooling temperature in furnace program
- CTE < 14,1: The object must be removed rapidly from the firing chamber (furnace)

C - Abutment preparation and restoration structural thicknesses

The Preparation & Framework Design Guidelines is a basic guideline for PFM restorations. It will only serve as a reference as the preparation design varies for each patient and the cases to be done.

1 - Abutment preparation

The tooth preparation is the first important step to allow enough place to achieve the best aesthetic result also as a durable and stable restoration.
Giving more space for the ceramic makes the light to be adequately reflected, absorbed and transmitted on the cervical, body and the incisal area which is essential to get the right desire chroma and value.
More space on the preparation design also give stability to the restoration, especially on the cervical area.

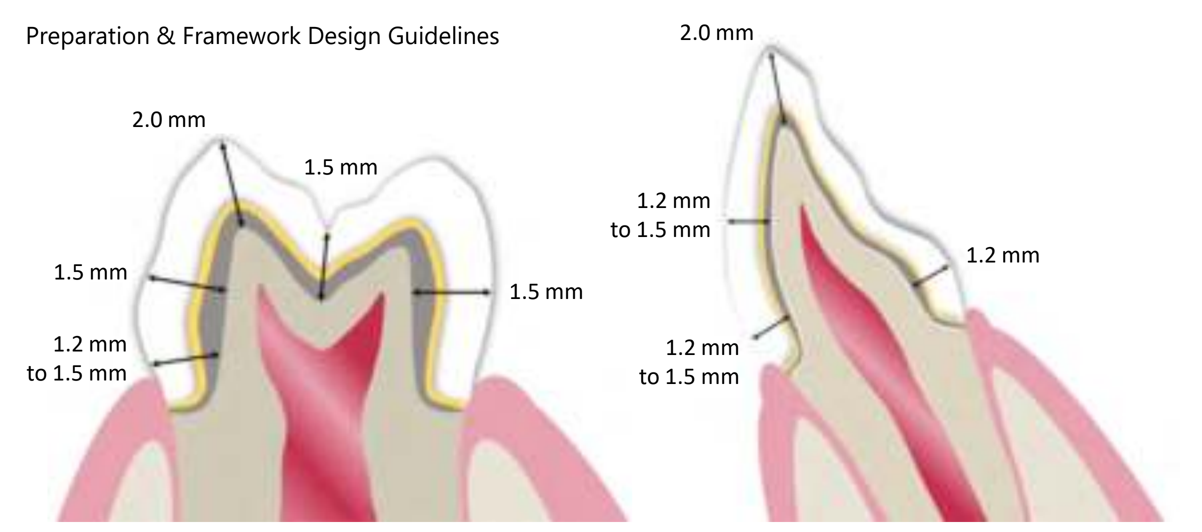


Fig. 4-1 – Preparation design and thickness

The reduction of the preparation must be at a minimum of 1.2 -1.3 mm in the center body area and a minimum of 1.5 - 1.6 mm in the incisal area.

<u>Ideally:</u>

- ✓ 1.2 to 1.5 mm in cervical
- ✓ 1.5 mm in the center body area
- ✓ 2.0 mm in the incisal area (cusp area)

When it is possible allowing more space for the metal substructure and the ceramic layers is always preferred for the Porcelain Fused to Metal restorations (PFM).

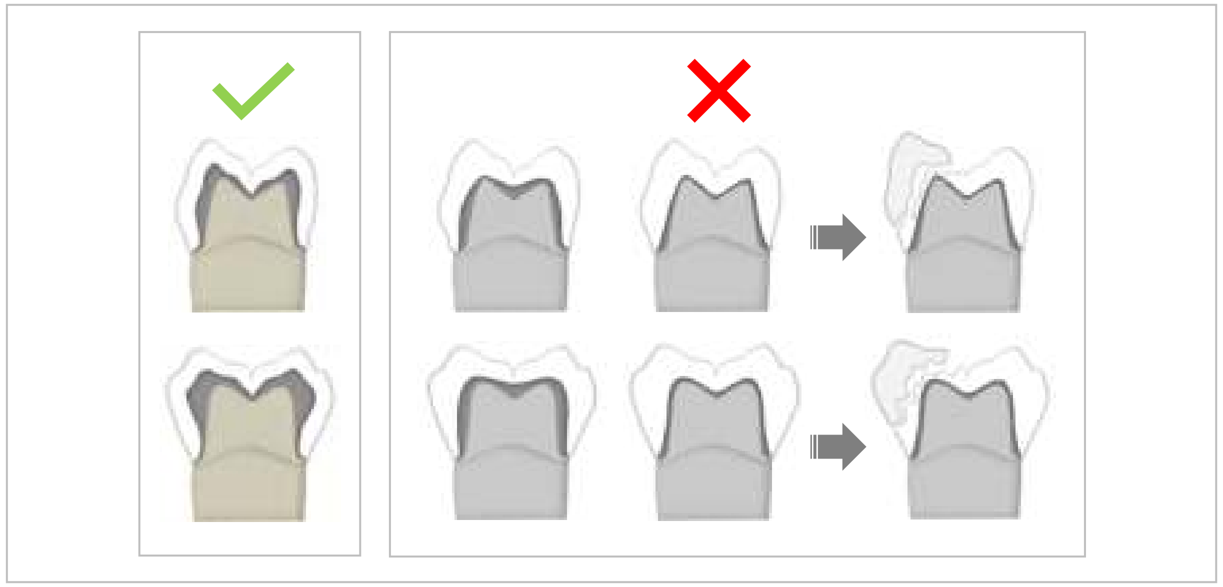
> Note:
> the average thickness of cement is about 30 to 80 µm and the gap that can exist between the coping and the tooth preparation in some part can be 100 µm (0.1 mm) due to laboratory manufacture process.

2 - Substructure thickness

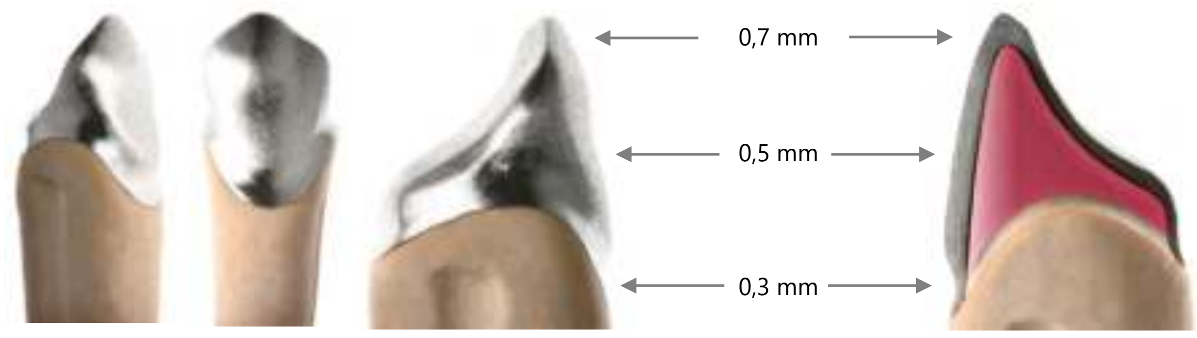
The design of the metal/alloy framework contributes to the longevity and durability of PFM restoration.
A well-designed framework provides a high-quality result, clinical success and patient satisfaction.
The metal framework must reflect the reduced final restoration shape.
The contouring of the framework must allow an equal layer thickness of the ceramic in all part of the restoration from labial to lingual as mesial to distal.

By achieving an equal and proportional ceramic layer thickness the masticatory forces and loads are transmitted to the framework through the ceramic and not to the ceramic layer alone which causes its fracture.

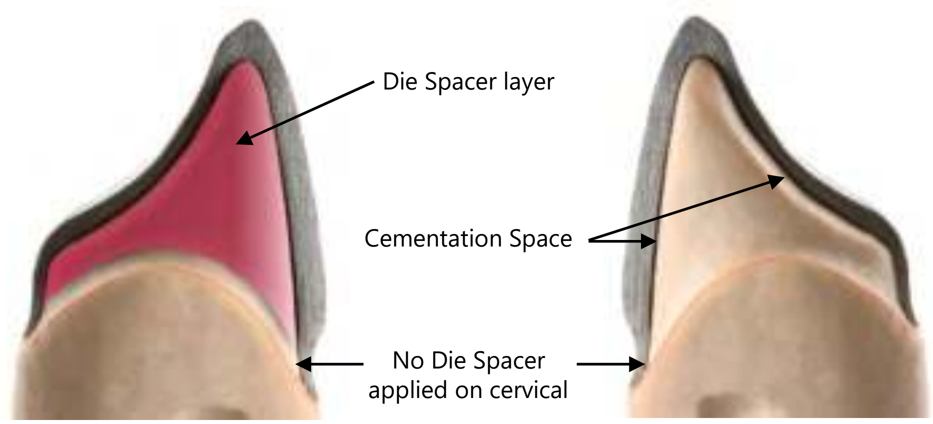
Fractures occur when the ceramic is not supported by the metal framework,, when the ceramic layer is thicker in some part (especially cusp and occlusal areas), when the ceramic doesn’t transmit forces to the framework.



The metal substructure should provide sufficient strength to support the shrinkage of the layer of ceramic as well as forces and stress applied on the restoration during the masticatory.
The metal substructure thickness should normally be between 0.3 and 0.7 mm.
Ideally the preparation design should give at least a 0.5 mm thickness for the metal substructure on the body wall, at least 0.3 mm on cervical and a greater thickness in the occlusal surface or cusp edge of at least 0.7 mm.



The total tooth preparation design thickness must include the metal substructure thickness as well as the space given to the cement to flow between the tooth and the metal coping.
To allow a complete seating of the metal ceramic restorations to the tooth, the cement must obtain an appropriate flow rate while maintaining a minimum film thickness.
The use of a die spacer applied on the die plaster preparation before the waxing of the coping substructure gives room for the cement to flow along the preparation body between the metal and the tooth preparation and is blocked on the cervical area where the metal coping fit perfectly to the preparation.



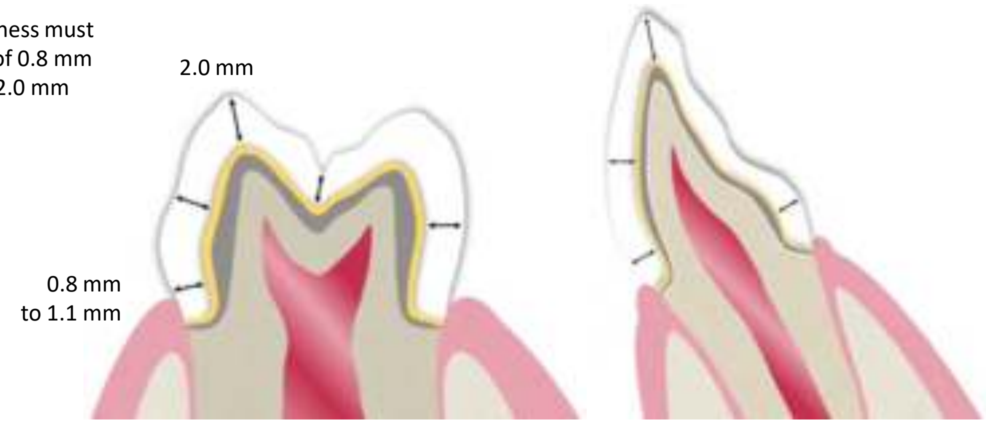
Note:
The cementation thickness in optimal condition has an average of 30 to 80 µm but due to the impression accuracy, plaster expansion and the manufacture process in the laboratory the gap between the 2 surfaces can give an additional 20 µm or slightly more.
To keep enough strength the minimum thickness of the framework **before opaquing** mustn't drop below 0.3 mm for single crowns and 0.5 mm for bridge frameworks.

3 - Ceramic thickness

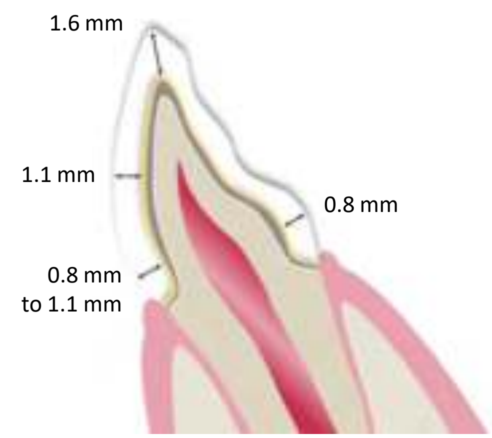
To achieve a matching shade with the ceramic, the layer of the ceramic must not fall below 0.8 mm or exceed 2.0 mm. If this layer thickness is not possible in the marginal area of the crown due to the risk of over contouring, the opaquer must at least be covered with a ceramic layer of 0.25 mm.
The minimum thickness of the framework **after finishing** must be at least 0.3 mm for single crowns and at least 0.5 mm for abutment crowns in bridge frameworks.

The thickness of the layer of ceramic must not fall below 0.8 mm or exceed 2.0 mm.

The layering thickness must have a minimum of 0.8 mm to a maximum of 2.0 mm



The framework must provide an equal ceramic thickness (uniform layer) over all surfaces.
Non-uniform layer thicknesses of the ceramic brings unwanted color differences and uncontrollable shrinkage of the ceramic.



Note:
The opaque surface must be covered in the marginal area with a minimum of 0.25 mm ceramic layer.

D - Margin’s framework design

1 - Generality and types of margin design

The margin’s design represent the physical transition between the finish line of the tooth tissue and the restoration itself.
Both alloy substructure and ceramic layer at the margin area must demonstrate a minimum thickness in order to achieve correct stability of the restoration, appropriate shade reproduction and periodontal health.

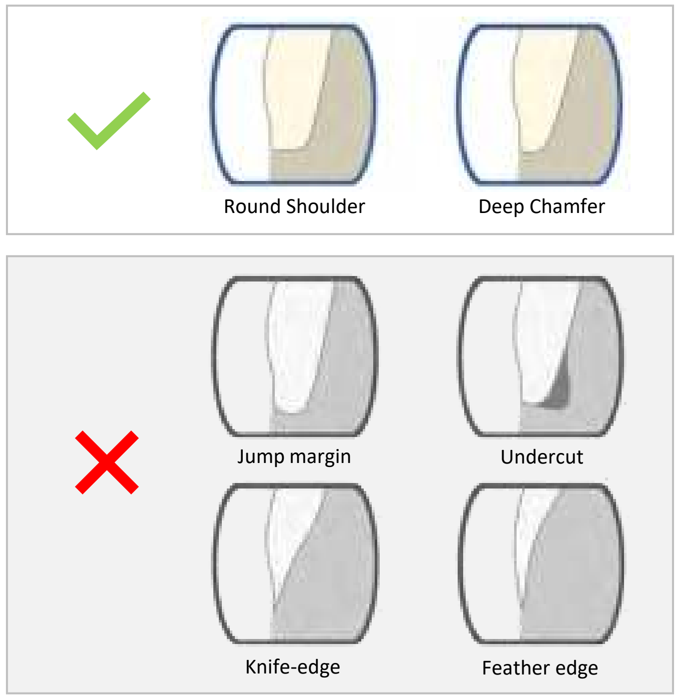
Designing a stable and robust margin framework by respecting a minimum thickness demonstrate to maintain an accuracy of fit even after several ceramic firing.
The deformation of the alloy occur during the ceramic firing cycles when it expand due to the difference between the solidus point of the alloy and the firing temperature of the ceramic when the thickness of the alloy substructure is too thin.

Round Shoulder with a width of 1 mm to 1.5 mm offers optimum rigidity compared to all other margin designs, it allows the metal substructure to bring good stability, good support for the ceramic and resistance to ceramic shrinkage.
The rounded axial line angle reduces load stress applied on the margin and gives a better fitting of the restoration on the tooth tissue.

The **Deep Chamfer** has less gap than shoulder design, is less likely to have undercuts and are more tissue conservative than shoulder preparations.
To ensure a smooth transition between the tooth and restoration a proper finishing of the preparation should be done.

The **Knife-edge** and **Feather edge** margins are difficult to be read on the preparation. The metal on these areas is at its thinnest, often compromises a good fitting and hence most vulnerable to failure. These margins are also prone to distortion during the firing of the ceramic.
Knife-edge and feather edge margins show a lack of aesthetic due to the opaque layer not covered with sufficient ceramic, if a proper amount of ceramic is covering the opaque on this zone it results on a margin being bulky.

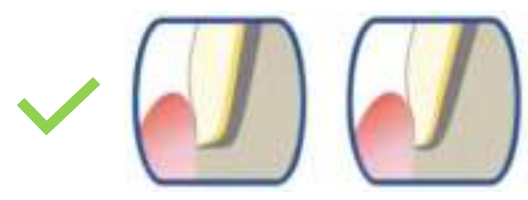
Here are the most accurate margin design for metal-ceramic restorations and the margin design that must be avoid.



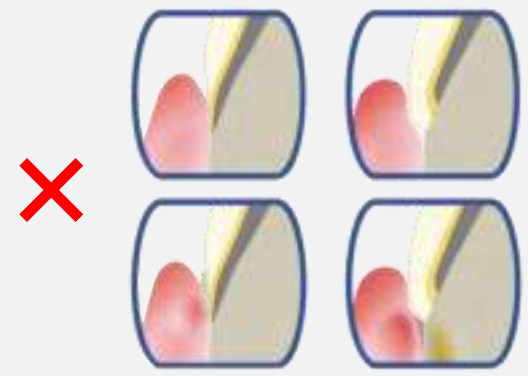
Margin's design plays a role in the lifetime of the restoration and an even more critical role in the lifetime of the supporting tissues of the tooth.

An imprecise fit and/or too thick margin (overbuild) disrupt the smooth intersection line between the restoration and the tooth surface and thus make the site vulnerable to plaque accumulation. This gap created at the margin between the prepared tooth and the restorative material can also allows the passage of foods, molecules, fluids or bacteria increasing cement dissolution and caries that will damage the tooth tissues.

Margins not allowing the opaque to be covered by a minimum layer of ceramic led to irritation of the gingiva. The opaque due to its rough surface is a great site for plaque accumulation.



Round shoulder and deep chamfer margin show less vulnerability against the gingiva site.



Knife-edge and feather edge margin often make the margin site vulnerable.

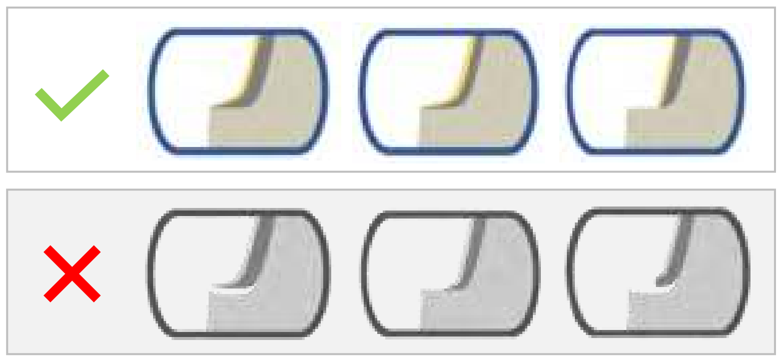
2 - Metal margin consideration

- The thickness of the alloy should be at a minimum of 0.3 mm when 0.5 mm should be considered as an optimum thickness.
- The angle of the axial line should be rounded to reduce stress in this area.
- The finish line of the alloy margin must be reduced and finely tapered .
- The opaque layer on the alloy substructure must be at least 0.20mm thick .
- Excessive contours in the marginal area should be avoided .
- The margin should be placed slightly subgingival (ideally at half of the sulcus depth).

Note:
Ideally for metal ceramic crown a buccal Round shoulder and palatal chamfer should be made.

A perfect margin design must show:

- ✓ A perfect stability of the restoration
- ✓ A smooth intersection line between the prepared tooth and the restoration
- ✓ A sound accuracy of fit with the preparation margin line
- ✓ Gapless margin line
- ✓ A sufficient thickness

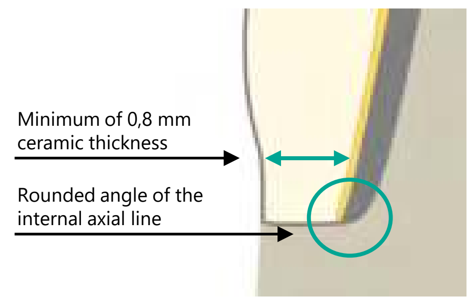


3 - Ceramic shoulder margin

When doing a fused-on ceramic shoulder margin (collarless metal ceramic), the framework and the ceramic must be well supported by the prepared tooth tissue.
To ensure a good support the framework must be reduced to finish on and cover the rounded angle of the internal axial line of the shoulder or chamfer preparation.
When a chamfer margin design is used, the preparation of the chamfer must be deep enough to provide enough volume of ceramic to resist fracture.

<u>Fused-on ceramic shoulder</u>

- ✓ The ceramic cover the entire horizontal axis till the finish line
- ✓ Metal not visible at the external surface of the restoration
- ✓ Allows light to be transmitted to underlying tissues
- ✓ Light transmission increased
- ✓ Opaquing effect on cervical area is eliminated
- ✓ Excellent aesthetic
- ✓ Procure precise marginal finish (supragingival or equigingival)
- ✓ Produces the least stress in the cervical area (subgingival or equigingival)
- ✓ Fused-on ceramic margin can be made on Rounded shoulder or Deep chamfer preparation



<u>Different techniques can be proposed to make a fused-on ceramic facial margin restorations:</u>

- HRM: Horizontal Reduction Margin.
  1 mm horizontal reduction of the metal framework (Fig. 2) .
- HVRM1: Horizontal and vertical Reduction Margin,
  1 mm horizontal reduction of the metal framework
  1 mm additional vertical reduction of the metal framework (Fig. 3)
- HVRM2: Horizontal and vertical Reduction Margin
  1 mm horizontal reduction of the metal framework
  2 mm additional vertical reduction of the metal framework (Fig. 4)

Metal margin extended to the finish line

Fig. 1

Fused-on ceramic shoulder margin

Fig. 2

Fig. 3

Fig. 4

E - Functional Framework Design

1 – Wax contouring and anatomical reduction

This section will intend to show how to master wax contouring for PFM restorations.

A quick waxing of the entire restoration is done with a complete contour from mesial to distal, from labial to palatal as well as occlusal placement details (cusp and fossa) as determine and dictate by mandibular movements. The goal is to get as close as possible to the entire volume that the future final restoration will have.

A silicone putty index is made by pressing the silicon carefully against the wax teeth elements, overlapping the lingual/palatal wax margins and taking impression of at least 5mm of the gingiva as well as taking the adjacent teeth. Gently remove the silicone after it has hardened.

Repeat the process to make 3 silicone putty indexes that will be respectively cut in:

- sagittal (cut vertically from labial to palatal on choosing tooth).
- transverse horizontal (the cutting will be made at mid-vestibular length and mid-palatal for the other side).
- longitudinal (cut in the place of the incisal edge of the anterior teeth, it can be cut on the incisal edge of labial cusps and palatal cusps for posterior teeth).

Wax-up

Silicon putty
Flexceed

Pressing of the silicon index against the wax framework

Cutting of the index

Sagittal index

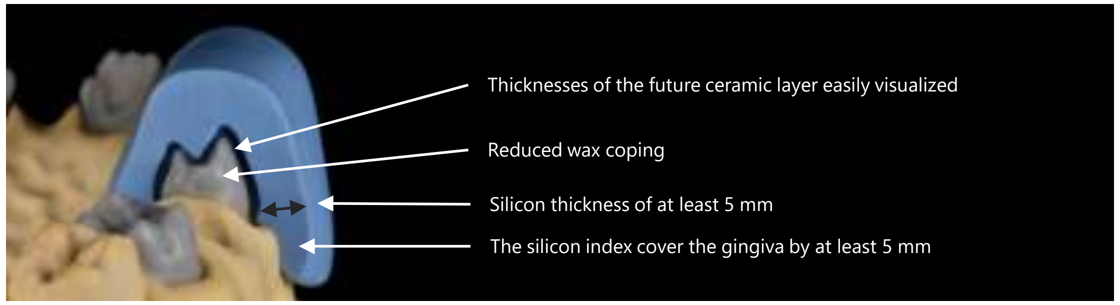
Transverse index

Note:
Make sure the silicone is thicker than 5 mm.
For optimum visual control, the walls of the silicone index can be reduced all around to keep at least a 5 mm to 8 mm thickness.

The silicone index result on an impression of the wax-up and is used for visualized the length, the width and the volume information of the desire final restoration and to reduce or build-up the wax coping to become the final alloy substructure framework.

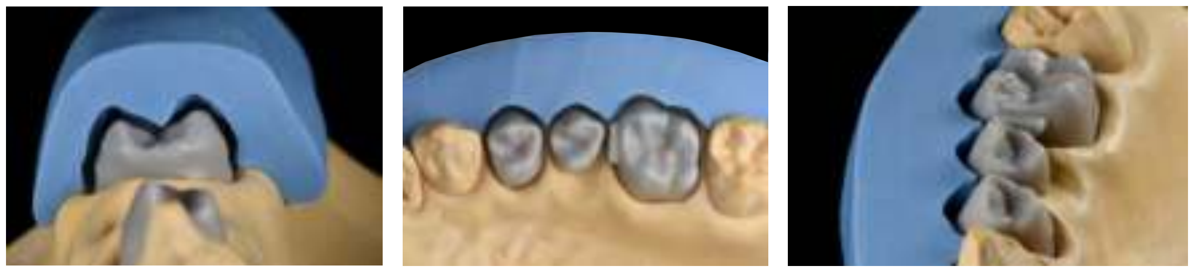
The advantages of this technique:

- the index is acting as a guide to design the substructure.
- the index helps to check the availability of space for the future ceramic build-up layer.
- the thicknesses of the future ceramic are easily visualized.
- overall reduction can be checked with the sagittal index.
- the occlusal function can be transmitted for a correct anatomical reduction of the coping framework.
- incisal edge position easily checked.
- the labial and palatal faces reduction easily aligned and checked with the transverse index.



Why do you have to leave a sufficient and equal space between the wax and the silicone index?

- Uneven ceramic layer thickness results in uneven shrinkage and tension in the ceramic (which can lead to the loss of the anatomy given during the ceramic build-up and cracking of the ceramic).
- Thick ceramic layers lead to chipping of the ceramic in the firing furnace or once in the patient's mouth.
- Thin layers of ceramic cause loss of aesthetics (opaque shade or unwanted shade)

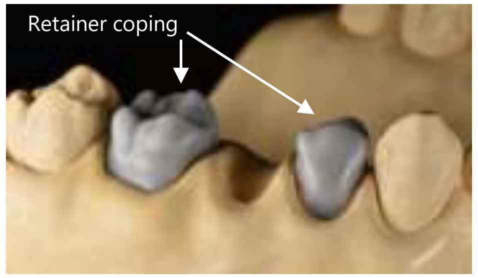


Note:
For optimum visual control, the walls of the silicone index can be reduced all around on the outside to maintain a thickness of at least 5 mm to 8 mm.

2 - Bridge framework design

If a good attention to details is made in the final wax-up, the finishing procedures of the restoration will be minimal. During the wax up of the bridge we must keep in mind the availability of space needed for the following ceramic layer.
This precise wax-up is evaluated in 2 levels, functional and esthetic:

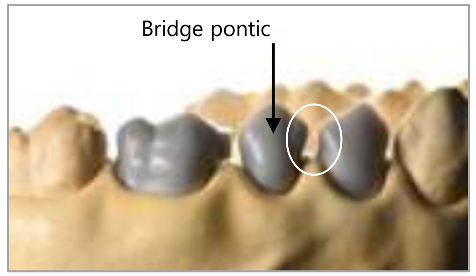
- **This silicone index** help to reproduce the proper anatomic contour, the anatomic position and inclination of the bridge substructure.
- **The articulator** (plaster models mounted in semi-adjustable articulator) help to check the functional mandibular jaw movement and adjust (reduce or build up) the anatomical occlusion contour and length, as necessary.



First, the wax-up of the copings on the abutment teeth (retainer copings) is modeled.

Second, the wax details for a proper anatomic contour, anatomic position and anatomical occlusion contour are added.

The complete contour occlusal wax-up detail (cusp and fossa) is accurately reproduced and placed as dictated by the silicon index and articulator movement.



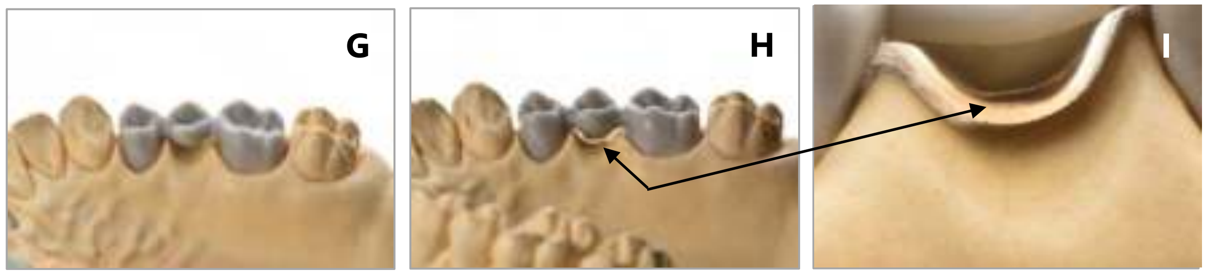
Once the anatomical and functional contour wax-up of the retainer copings is finished, the pontic is sculpted between them.
The wax pontic is first build-up and positioned with wax and not fixed to the wax copings.

Note:
The coping's opposing teeth (antagonist teeth) must be distanced from 1.5 to 2 mm so that the ceramic layers can be correctly built up on top of the incisal frame.

Details of the anatomic wax coping

As for the retainer coping the wax up of the pontic should be made in a way to give sufficient thickness for the future layer of ceramic (Fig. A). The silicon index is a good help to check if enough room is left for the ceramic to cover the connector cross-sections and make an aesthetic labial embrasure (Fig. B & C)

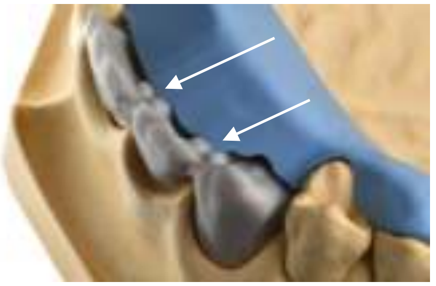
The wax pontic will be fixed to the retainer copings by an appropriate interdental connector cross-section design. This interdental connector cross-section (Fig. D) is wax first then the pontic is build-up and positioned with wax and not fixed to the wax retainer copings (Fig. E & F).



The wax pontic is fixed to the retainer copings by adding wax and by carefully keeping the shape design of the connectors cross-section (Fig G). The final step gives the pontic a lingual convex shape till the center of the alveolar ridge, a mesio-distal convex shape is also made (Fig. H). A distance between the framework and the gingiva is created to ensure enough layer of ceramic at the basal surface (Fig. I).

The bridge is finished and a last check is done with the silicon index

Waxing of an anterior bridge



Use of the silicone index to check and control the step-by-step reduction wax pattern of the contoured anteriors. Wax interdental connectors (struts) are extended to the lingual/occlusal surface for extra strength of the framework under movement loads.

The pontic is given a lingual and labial convex shape till the center of the alveolar ridge, a mesio-distal convex shape is also made. A distance between the framework and the gingiva is created to ensure enough layer of ceramic at the basal surface.

(At this step, the pontic basal surface can also be in contact with the alveolar ridge, the reduction can be made during the metal contouring)

Enough place is given in the interdental space for an even layer of ceramic on each tooth.

Completely contoured and finished wax framework on its model.

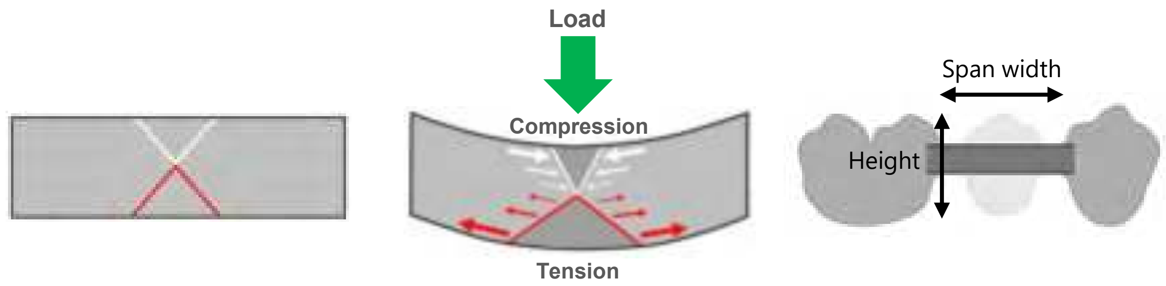
Metallic scallop acting as a lingual reinforcement of the bridge pontics to reduce tension and cingulum fracture under masticatory loads.

3 - Bridge connection

Connection areas on a bridge framework play a role in the aesthetics of the final restoration, but the primary role of the connection area is to achieve the best possible strength of the bridge framework under functional loads.

The compressive loads and tensile strengths applied on a bridge and mostly on the pontic lead to extreme or moderate stresses directed on the abutments depending on the design of the connector cross-section.
The size and geometry of the connector cross-section directly influence the strength of the bridge framework.

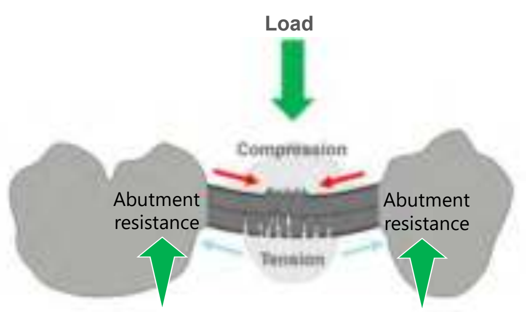
The interdental connector cross-section should be adequately design in accordance with the span width and height of the bridge framework.



Here are the different stress forces that can be experienced by a bridge metal-alloy framework:

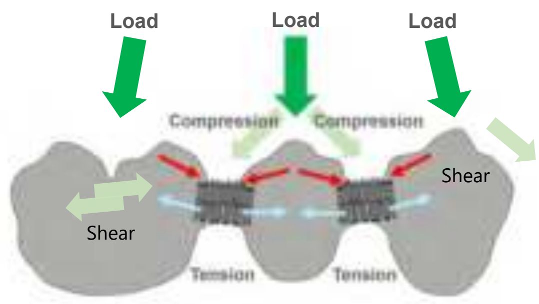
Explanatory drawings of the distribution of the different forces applied to a bridge framework:

The bending is the reaction induced in the bridge when an external force is applied to the pontic element causing the pontic span length structure between the retainer abutment to bend.



Bending

A multi-load tend to induce different stresses at a different strength on different part, causing compression, tension, bending and shear at the same time.



Multi-load

The longer the span width between each retainer abutment the bigger the interdental connector cross-section should be.
From a physical stability point of view, height can hardly be replaced by width.
Doubling the height of a cross section connector offer an eightfold stability (8x), while doubling its width only offer a double stability (2x).
For optimum stability, it is therefore advisable to double the horizontal width and height of the connectors, especially in the case of a long span width bridge with more than 1 pontic.

Round single width cross section connector.

= Very low stability and strength under compressive loads and tensile strengths. (Fig. 1)

Round double horizontal width cross section connector.

= Moderate stability and strength under compressive loads and tensile strengths
By doubling the horizontal width of the connector cross section, it double its stability (x2). (Fig. 2)

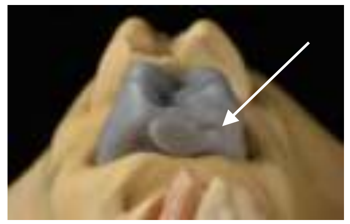
Round double height cross section connector.

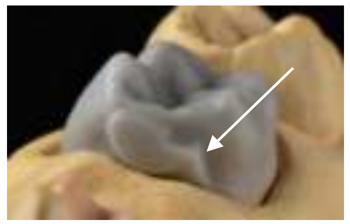
= Strong stability and strength under compressive loads and tensile strengths.
By doubling the height of the connector cross section, it increase the stability (degree of deformation) by a factor of 8 (x8). (Fig. 3)

Round double horizontal width and double height cross section connector.

= Very strong stability and strength under compressive loads and tensile strengths. (Fig. 4)

For the bridge presented in this technical manual a double horizontal width with double height cross section connectors was chosen. The cross section is also reinforced with an interdental metal band (strut) extended to the lingual/cervical surface for extra strength of the framework



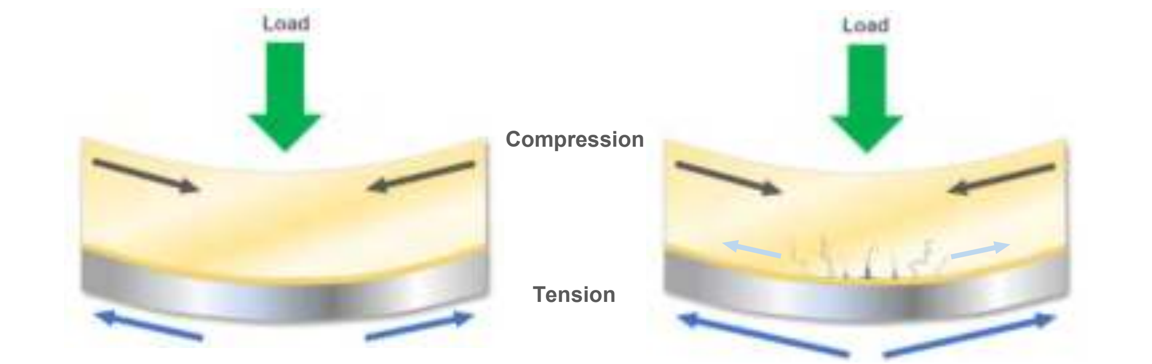


Note:
The minimum thickness of connector for posterior bridge should be 3 mm occluso-gingivally and 3 mm facio-lingually. For anterior the occluso-gingival thickness dimension may be decreased to 2.5 mm in small single pontic with a 1.5/2.0 mm facio-lingual. For posterior, the maximum thickness available should be used

4 - Distribution of stresses in the ceramic restoration

The distribution of forces in the ceramic layer

The metal-ceramic restoration strength is also determined by important factors:
- the bonding strength between the metal-alloy and the ceramic (metal-alloy ceramic interface)
- the strength of the framework (including the strength of the connectors cross section for bridges)
- the matching CTE (coefficients of thermal expansion) of the metal-alloy and the ceramic.
- the equal compressive and tensile strength of both metal-alloy and ceramic



A strong framework show balanced stresses in the ceramic upper side (compressive stresses) and metal underside (tensile stresses).

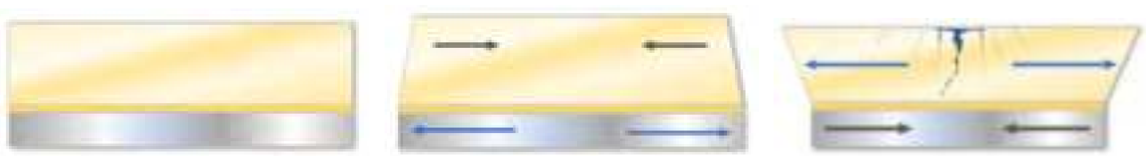
Cracks and fractures happen when the metal framework have a tensile stress exceeding the tensile strength of the ceramic.

Stresses on the restoration occur during chewing load but stresses can also happen during the firing process of the ceramic in the ceramic furnace.
When firing the metal-ceramic at high temperature (850 to 980ºC) the ceramic is at a melting soft state and is forced to be compressed to the metal substrate under vacuum where the bonding occurred. At the end of the firing cycle during the ceramic hardening from 600ºC to ambient temperature different complex tensions occur between the metal/alloy and the ceramic at the bonding interface.

When the difference of CTEs is positive
- the CTE of the metal/alloy is ***higher*** than the CTE of the ceramic
- the metal/alloy is under tension and the ceramic is under compression.
- The tension and the compression are at a near equal strength

When the difference of CTEs is negative
- the CTE of the metal/alloy is ***lower*** than the CTE of the ceramic
- the metal/alloy is under compression and the ceramic is under tension.
- The tension and the compression are too far opposite and result in failure (cracks)

A high difference of CTE results in bonding failure from which cracks may occur.



Optimum stresses distribution

Positive CTEs
Acceptable stresses differences

Negative CTEs
Inadequacy of stresses

5 - Pontic design

a) Pontic metal framework design considerations

A bridge pontics framework on a metal-ceramic bridge is the reduction of the original shape of the missing natural tooth to be replaced between the abutment crowns and cover with the veneering ceramic.
An ideal pontic design must bring together aesthetic, function, hygiene, patient comfort (included phonetic), and an easy maintenance of healthy tissue on the edentulous gingiva ridge (some bridge pontics require adequate personal oral hygiene).

The bridge pontics that meet long-term success for strength, longevity and prevent irritation of the tissue are design with an attentive form and shape following 3 principles:
- **Mechanical principles:** offer stability with strong cross-section connectors to prevent stresses, rigidity to resist deformation and porcelain fracture.
- **Biologic principles**: no pressure on the gingiva ridge, cleaning capability, great for the health of the tissue surface.
- **Esthetic principles:** giving enough space for the layer of ceramic design, looking like the tooth it is replacing, appearing to come out of the ridge naturally.

b) Type of bridge pontic

There are different type of pontic depending on their design and indication:
- Sanitary bridge pontic
- Reduced bridge pontic
- Spot bridge pontic
- Saddle bridge pontic

Sanitary bridge pontic

= This pontic type is called sanitary due to its ease of cleaning as it doesn't touch the mucosa ridge. Indicated for its minimal tissue inflammation, no chance of food lodgment.
Not aesthetic at all, can cause some phonetic issues but great for the health of the tissue.

Spot bridge pontic (modified ridge lap pontic & conical pontic)

= The saddle laps over the buccal side only and leaves the lingual ridge exposed. It's less aesthetic and the concave lingual shape of the pontic can cause food to get stuck between the gingiva tissue and the pontic.

The conical pontic also called egg shaped has a single point contact with the ridge. Poor aesthetic but easy to clean due to its convex shape

Reduced saddle bridge pontic (lingual reduced ridge lap pontic)

= The pontic does not contact the lingual part of the ridge but the saddle laps over the ridge edge and labially.
This is the most used type of pontic
It's less aesthetic but easier to clean due to its convex lingual shape

Saddle bridge pontic (Ridge lap pontic)

= Overlap the buccal and lingual surfaces of the ridge. It forms a large concave contact with the ridge, looks like the natural shape of the tooth.
More comfortable and more aesthetic but difficult to clean and maintain a good hygiene, can result in chronic tissue irritation.

c) Pontic functional framework tips

We saw that the requirements of a bridge pontic are to be easily clean, to have a minimal contact with the gingival tissues, not to cause any food impaction, to look like a natural tooth and to be in correct occlusal harmony with the opposing teeth.
Nonetheless, a successful functional design is one that does not cause metal framework deformation under stresses and ceramic to fracture.

- Adequate cross-section connectors prevent the framework to stresses, bring rigidity and stability to resist deformation.

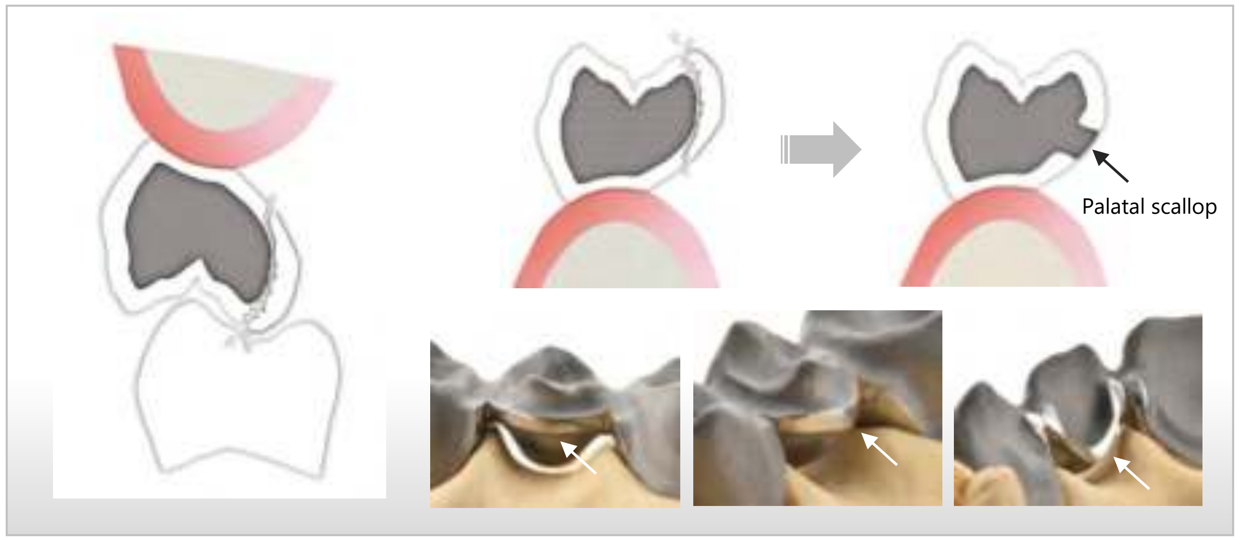
Palatal strut proximally on each side of the pontic, reinforcing the interdental connectors

- The bridge pontic must allow and support an even layer thickness of ceramic all around its structure but also support the seating of the ceramic at the basal surface towards the gingival tissues. The distance between the framework and the gingiva must not be too great, too great a distance can cause the rupture of the too thick ceramic layer underneath.

Metal not extended can cause the fracture of the ceramic

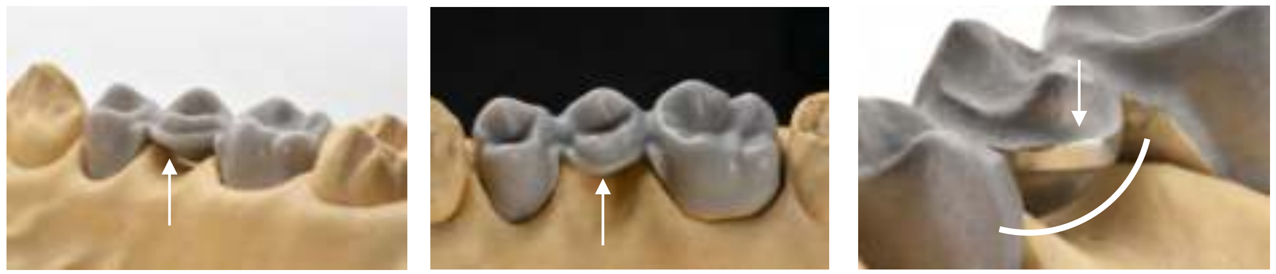
- The metal framework mustn't show sharp edges and angles, the framework angles have to be rounded to prevent fracture of the ceramic.

- The palatal cusps in the maxilla are under higher intercuspation masticatory stress than the lingual cusps in the mandible under normal bite.
  Providing lingual reinforcement of the bridge pontics by contoured scallops is indicated to prevent the fracture of the ceramic on the palatal cusp of the maxilla. Lingual scallops also make bridge pontics to be better cooled, especially with large bridge with more than 1 pontic and indicated for certain softer alloy types (e.g., gold).



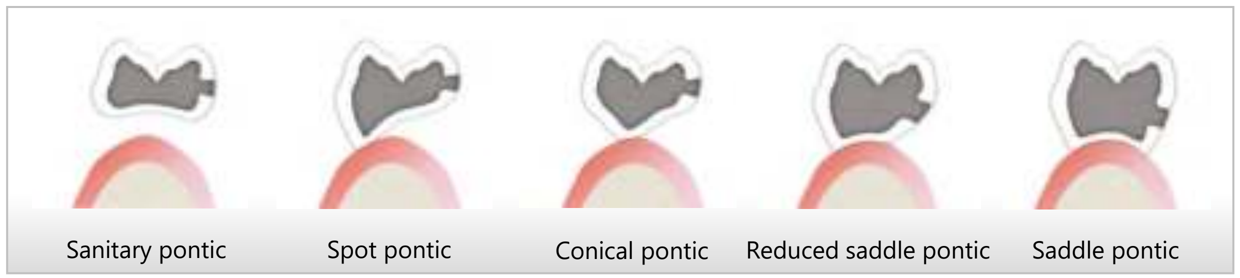
Metal is extended at the basal surface towards the gingiva with a convex shape allowing an even layer thickness of ceramic

Palatal strut proximally on each side of the pontic, reinforcing the interdental connectors



Contoured palatal scallop on posterior bridge preventing the fracture of the ceramic on the palatal cusp of the maxilla

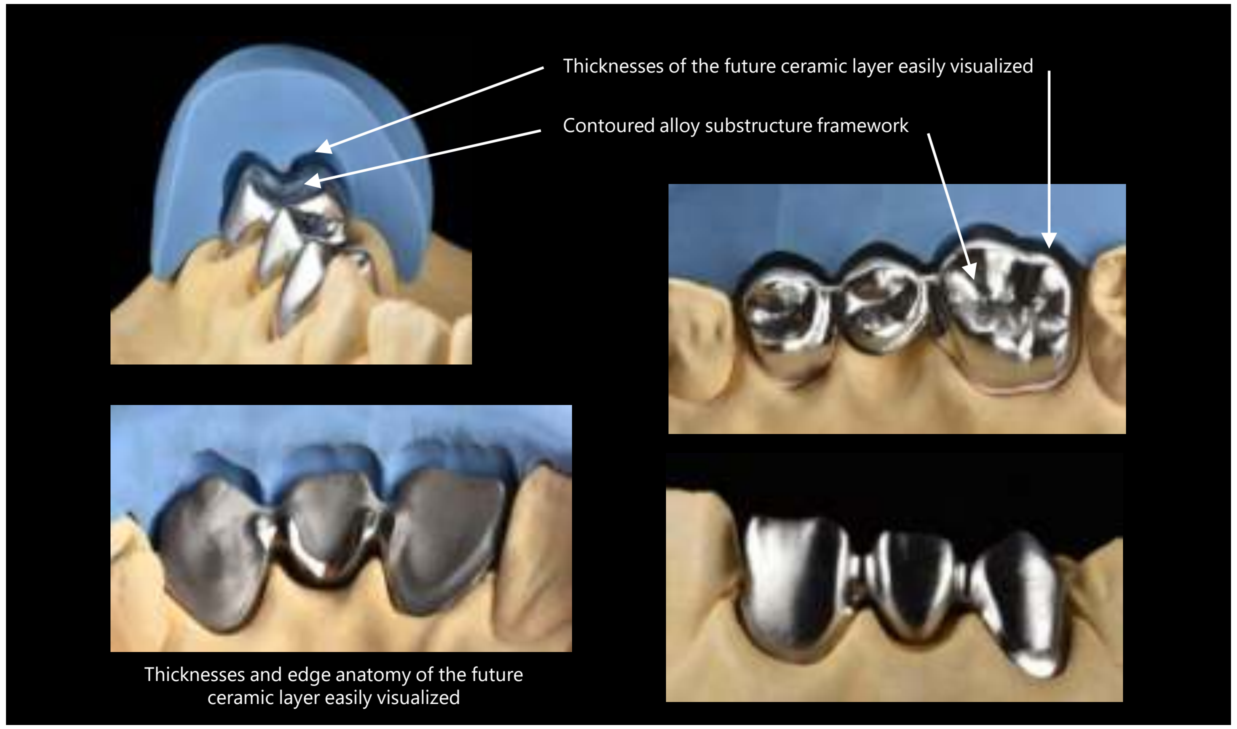
Contoured palatal scallop on incisal bridge

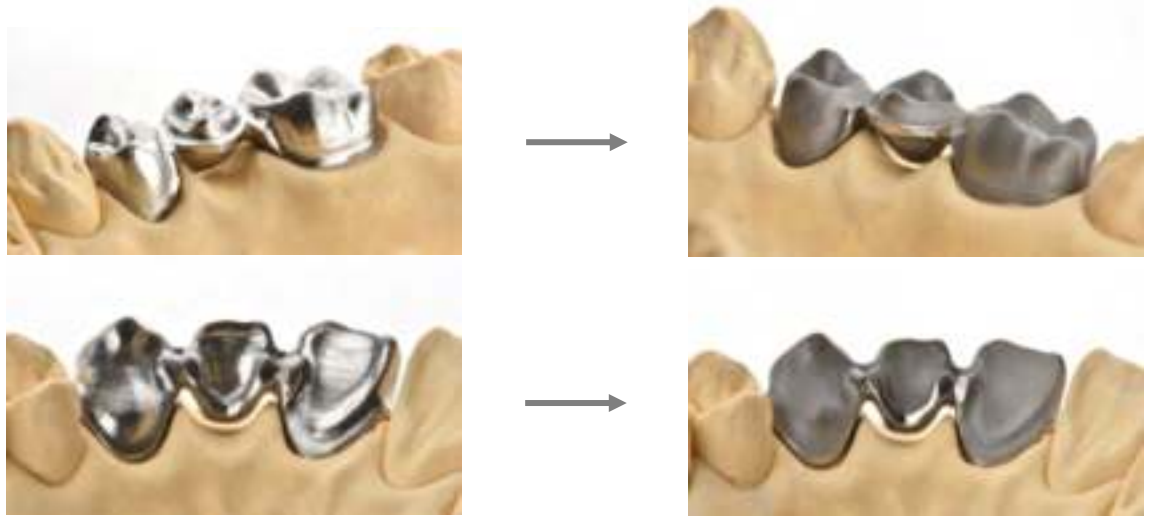


6 – Bridges contouring & finishing

Before and during the metal contouring checking and control of the availability of space:

- Uneven ceramic layer thickness results in uneven shrinkage and tension in the ceramic (which can lead to the loss of the anatomy given during the ceramic build-up and cracking of the ceramic).
- Thick ceramic layers lead to chipping of the ceramic in the firing furnace or once in the patient's mouth.
- Thin layers of ceramic cause loss of aesthetics (to opaque shade or unwanted shade)





When the length, width, volume of the framework and the spacing information are verified, the framework is ready to be sandblasted with aluminum oxide (Al_2O_3) particles with a size of 110 µm at 2.5 Bar pressure (35 psi) for 30 seconds/unit on the inside (intaglio) and outside.
The collars, struts and scallop are polished for an easy removal of the excess of ceramic during the ceramic finishing process.

IV - PROCEED MC recommendation for use

UNLOCKING **Skills**

A - Oxide firing, sandblasting and application of opaquer

<u>Oxide firing:</u>

Oxidation-firing of non-precious alloys is recommended but not always obligatory indicated, check the manufacturer's instruction of the alloy before use.
From an esthetical and chemical point of view it is highly recommended to remove the "excess" of oxides.

<u>Sandblasting:</u>

Sandblast with a 110µ-250µ alumina oxide at 3 – 4 bar. High gold content alloys and palladium free alloys must be sandblasted with a 125 µm alumina oxide at a pressure of 2 - 3 bar and at a correct angle.
The sandblasting process must be done at a correct angle of 45° towards the framework, this prevents the alumina oxide particles to penetrate the surface of the framework or to create micro cavities where air bubbles will be trap during the opaque firing.
After sandblasting try to directly apply the Opaquer or Bonder* (in the next 10 minutes) just after the cleaning of the framework.
During sandblasting a kind of electrostatic charge/activity is generated in the metal resulting in a better adaptation/wettability of the Bonder*/Opaque (*see at the end of the Technical Manual the PROCEED related products).

<u>Application of Opaquer:</u>

The primary functions of the opaque are to create an adequate light reflective and light absorbing layer as well as a total covering the metal shade. The opaque also produce a good bonding between the metal substructure and the ceramic.
The Paste Opaque must be "rubbed into the rough surface" followed by an application of a Wash Opaque layer and then fired. The "rub effect" allows the Opaque to flow into the small retentions created by the sandblasting. The intention is to obtain a good wetting with the Opaque.
Simply brushing the Opaque is not optimal as this might cause a "lifting off" of the Opaque and therefore only sinter on top of the alloy. If a good surface wetting is not achieved, it result bubbles and reduction of adhesion values. This first layer shouldn't be too thick to not cause the occurrence of bubbles.

(Fig.1) In case of unknown or non-matching CTE of the metal framework the NE Bonder can be applied before Opaque.
(Fig.2) The first Opaque is applied in very thin layer then fired.
(Fig.3) The second Opaque is applied, covering very well all the surface. It should have a shiny surface after firing.

Bridge metal framework after
Oxide firing

Bridge metal framework with the **NE Bonder** applied

Bridge metal framework after
NE Bonder firing

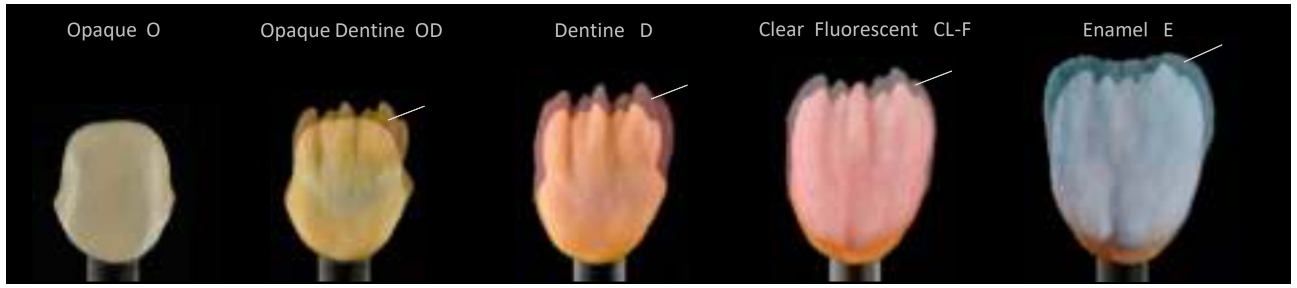
Bridge metal framework after
Opaque firing

PROCEED MC oxide, NE Bonder and opaque firing instruction

	Preheating temp.	Drying time	Raise of temp.	Vacuum	Final temp.	Holding time	Appearance
Oxide Firing	According to alloy manufacturer's instructions						
NE Bonder	550°C	6 min	80°C/min	Yes	980°C	1 min	Shining
1st Paste Opaque Firing*	550°C	6 min	80°C/min	Yes	940°C	1 min	Shining
1st Powder Opaque Firing*	600°C	2 min	80°C/min	Yes	940°C	1 min	Shining
2nd Paste Opaque Firing	550°C	6 min	80°C/min	Yes	930°C	1 min	Slightly Shining
2nd Powder Opaque Firing	600°C	2 min	80°C/min	Yes	930°C	1 min	Slightly Shining

The firing parameters given above are guidelines, which must always be adjusted to suit the furnace used and the situation of the furnace.
What is essential is getting the right firing result.

B - PROCEED MC standardized build-up procedure

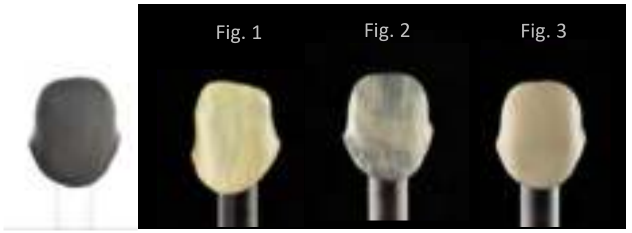


Build-up and photography Frederic Furgier - CDT

(Fig.1) NE Bonder.

(Fig.2) First Opaque.

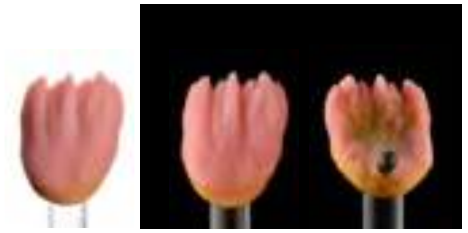
(Fig.3) Second Opaque.



Dentine Opaque is applied as first ceramic layer on cervical and on incisal border of the framework.
Dentine opaque brings more intensity in chroma and diminish the light reflection of the opaque framework

Complete Dentine layer with the desired shape covering all the Dentine Opaque.

The 3 principal dentine flames (mamelons) go up to the small secondary Dentine flames

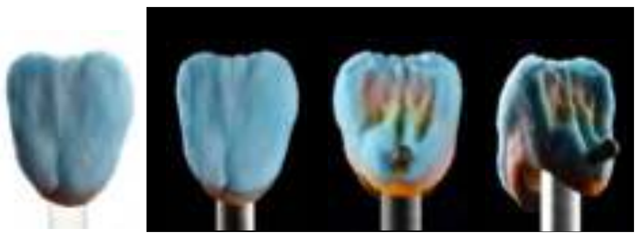


A thin layer of CL-F (Clear Fluorescent) cover the entire Dentine surface.

This layer can be uniform or following the shape of the Dentine (max. 0,2 mm)

Enamel (E) or Translucent (T) are applied on top of the CL-F (Clear Fluorescent) and in the desired final tooth shape.

For the lingual face the same mixture is used.



C – Multi-chromatic build-up

OPAQUE

Bridge framework with the 2 layers of opaque.

Opacity level: 100%

SHOULDER OPAQUE

First layer of a high fluorescence material.

Opacity level: 80%

SHOULDER TRANSPARENT

Second layer carried out with a translucent powder to allow light transmission through the gingiva.
Used at 100% or mixed with dentine it also offers a smooth transition between the cervical shade and the body shade.

Opacity level: 60%

DENTINE OPAQUE

The layer of *Dentine Opaque* brings on cervical an inner deep color of the selected shade.

Opacity level: 80%

(Frederic Furgier – CDT)

OPAQUE DENTINE (OD)

Applied on the edge of the coping in the form of the desire mamelons, it gives an inner deep color of the selected shade.
Dentine opaque brings more intensity in chroma and diminish the light reflection of the opaque framework

Opacity level: 80%

DENTINE MODIFIER (DM)

In center of the body it changes the chroma intensity when mixed with dentine or changes the body shade when used at 100%.

4 different shades: DM-1 (cream), DM-2 (dark brown), DM-3 (Yellow), DM-4 (orange).

Opacity level: 75%

DENTINE (D)

Dentine masses are first placed in cervical before being spread along all the cervical area and body.

Opacity level: 75%

DENTINE (D)

Dentine masses are placed in the incisal mamelons before being spread along the edge and body.

Opacity level: 75%

(Frederic Furgier – CDT)

DENTINE (D)

Dentine covers the entire build-up to allow the desired base shade to diffuse over the entire restoration.

Opacity level: 75%

DENTINE MODIFIER (DM)

The *Dentine Modifier* masses are applied at the top of the dentine mamelons.

Opacity level: 75%

DENTINE MODIFIER (DM)

The *Dentine Modifier* is then spread over 1/3 of the mamelons, favoring a better thickness on the top.
The powders *Dentine Modifier* have more chroma and gives intensity to the mamelons.

Opacity level: 75%

TRANSPARENT CLEAR FLUORESCENT (CL-F)

Clear Fluorescent is applied through the palatal side, passing through the top of the mamelons and emerging in the vestibular area.

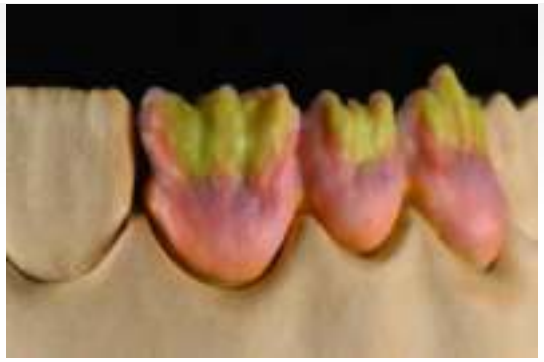
Opacity level: 15%

(Frederic Furgier – CDT)

TRANSPARENT CLEAR FLUORESCENT (CL-F)

The *Clear Transparent* is then spread in labial between each edge of the mamelons.
This 15% opacity powder allows light transmission through the incisal edge, it brings an inner deep translucency which makes the mamelons show up though the enamel.

Opacity level: 15%



NECK TRANSPARENT (NT)

The *Neck Transparent* is applied in the 1/3 incisal to brings a orangish translucent effect

Opacity level: 40%

OPAL ENAMEL (OE)

On the 1/3 cervical area, it forms a smooth white layer which contrast with the warmth layer of Dentine underneath.
Its opalescent property bring life to the core body.

Opacity level: 50%

DENTINE MODIFIER + DENTINE – 1/1 (DM 50% +D 50%)

To bring even more contrast a mix of Dentine Modifier + Dentine (50/50) is applied between each horizontal layer of Opal Enamel (OE).

Opacity level: 75%

(Frederic Furgier – CDT)

TRANSPARENT CLEAR FLUORESCENT (CL-F)

The overall build-up is covered with *Clear Transparent* in a thin layer of no more than 0,2 mm in depth.
This layer mimic the natural tooth layer transition between the dentine and enamel called the dentine-enamel layer.

Opacity level: 15%

<u>HORIZONTAL ALTERNATE INCISAL BUILD-UP:</u>

ENAMEL (E) – Opacity level: 45%
TRANSPARENT NEUTRAL (TN) – Opacity: 35%
CLEAR TRANSPARENT (CL-F) – Opacity: 15%
EFFECT TRANSPARENT (ET) – Opacity: 40%

Alternate layering of different powders for a true to nature enamel effect, each different powders are placed horizontally next to another.

ENAMEL (E)

The entire build-up is covered by *Enamel* powder in the desire final shape.

Opacity level: 45%

(Frederic Furgier – CDT)

ENAMEL (E)

Depending the age of the patient and the morphology of the teeth, the translucent level and/or value level can be modified by mixing different powders with different opacity level and color.

Enamel + CL-F = high increased of translucency

Enamel + TN = moderate increased of translucency

Enamel + Effect Enamel = add value or chroma

- Enamel + E-5 (greyish) = decrease value
- Enamel + E-6 (yellow soft) = increase value, slightly yellow
- Enamel + E-7 (orange) = add orangish chroma
- Enamel + E-8 (yellow) = add yellowish chroma

Enamel + Effect Transparent = add value or chroma

- Enamel + ET-1 (blue) = add blueish translucency
- Enamel + ET-2 (white) = increase value, whitish translucency
- Enamel + ET-3 (rosa) = increase value and translucency (especially for white shade)
- Enamel + ET-4 (yellow) = yellowish translucency
- Enamel + ET-5 (grey) = decrease value, greyish translucency

(Frederic Furgier – CDT)

RESULT AFTER THE 1ST DENTINE FIRING CYCLE

The appearance is slightly shining, and the low shrinkage of the ceramic brings the restoration at the correct length and width.
The low shrinkage of the ceramic in proximal also allows a correct insertion of the bridge on the plaster model, the contact points are not too compressive and not too loose.

	Preheating temp.	Drying time	Raise of temp.	Vacuum	Final temp.	Holding time	Appearance
1st Dentine Firing	580°C	4 min	55°C/min	Yes	905°C	1 min	Slightly Shining

Surface-texture mapping transferred to the bridge teeth (Fig. 1)

Outline the labial lobes as at they are on the natural teeth (incisal teeth are often made of 3 lobes)
From these lobes the vertical ridges and vertical grooves can naturally be designed, or at least in a way closest to natural.

Transition line angles and horizontal texture lines (Fig. 2) are marked on labial surface of the bridge with a pencil

The transition line angles (blue pencil) are critical as the light reflects from these line, they reflect the exact form of the natural teeth. The facial embrasure they form (blue stripes) dictate the volume of the tooth, and the distance between each transition line angles can make a tooth look wider or thinner.
Their direction can be adjusted by using diamond burs, green stones or abrasive discs.

The horizontal lines (red pencil) help to reproduce the natural texture which will show the same reflexion of light as on natural teeth.

Contouring and finishing (Fig. 3)

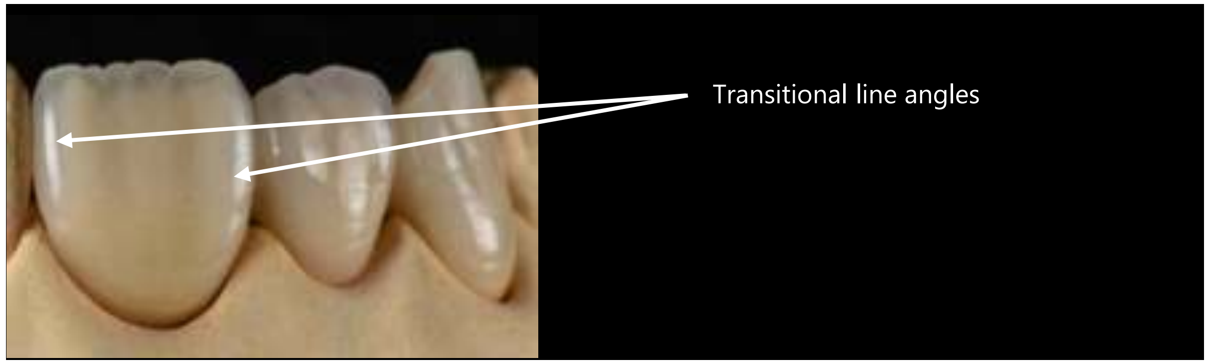
Finished contouring and surface contouring of the bridge in 4 steps:

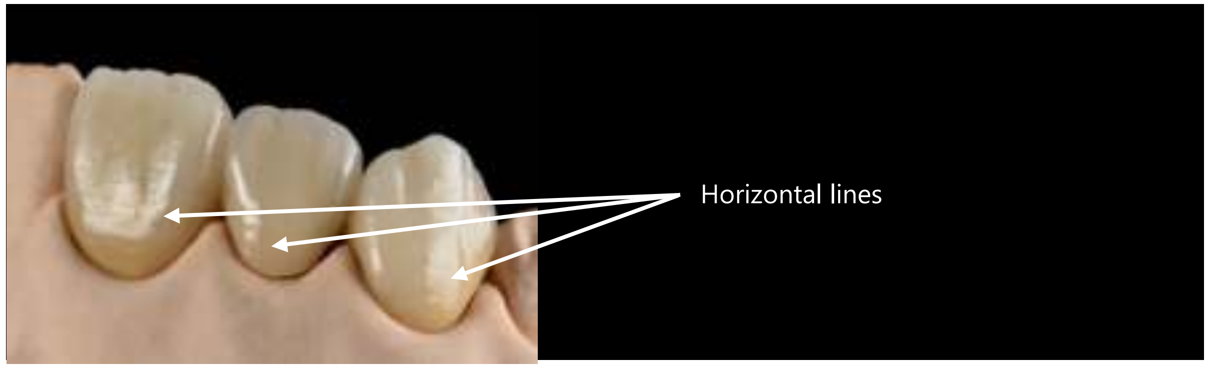
1. The contour (the anatomy and volume of the teeth)
2. Primary morphology (transition lines)
3. Secondary morphology (vestibular lobes)
4. Tertiary morphology (the texture lines, lines of enamel development).

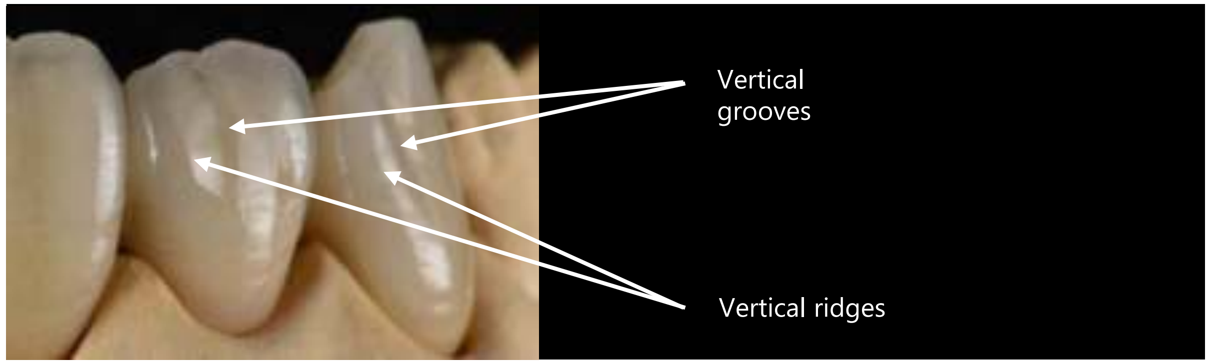
A specific dental compass was used to create the symmetry in shape.

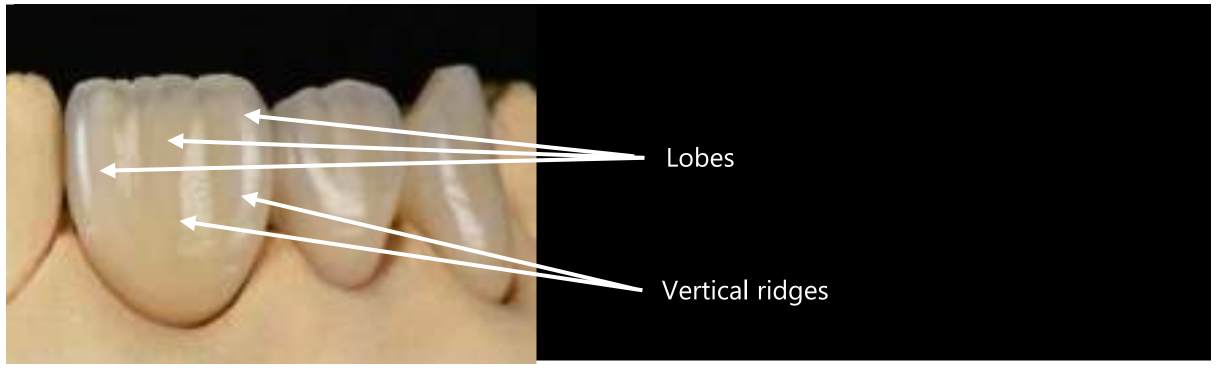
The entire bridge was hand polish with *GC Diapolisher paste.*

(Frederic Furgier – CDT)







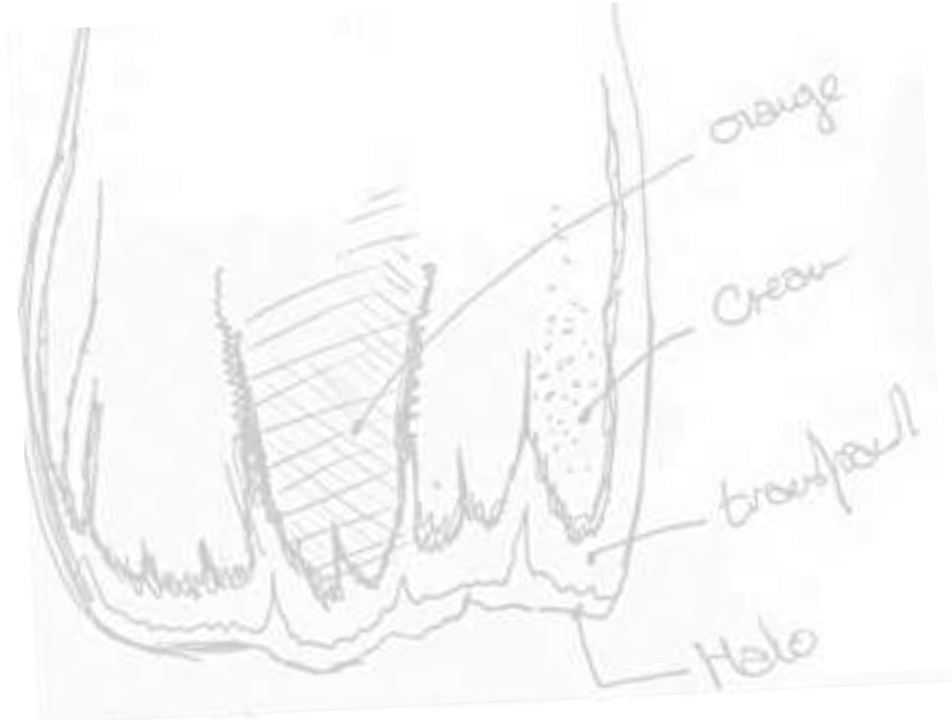


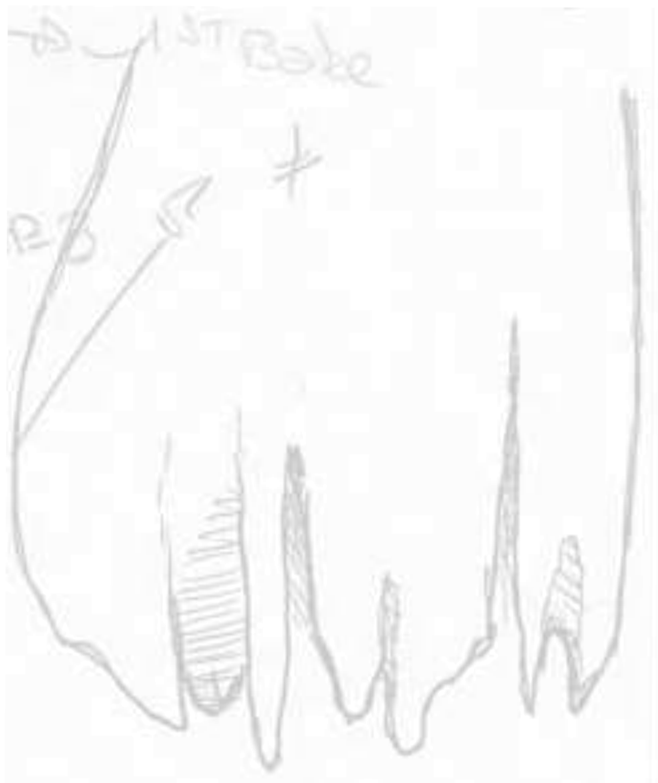
(Frederic Furgier – CDT)

Result of the chromatic build-up

Frederic Furgier - CDT

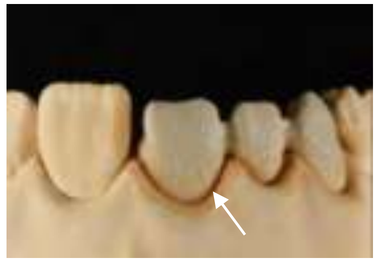
Frederic Furgier - CDT



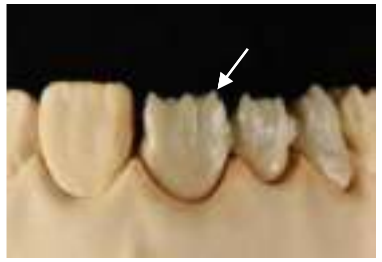


D – Ceramic stability during multiple firing

The following photos show 12 different firing cycles of different powders during the ceramic build-up of a bridge. This shows the extreme stability of the PROCEED MC ceramic after 12 firing cycles, all powders remain in their place while keeping their initial optical properties.



1st firing
SHOULDER OPAQUE



2nd firing
DENTINE OPAQUE

3rd firing
DENTINE MODIFIER

4th firing
DENTINE

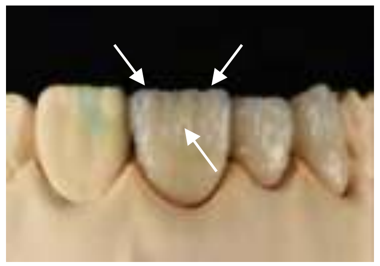
5th firing
DENTINE MODIFIER

6th firing
TRANSPA CLEAR (CL-F)

7th firing
NECK TRANSPARENT

8th firing
OPAL ENAMEL

9th firing
DENTINE MODIFIER + DENTINE - (DM 50% +D 50%)



10th firing
Alternate enamel layering
(E + TN + CL-F + ET)

11th firing
ENAMEL

12th firing
GLAZE

V – Zirconia Structural Framework Design

Different **SHADE** of knowledge

A - Introduction

All-ceramic restorations has become popular in clinical dentistry due to the increased demand of fully biocompatible and high esthetic prosthetic material.
Zirconia becomes a material of choice for dentists wishing to provide the most technologically advanced metal-free restorations.
Layered zirconia oxide crown and bridge are aesthetically pleasing due to their tooth-like colour and are also nowadays cost-effective restorations.

The strength of zirconia restorations depend not only on the fracture resistance of the material, but also on a suitable tooth and framework preparation design with adequate material thickness.
Like porcelain fused to metal (PFM) restorations, porcelain fused to zirconia (PFZ) restoration frameworks must be adequately designed to provide and support appropriate layer porcelain thickness to minimize external and internal stresses, reduce mechanical failures, and optimize esthetics of the veneering ceramic.

Zirconia frameworks have to be fabricated in CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) procedures.

B - Abutment preparation and restoration structural thicknesses

To maximize the success of zirconia restorations, it is essential to ensure that proper preparation guidelines are followed.
The hypothesis that increasing the thickness of zirconia automatically produces greater strength has been refuted by various studies. Cracks, chipping and fractures mainly occurred first in the layering ceramic as it is directly confronted with chewing forces and moisture and then transmitted to the zirconia substructure.

When the zirconia frameworks have to be veneered with glass ceramic for esthetic reasons, the strength of the Porcelain Fused to Zirconia (PFZ) restoration depends not only on the strength of the zirconia, but also on a suitable preparation design that will give an adequate thickness of the zirconia substructure and consequently allow an exact thickness of the veneering glass ceramic.

Zirconia substructure are be fabricated in CAD/CAM procedures, from the CAD software, framework modifications can be suggested to improve the strength by providing adequate support to the veneering ceramic and also improve aesthetic.

1 - Preparation Guidelines

Anterior Zirconia Crown:

For an anterior Zirconia crown preparation, ensure to have a minimum of 1.0 mm (single unit) and 1.5 mm (multi-unit bridge) for the wall thickness, a minimum of 1.5 (single unit) to 2.0 mm (multi-unit bridge) incisal reduction to achieve appropriate occlusal anatomy of the functional cusp, and there should be a reduction of at least 0.8 mm at the gingival margin.

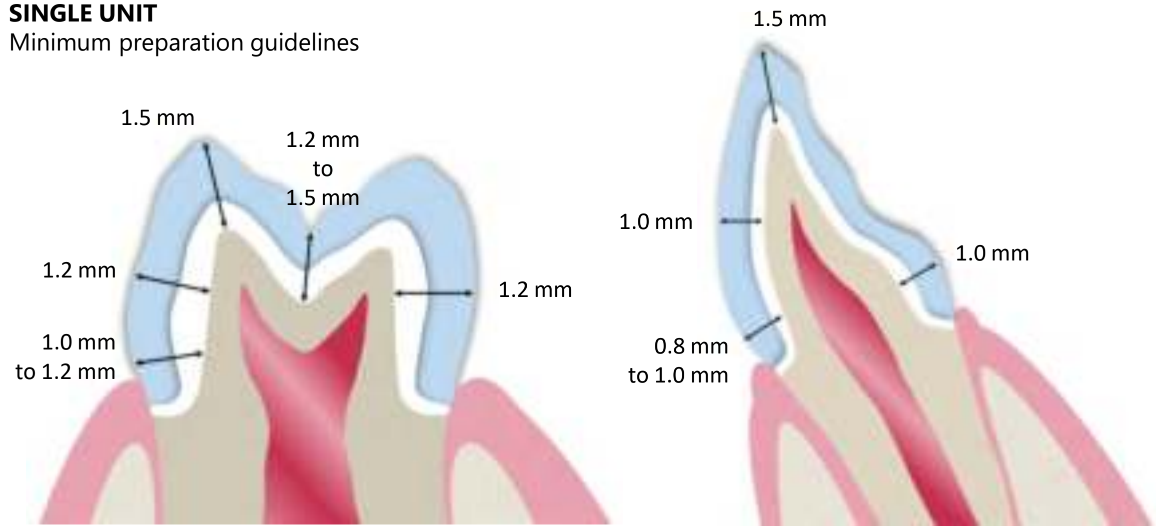
The preparation of the axial wall reduction should be tapered at an angle of at least approximately 5°. The incisal edges should be rounded, and the lingual face of anteriors reduced to create a concave lingual surface.

Posterior Zirconia Crown:

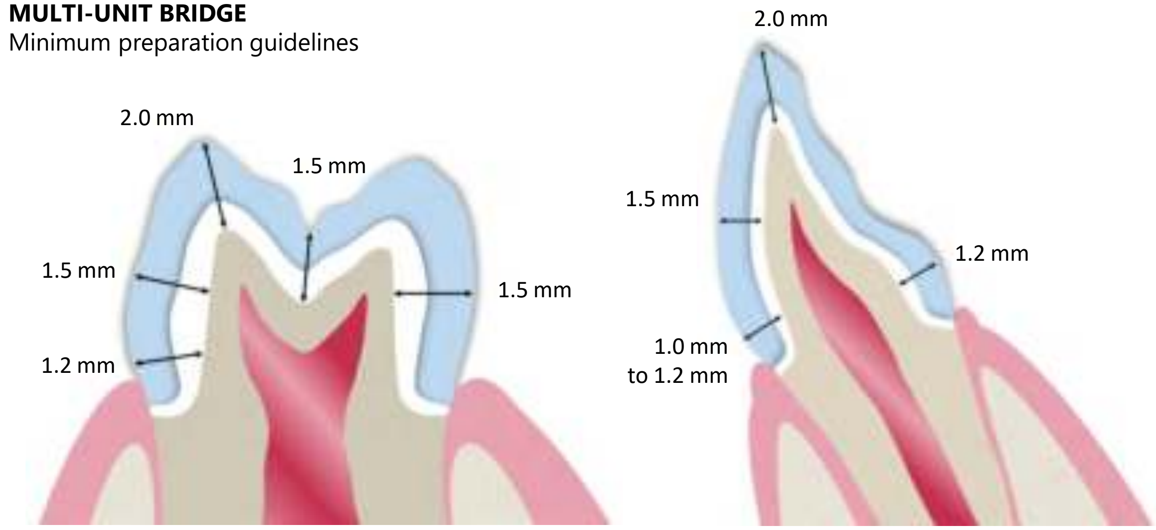
When prepping a posterior Zirconia crown, ensure to have a minimum of 1.2 mm (single unit) and 1.5 mm (multi-unit bridge) for the wall thickness, a minimum of 1.5 (single unit) to 2.0 mm (multi-unit bridge) incisal reduction to achieve appropriate occlusal anatomy, and there should be a reduction of at least 1.0 mm at the gingival margin.

The preparation of the axial wall reduction should be tapered between 5°and 12°. The incisal edges should be rounded, and the preparation of the occlusal surfaces should be angled respecting the original shapes and inclination of the cusps.

SINGLE UNIT
Minimum preparation guidelines



MULTI-UNIT BRIDGE
Minimum preparation guidelines

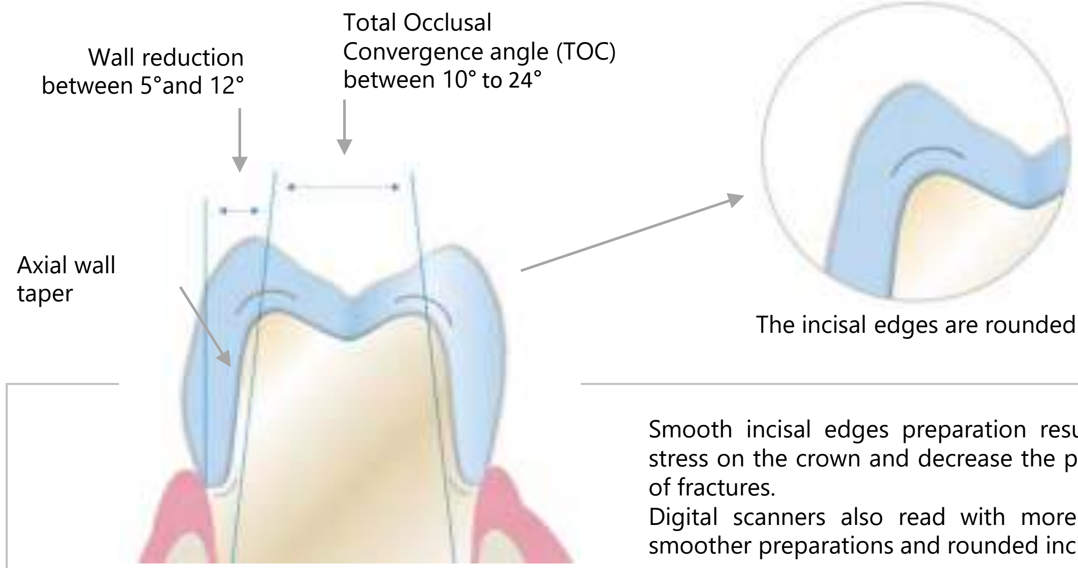


The preparation of the axial wall reduction (buccal wall inclination and lingual wall inclination) also call axial wall taper should be tapered between 5°and 12° in relation with the vertical plane, or between 95° and 102° in relation with the horizontal plane.

The Total Occlusal Convergence angle (TOC) should have an acceptable convergence angle of between 10° and 24°.

Axial wall taper = is the axial inclination angle of the preparation in reference to the vertical plane (or horizontal plane by subtracting it from 90º), which represents a degree of taper inclination starting from the vertical plane at the margin

Total convergence angle = is the angle formed by two axial walls of a preparation and is equal of the sum of these 2 axial walls inclination degrees (i.e., the sum of the degree angles of the buccal and lingual wall inclination).

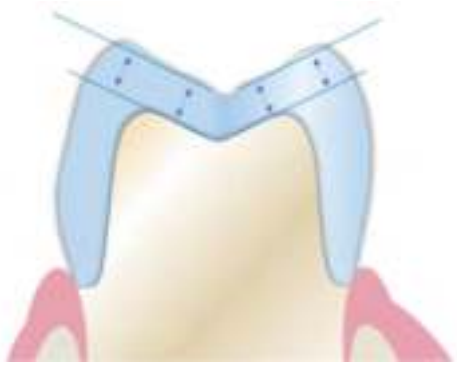


The incisal edges are rounded

Smooth incisal edges preparation result in less stress on the crown and decrease the percentage of fractures.
Digital scanners also read with more accuracy smoother preparations and rounded incisal edge.

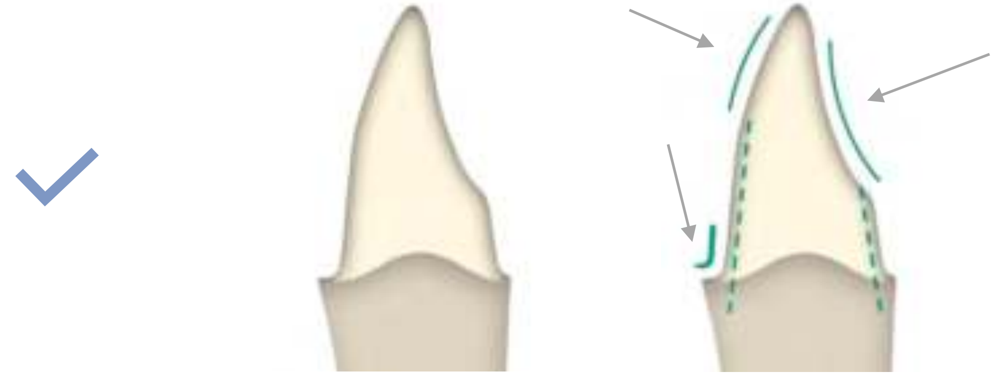
Note:
The rounded incisal edges are also easier to reproduce with burs during the milling process.
The thickness of the burs does not allow fine edge milling in the inner surface of the crowns and instead of reproducing the initial design an overmilling happen with the applied bur thickness.

The overmilling compensation results in a significant difference in trueness by forming an empty part around the internal shape as well as increased cement space which is potentially reducing the effectiveness of resin adhesion.

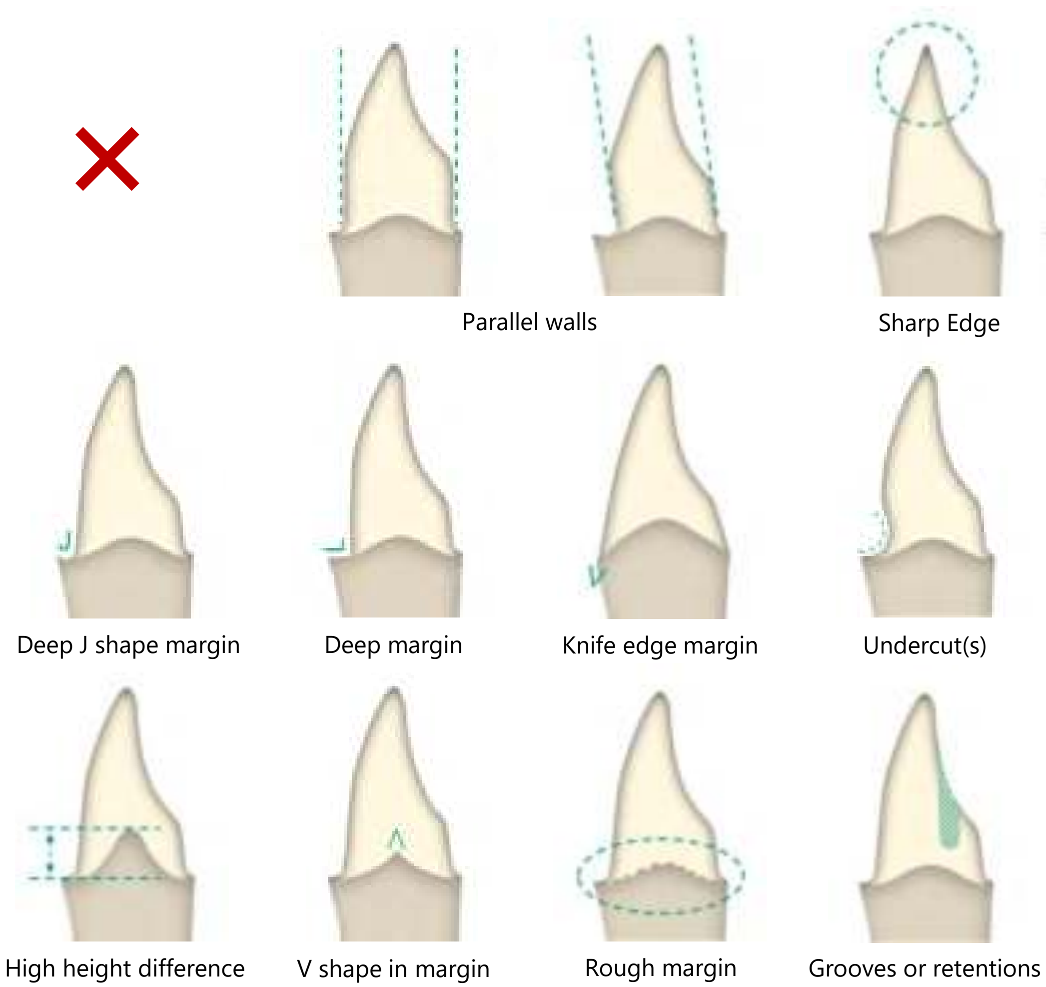


The preparation of the occlusal surfaces should be angled respecting the original shapes and inclination of the cusps which allows to build back the original anatomy with a uniform ceramic layer thickness. This uniform reduction gives the ceramic ideal resistance under load.

Correct preparation design



Contraindications of preparation design



2 - Substructure thickness

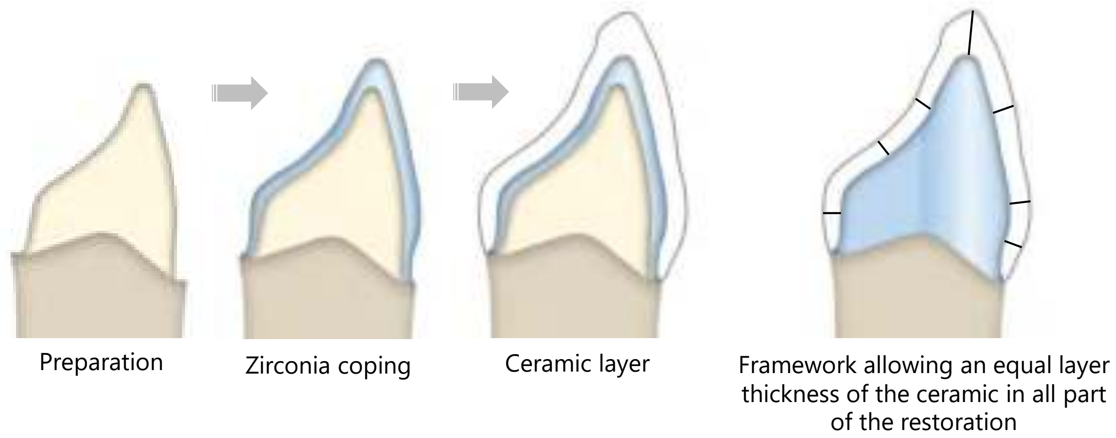
As for PFM the design of the zirconia framework contributes to the longevity and durability of PFZ restoration. A well-designed framework provides a high-quality result and clinical success.
The zirconia framework must reflect the reduced final restoration shape.
The contouring of the framework must allow an equal layer thickness of the ceramic in all part of the restoration from labial to lingual as mesial to distal.

By achieving an equal and proportional ceramic layer thickness the masticatory forces and loads are transmitted to the framework through the ceramic and not to the ceramic layer alone which causes its fracture.

Fractures occur:

- when the ceramic is not supported by the zirconia framework
- when the ceramic layer is thicker in some part (especially cusp and occlusal areas)
- when the ceramic doesn't transmit forces to the framework.

Proper design = appropriate support = proper ceramic thickness



Improper framework design = improper support for the ceramic layer = non-appropriate thickness of ceramic = fracture and chipping

The zirconia substructure should provide sufficient strength to support the shrinkage of the layer of ceramic as well as forces and stress applied on the restoration during the mastication.
The zirconia substructure thickness should normally be at minimum between 0.4 and 0.9 mm.

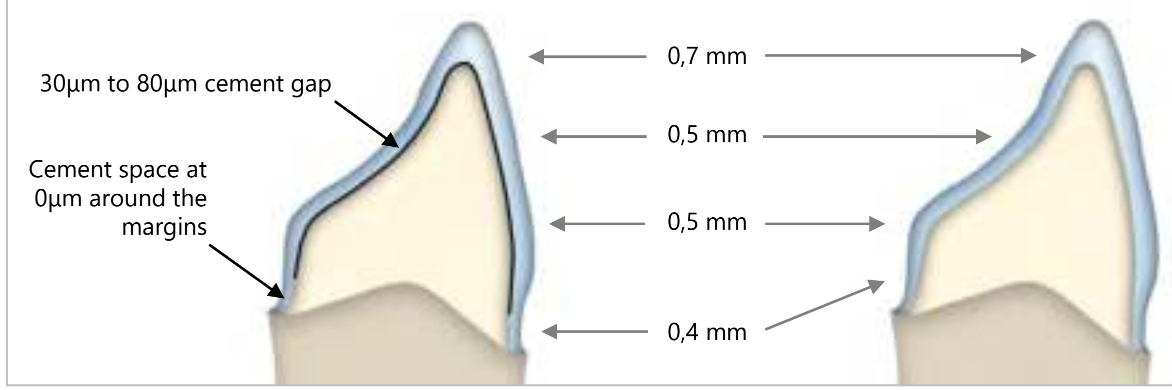
Ideally the minimum thickness of the zirconia framework after finishing must be at least:

Occlusal
- 0.7 mm for single crowns
- 0.9 mm for abutment crowns in bridge frameworks

Body
- 0.5 mm for single crowns
- 0.6 mm for abutment crowns in bridge frameworks

Cervical
- 0.4 mm for single crowns
- 0.5 mm for abutment crowns in bridge frameworks

Minimum framework thickness



The total tooth preparation design thickness must include the zirconia substructure thickness as well as the space given to the cement to flow between the tooth and the zirconia crown.
To allow a complete seating of the zirconia ceramic restoration to the tooth, the cement must obtain an appropriate flow rate while maintaining a minimum film thickness.

The range of cement gap settings in CAD design software programs is quite wide: from 0 to 200 µm, however, the best cement gap settings for certain types of zirconia are not stated by manufacturers.

We would recommend for a better marginal and internal fit to set a cement space at 0µm around the margins forming a 1 mm belt above the margin finish lines of the tooth, followed by an 30µm to 80µm (0,03 mm to 0,08 mm) cement gap on the body wall and incisal parts.

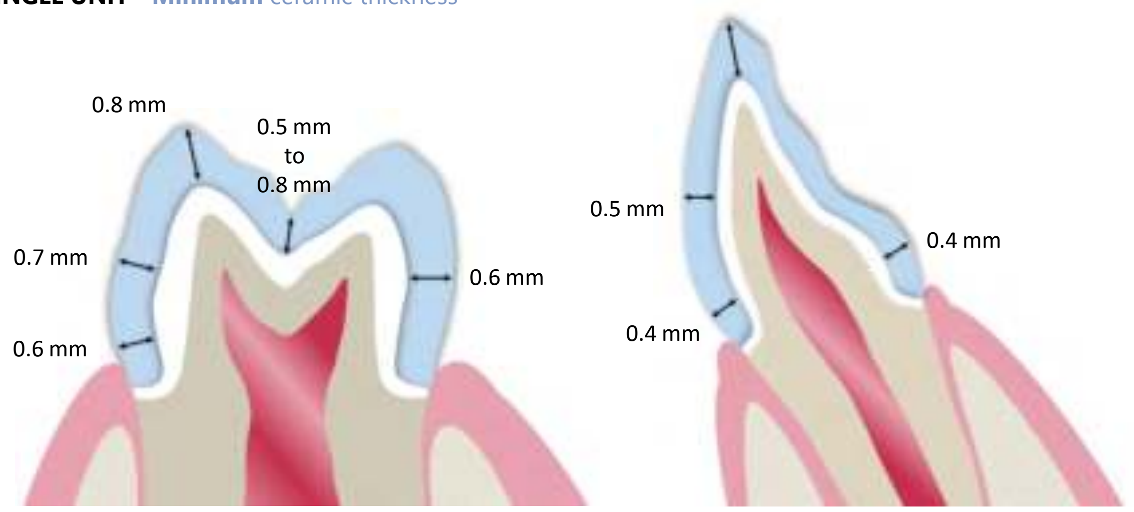
Note:
The cementation thickness in optimal condition has an average of 30 to 80 µm but due to the impression accuracy, plaster expansion, 3D print model and manufacture process in the laboratory the gap between the 2 surfaces can give an additional 20 µm or slightly more.

3 - Ceramic thickness

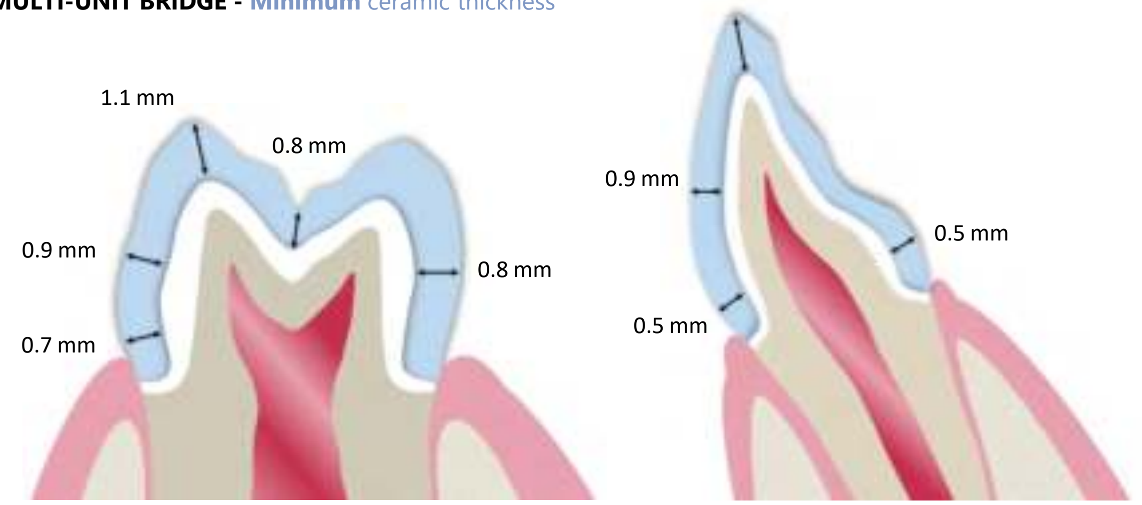
To achieve a matching shade with the ceramic, the layer of the ceramic must not fall below 0.4 mm or exceed 2.0 mm. If this layer thickness is not possible in the marginal area of the crown due to the risk of over contouring, the marginal area must at least be covered with a ceramic layer of 0.25 mm.

The framework must provide an equal ceramic thickness (uniform layer) over all surfaces.
Non-uniform layer thicknesses of the ceramic brings unwanted color differences and uncontrollable shrinkage of the ceramic.

SINGLE UNIT - **Minimum** ceramic thickness



MULTI-UNIT BRIDGE - **Minimum** ceramic thickness



Thickness table

THICKNESS TABLE

Minimum preparation thickness - **Minimum** framework thickness - **Minimum** ceramic layer thickness

MOLAR	Single crown			Abutment crowns in bridge		
	Tooth preparation	Framework thickness	Ceramic thickness	Tooth preparation	Framework thickness	Ceramic thickness
Occlusal	1.5 mm	0.7 mm	0.8 mm	2.0 mm	0.9 mm	1.1 mm
Body	1.2 mm	0.5 mm	0.7 mm	1.5 mm	0.6 mm	0.9 mm
Cervical	1.0 mm	0.4 mm	0.6 mm	1.2 mm	0.5 mm	0.7 mm

INCISOR	Single crown			Abutment crowns in bridge		
	Tooth preparation	Framework thickness	Ceramic thickness	Tooth preparation	Framework thickness	Ceramic thickness
Occlusal	1.5 mm	0.7 mm	0.8 mm	2.0 mm	0.9 mm	1.1 mm
Body	1.0 mm	0.5 mm	0.5 mm	1.5 mm	0.6 mm	0.9 mm
Cervical	0.8 mm	0.4 mm	0.4 mm	1.0 mm	0.5 mm	0.5 mm

Note:
This table is only intended to show the minimum thickness allowed for ceramics layered on a zirconia framework (PFZ), and not for the monolithic zirconia crown.
If maximum strength is required because a patient has bruxism, a heavy bite or where there is only limited occlusal clearance, a monolithic crown may be a better posterior solution.

C - Margins framework design

1 - Generality and recommended types of margin design

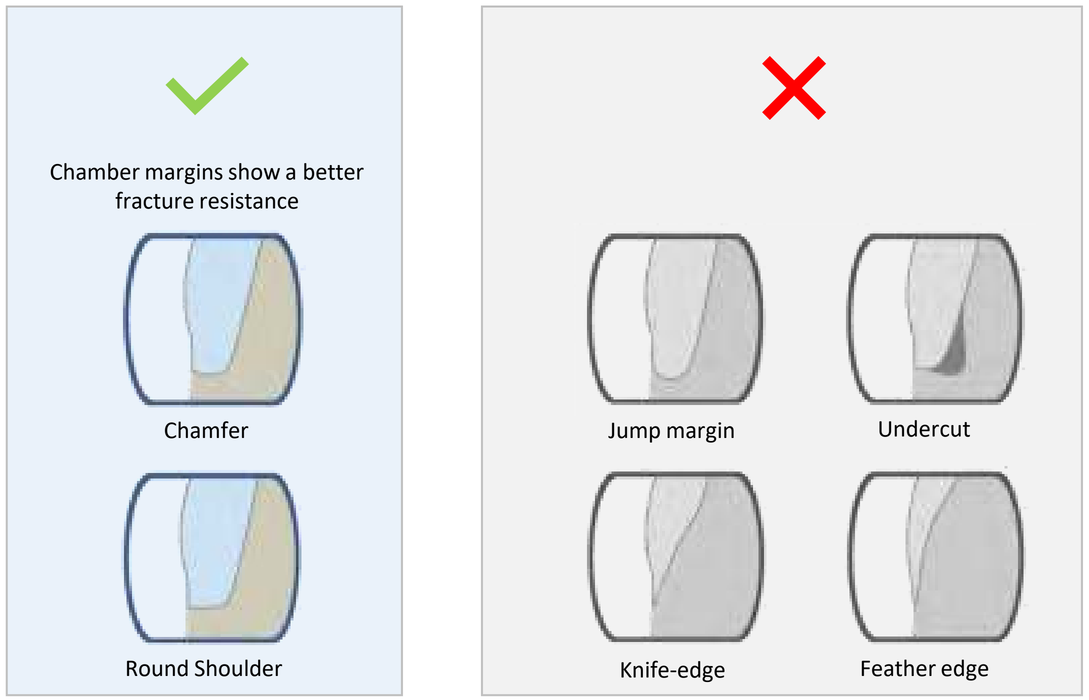
The margin's design represent the physical transition between the finish line of the tooth tissue and the restoration itself.
Both zirconia substructure and ceramic layer at the margin area must demonstrate a minimum thickness in order to achieve correct stability of the restoration, appropriate shade reproduction and periodontal health.
Designing a stable and robust margin framework by respecting a minimum thickness demonstrate to maintain an accuracy of fit even after several ceramic firing.

For zirconia copings the chamfer margins show a better fracture resistance than the round shoulder. Deep chamfer margins design provide a stronger zirconia and more durable crown.

<u>A visible and continuous circumferential chamfer:</u>

- of at least 0.8 mm reduction must be made for single anterior crown.
- of at least 1.0 mm reduction must be made for single posterior crown.
- of at least 1,0 mm reduction must be made for anterior abutment crown in bridge.
- of at least 1.2 mm reduction must be made for posterior abutment crown in bridge.

Here is the most accurate margin design for ceramic layered over zirconia framework restorations and the margins design that must be avoid.



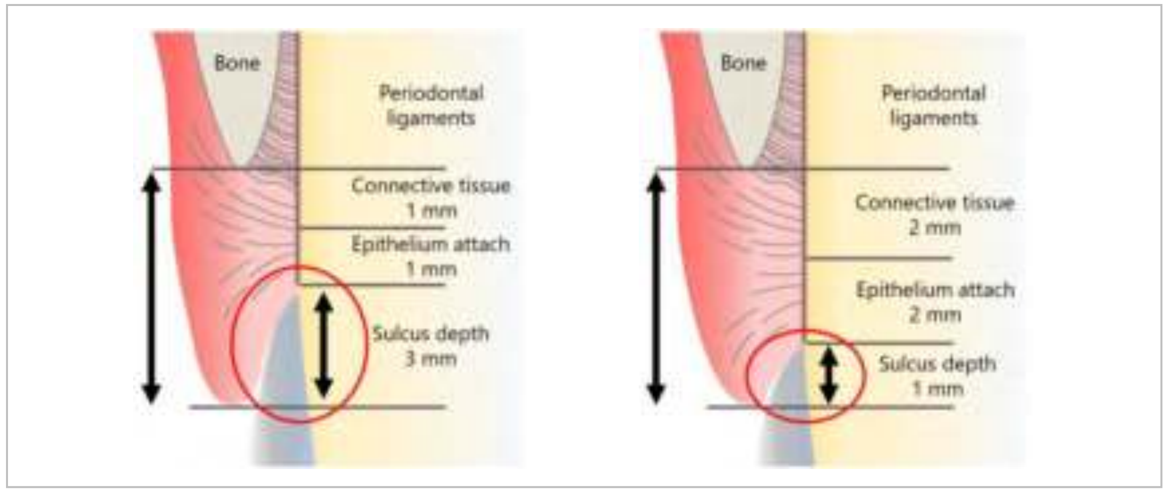
Note:
The marginal gaps reported in dental literature range from 3.7 µm to 200 µm. The maximum acceptable marginal gaps is considered to be 120 µm.

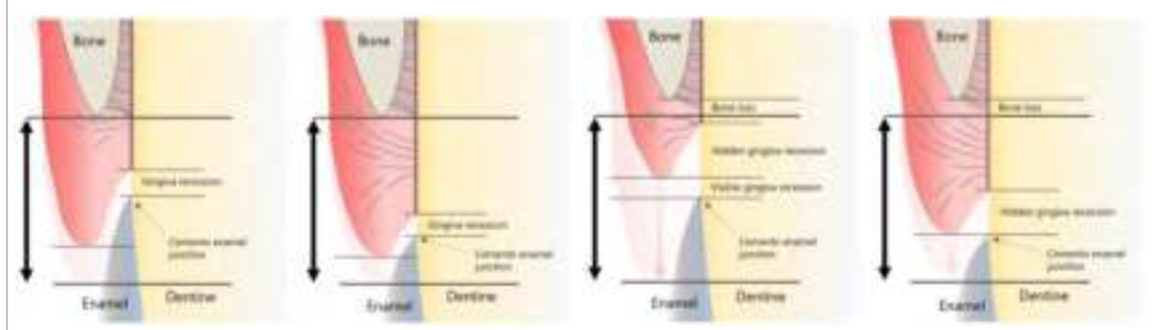
2 - The importance of margin placement

Whenever is possible, keeping the margins supragingival is healthier and more predictable.
Subgingival margins are often unhealthy, can cause inflamed gingiva, periodontal damage and bleeding, colored gum.
The preparation of subgingival margins often require the cutting of healthy tooth structure under the enamel end as well as often dropping the gingival floor to create cervical clearance during the double-cord technique impression increasing the sulcus depth and the risk of future recession.

For subgingival margin placement, it is very important to analyzed the patient's sulcus depth. For a predictable and esthetic final result, the best is to not prepping the margin line at more than half the sulcus depth, because if recession of the sulcus depth occurs it may likely stop before exposing the restoration margin line.

- For a 1 mm sulcus depth = prepping 0.5 mm below tissue
- For a 1.5 mm sulcus depth = prepping 0.7 mm below tissue
- For a 3 mm sulcus depth = prepping 1.5 mm below tissue





Gingiva recession

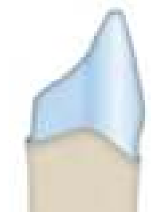
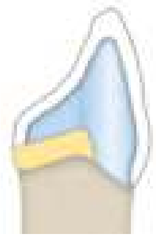
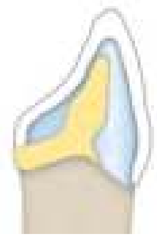
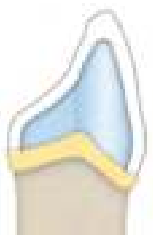
Gingiva recession with bone loss

Note:
When the gingiva tissue is very thick the gingiva tend to be more stable, but when the tissue is thin, it is more subject to a risk of recession and the lost of sulcus depth

D - Functional Framework Design

Proper framework design provide a better ceramic support when under masticatory load and reduce the ceramic chipping rates.
Improper framework design is one of the reason for porcelain fracture and have a direct influence on the failure load and failure characteristics.

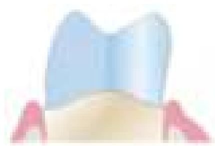
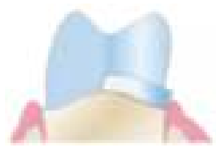
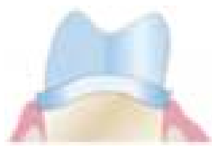
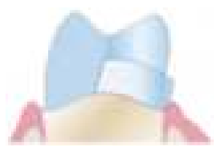
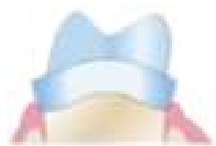
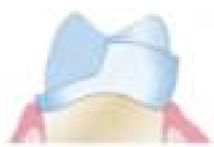
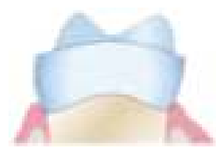
Here are some suggested frameworks with collars and struts reinforcing the strength of the ceramic layer:

	zirconia crown without struts	zirconia crown with struts	zirconia crown with extended struts	
zirconia crown without collar	 Anatomic coping	 Struts	 Extended Struts	Lower strength
zirconia crown with a lingual collar	 lingual collar	 Struts & lingual collar	 Extended struts & collar	
zirconia crown with continuous collar	 Continuous circumferential collar	 Continuous collar with struts	 Continuous collar with extended struts	
	Lower strength			Higher strength

- The design of zirconia crown with a collar demonstrate a better load-bearing capacity as well as offering a favorable emergence profile (highly recommended for subgingival margin).
- The struts support the marginal ridges and bring additional strength to the coping and ceramic layer.
- The extended struts have the benefit of the simple trusts but adding more support for the ceramic as well as supporting all the proximal contact points.
- The design of zirconia with no collar must be limited to cases of good periodontal health as well as good masticatory functions.

Zirconia crowns design with a lingual or circumferential collar have a positive influence against ceramic chipping on the PFZ.
Several design of collars can be integrated to the coping from a simple 1 mm lingual collar to a 3 mm full circumferential collar. The higher the collar the greater the strength of the zirconia coping, also the greater the strength against ceramic chipping. As the collar height increased, the tensile stresses decreased which prevent the ceramic fracture.

The use of collars are not favorable in an optical point of view but are advantageous on many clinical functions:
- Offer better emergence profile
- Greater mechanical properties (against tensile and compressive loads)
- Favorable when use on bad periodontal health patient
- Indicated in case of masticatory mal-functions.
- Offers better longevity.

	No circumferential collar	1 mm circumferential collar	2 mm circumferential collar	3 mm circumferential collar	
No lingual collar					Lower strength
1 mm lingual collar					
2 mm lingual collar					
3 mm lingual collar					
	Lower strength				Higher strength

VI - PROCEED Zr recommendation for use

UNLOCKING **Skills**

A – Framework contouring, sandblasting and application of Liner

Framework contouring:

The entire zirconia framework restoration should be grinding with a diamond bur or a diamond particles silicone point. The surface must be spray by water or wet enough while working on it.

Make sure the zirconia framework has a proper thickness and no cracks on its surface.

Sandblasting:

Sandblast the restoration surface with a 50µ aluminoxide at 2bar to allow the porcelain to bond well to the zirconia.
Following the sandblasting it's recommended to process a cleaning of 10 minutes in ultrasonic using acetone or alcohol. After cleaning, please avoid touching the framework(s) with bare fingers.

Liner first firing

To improve the bond strength of PROCEED Zr as well as matching the correct shade base of the zirconia to the final desired shade, apply a thin layer of the corresponding Liner (L1-L2-L3) over the entire zirconia framework (from the margins to top incisal on each faces) and fire the restoration.
If it needs to adjust the degree of masking of the framework a second Liner can be applied, or a Wash Body firing can be done to correct the shade of the underlying final shade.

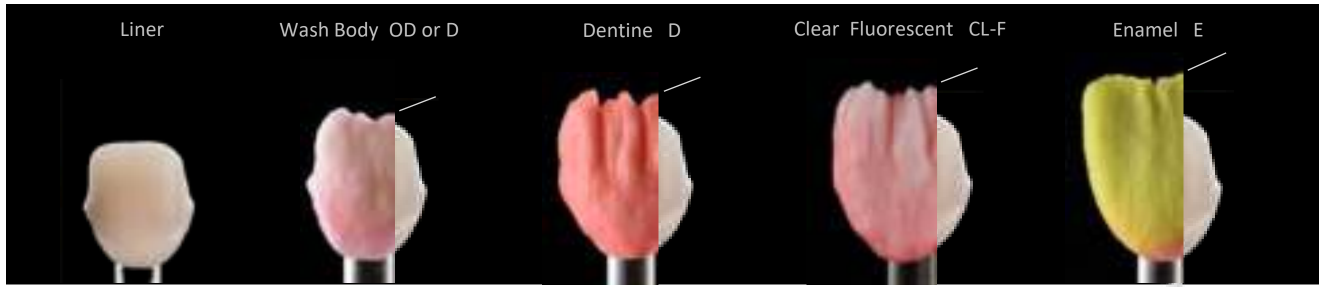
The last step is the build-up with PROCEED Zr and it will make you feel how it's easy to get a life-like aesthetic result with a minimum effort.

PROCEED Zr Firing instructions

	Preheating temp.	Drying time	Raise of temp.	Vacuum	Final temp.	Holding time	Appearance
Shoulder Firing	450°C	4 min	45°C/min	Yes	830°C	1 min	Shining
Liner	450°C	4 min	55°C/min	Yes	800°C	1 min	Slightly Shining
Wash Body	450°C	6 min	45°C/min	Yes	810°C	1 min	Slightly Shining
1st Dentine Firing	450°C	6 min	45°C/min	Yes	810°C	1 min	Slightly Shining
2nd Dentine Firing	450°C	6 min	45°C/min	Yes	800°C	1 min	Slightly Shining
Glaze Firing	480°C	2 min	45°C/min	–	820°C	–	Shining
Glaze Firing with glaze powder	480°C	2 min	45°C/min	–	790°C	1 min	Shining
Correction Powder Firing	450°C	4 min	45°C/min	Yes	690°C	1 min	Shining

The above mentioned firing parameters are only guidelines and therefore always need to be adjusted to the firing furnace and its correct functionality. Most important is to obtain the right firing result. These firing parameters can only be used as guidelines.

B – PROCEED Zr Standardized build-up procedure



Build-up and photography Frederic Furgier - CDT

Fig. 1

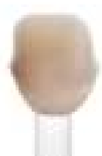


Fig. 2

(Fig.1) Liner .

(Fig.2) the Wash Body can be build-up with Dentine or Opaque Dentine.

The Wash dentine fired. It gives a great bonding of the ceramic on the Zirconia frame as well as to increase shade matching.

Complete Dentine layer with the desired shape covering all the Wash firing. The 3 principal dentine flames (mamelons) go up to the small secondary dentine flames and are thicker which will bring natural differences in enamel with the reflective and absorbed light.

A thin layer of CL-F (Clear Fluorescent) cover the entire Dentine surface.

This layer can be uniform or following the shape of the Dentine (max. 0,2 mm)

Enamel (E) or Translucent (T) are applied on top of the CL-F (Clear Fluorescent) and in the desired final tooth shape.

For the lingual face the same mixture is used.

VII - Firing program PROCEED MC & Zr

Firing instructions

Firing parameters are only guidelines and therefore always need to be adjusted to suit the firing furnace used, its situation and its correct functionality.

Most important is to obtain the right firing result. These firing parameters can only be used as guidelines.

PROCEED MC Firing instructions

	Preheating temp.	Drying time	Raise of temp.	Vacuum	Final temp.	Holding time	Appearance
Oxide Firing	According to alloy manufacturer's instructions						
NE Bonder	550°C	6 min	80°C/min	Yes	980°C	1 min	Shining
1st Paste Opaque Firing*	550°C	6 min	80°C/min	Yes	940°C	1 min	Shining
1st Powder Opaque Firing*	600°C	2 min	80°C/min	Yes	940°C	1 min	Shining
2nd Paste Opaque Firing	550°C	6 min	80°C/min	Yes	930°C	1 min	Slightly Shining
2nd Powder Opaque Firing	600°C	2 min	80°C/min	Yes	930°C	1 min	Slightly Shining
1st and 2nd Shoulder Firing	550°C	2 min	80°C/min	Yes	940°C	1 min	Slightly Shining
1st Dentine Firing	580°C	4 min	55°C/min	Yes	905°C	1 min	Slightly Shining
2nd Dentine Firing	580°C	6 min	55°C/min	Yes	895°C	1 min	Slightly Shining
Glaze Firing	600°C	2 min	55°C/min	-	910°C	1 min	Shining
Glaze Firing with glaze powder	480°C	2 min	55°C/min	-	850°C	1 min	Shining
Correction Powder Firing	450°C	4 min	45°C/min	Yes	780°C	1 min	Shining

*When using non-precious alloy: final temperature 960 C
The firing parameters given above are guidelines, which must always be adjusted to suit the furnace used and the situation of the furnace.
What is essential is getting the right firing result.

PROCEED Zr Firing instructions

	Preheating temp.	Drying time	Raise of temp.	Vacuum	Final temp.	Holding time	Appearance
Shoulder Firing	450°C	4 min	45°C/min	Yes	830°C	1 min	Shining
Liner	450°C	4 min	55°C/min	Yes	800°C	1 min	Slightly Shining
Wash Body	450°C	6 min	45°C/min	Yes	810°C	1 min	Slightly Shining
1st Dentine Firing	450°C	6 min	45°C/min	Yes	810°C	1 min	Slightly Shining
2nd Dentine Firing	450°C	6 min	45°C/min	Yes	800°C	1 min	Slightly Shining
Glaze Firing	480°C	2 min	45°C/min	-	820°C	-	Shining
Glaze Firing with glaze powder	480°C	2 min	45°C/min	-	790°C	1 min	Shining
Correction Powder Firing	450°C	4 min	45°C/min	Yes	690°C	1 min	Shining

The above mentioned firing parameters are only guidelines and therefore always need to be adjusted to the firing furnace and its correct functionality. Most important is to obtain the right firing result. These firing parameters can only be used as guidelines.

VIII - PROCEED MC Conversion to 3D Master shade

Mixing Chart **PROCEED MC** to Vita 3D-Master*

Vita 3D Maste r	Opaquer	PROCEED MC powder	Ratio	Enamel
1M1	A1	BD-1 + D-D2	1:1	E1
1M2	A2	D-A1 + D-A2	5:1	E2
2L1,5	A2	D-A1 + D-C3	6:1	E2
2L2,5	B2	D-B2 + D-D4	1:2	E3
2M1	A2	BD-1 + D-D2 + E5	1:4:1	E2
2M2	A3	D-A1 + D-A4 + D-D4	6:1:1	E2
2M3	B3	D-B2 + D-B4	1:1	E3
2R1,5	D3	D-A1 + ET-3 + E5	3:1:1	E3
2R2,5	A2	D-A2 + D-C3	8:1	E3
3L1,5	D4	D-A1 + D-C3	1:2	E3
3L2,5	B3	D-B4 + D-A3 + E5	4:1:1	E4
3M1	A2	D-A1 + NT-3 + ET-5	3:2:1	E4
3M2	D3	D-D3 + D-A4	4:1	E4
3M3	B3	D-B4 + D-A3 + ET-3	4:1:2	E4
3R1,5	A2	D-C1 + NT-5 + E5	4:1:3	E4
3R2,5	A4	D-B3 + NT-3	3:1	E4
4L1,5	D3	D-C3 + NT-3	5:1	E4
4L2,5	C4	D-A4 + D-C4 + NT-4	5:2:1	E4
4M1	C2	D-A2 + NT-5 + ET-5	5:1:3	E4
4M2	A3	D-A3 + NT-3 + ET-5	2:1:1	E4
4M3	A4	D-A4 + NT-4	5:2	E4
4R1,5	D3	D-D3 + NT-5 + ET-5	3:1:1	E4
4R2,5	A4	D-A4 + NT-5 + E5	2:1:1	E4
5M1	C4	D-D3 + NT-5 + ET-5	4:2:4	E4
5M2	A3	D-A3 + D-C4 + NT-5	1:4:2	E4
5M3	A4	D-A4 + NT-4 + NT-5	3:2:1	E4

Mixing Chart **PROCEED MC** to Vita 3D-Master*

Color	Opaquer	Powder	Ratio	Enamel
	A1	BD-1 + D-D2	1:1	E1
	A2	D-A1 + D-A2	5:1	E2
	A2	D-A1 + D-C3	6:1	E2

Color	Opaquer	Powder	Ratio	Enamel
	B2	D-B2 + D-D4	1:2	E3
	A2	BD-1 + D-D2 + E5	1:4:1	E2
	A3	D-A1 + D-A4 + D-D4	6:1:1	E2
	B3	D-B2 + D-B4	1:1	E3

Color	Opaquer	Powder	Ratio	Enamel
	D3	D-A1 + ET-3 + E5	3:1:1	E3
	A2	D-A2 + D-C3	8:1	E3
	D4	D-A1 + D-C3	1:2	E3
	B3	D-B4 + D-A3 + E5	4:1:1	E4

Color	Opaquer	Powder	Ratio	Enamel
	A2	D-A1 + NT-3 + ET-5	3:2:1	E4
	D3	D-D3 + D-A4	4:1	E4
	B3	D-B4 + D-A3 + ET-3	4:1:2	E4
	A2	D-C1 + NT-5 + E5	4:1:3	E4

Color	Opaquer	Powder	Ratio	Enamel
	A4	D-B3 + NT-3	3:1	E4
	D3	D-C3 + NT-3	5:1	E4
	C4	D-A4 + D-C4 + NT-4	5:2:1	E4
	C2	D-A2 + NT-5 + ET-5	5:1:3	E4

Color	Opaquer	Powder	Ratio	Enamel
	A3	D-A3 + NT-3 + ET-5	2:1:1	E4
	A4	D-A4 + NT-4	5:2	E4
	D3	D-D3 + NT-5 + ET-5	3:1:1	E4
	A4	D-A4 + NT-5 + E5	2:1:1	E4

Color	Opaquer	Powder	Ratio	Enamel
	C4	D-D3 + NT-5 + ET-5	4:2:4	E4
	A3	D-A3 + D-C4 + NT-5	1:4:2	E4
	A4	D-A4 + NT-4 + NT-5	3:2:1	E4

IX – A guide to proper cementation protocols for PROCEED MC & Zr

Dr. Mamtha Thomas
and
Dr. Yessi Margaretha Budiono
section.

Cementation protocol for PFM

Dr. Mamtha Thomas
and
Dr. Yessi Margaretha Budiono
section.

Cementation protocol for Zirconia

X - PROCEED MC & Zr related products

PROCEED MC & Zr related products

The following GC products are compatible and can be used with PROCEED MC & Zr

GC Fujivest II:

Rapid fire, carbon-free phosphate bonded investment that produces ultra smooth, precision castings quickly and easily.

- Easy to devest and fracture-resistancy suitable for all crown and bridge dental alloys.
- Once GC Fujivest II has set (20 minutes after investing), it can be placed directly into a preheated furnace at final temperature.

NOTE: GC Fujivest II Liquid should NOT be allowed to freeze - the liquid crystallizes and can no longer be used.
NOTE: GC Fujivest II Liquid is NOT compatible with GC Fujivest I Investment Material.

Initial™ IQ Lustre Paste NF

GC Initial IQ Lustre Pastes NF are 3-dimensional ceramic pastes developed to create color depth and life-like translucency with a single paint on application. Thanks to the "New Formula" (NF), you can really bring your crowns and bridges to life.

The product is available in a ready to use consistency and is based on fine ceramic particles, allowing a thin but also a thicker application compared to conventional stains & glazes.

2 Sets available:

- GC Initial Lustre Pastes NF - V-Shade (for tooth restoration)
- GC Initial Lustre Pastes – Gum Shade (for gingiva reproduction)

NE Bonder:

NE Bonder is a ceramic-to-alloy adhesion used as a thin layer between the alloy and the first opaque layer.
NE Bonder blocs the metal oxides during the heating process and neutralizes differences in thermal expansion stabilising the interface between the alloy and the ceramic, it allows a wider span of CTE compatibility.

- Stir paste before using.
- Apply the Bonder in a thin layer but mask the alloy completely

GC Initial FIRING FOAM:

The GC Initial FIRING FOAM ensures a stable fixation of objects onto ceramic firing pins and trays.
The GC Initial FIRING FOAM will furthermore enable an improved heat distribution during the firing cycles whilst it remains dimensionally stable during the entire process.
Thanks to its special creamy consistency it is easy to apply onto the object and removal after firing is trouble-free.

For the use of PROCEED MC make sure that the CTE of the alloy you use for casting or milling the substructure stays strictly with a coefficient of thermal expansion in the range of 13,8 - 14,9 · 10-6 K-1 (25-500 °C).

Calibrate your furnace according to the manufacturer's instruction in order to obtain the best results and to be able to make optimal use of the properties
As each dental ceramic is sensitive to contamination, take care that you work in a clean environment.

Dental ceramic PROCEED MC is complying with **EN ISO 6872** for the ceramic veneering of precious and non-precious metal substructures.
Dental ceramic PROCEED Zr is complying with **EN ISO 6872** for the ceramic veneering of Zirconia framework substructures.

PROCEED MC & Zr is a product of GC

Manufacturer :
KLEMA Dentalprodukte (Austria – Europe)

Repacking, labels:
GC India Dental Pvt. Ltd

- **Chapter IX**
Cementation protocols

Dr. Mamtha THOMAS
Dr. Yessi Margaretha BUDIONO

- **Chapter VIII**
Conversion to 3D Master shades

KLEMA Dentalprodukte
Frederic FURGIER - CDT

- **Chapters I, II, III, IV, V, VI, VII, VIII**,
Contents write-up
Fixed dental prostheses (FDPs)
(Metal-ceramic bridge & zirconia bridge)
Photography
Design

Frederic FURGIER - CDT

- **Chapter X**
Related products

GC Europe (Leuven)

Date of issue: Nov 2021

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PROCEED MC & Zr

AESTHETIC
JUST HAPPENS EFFORTLESSLY

GC

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