VITA

Technical and scientific **documentation**

VITA DENTURE TEETH

VITA PHYSIODENS®
VITAPAN EXCELL®
VITAPAN® LINGOFORM
VITAPAN®

Content overview

1. Description of the material

1. Description of the material

1.1 Description of PMMA

The denture teeth available on the market today are mainly made of polymethyl methacrylate (PMMA). The smallest molecular single component of PMMA is the liquid methyl methacrylate (MMA) monomer. During the manufacture of the teeth, PMMA, which is in the form of small spheres, and MMA are mixed together homogeneously with pigments and crosslinked monomers (e.g., ethylene glycol dimethacrylate (EGDMA)), as well as stabilizers and initiators. This still mouldable mass is then cured in the tooth moulds under heat and increasing pressure. In this polymerization process, tooth material is crosslinked to a greater or lesser extent, depending on the proportion of crosslinked monomers.

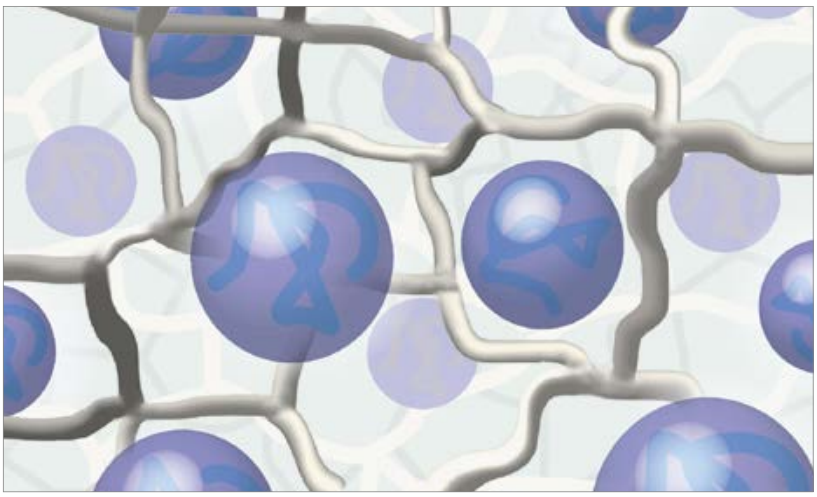


Figure 4: Schematic structure of PMMA; source VITA R&D

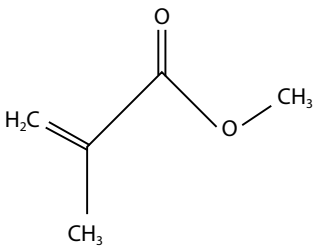


Figure 1: Structural formula of MMA

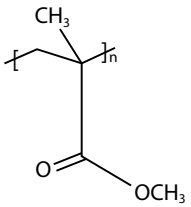


Figure 2: Structural formula of PMMA

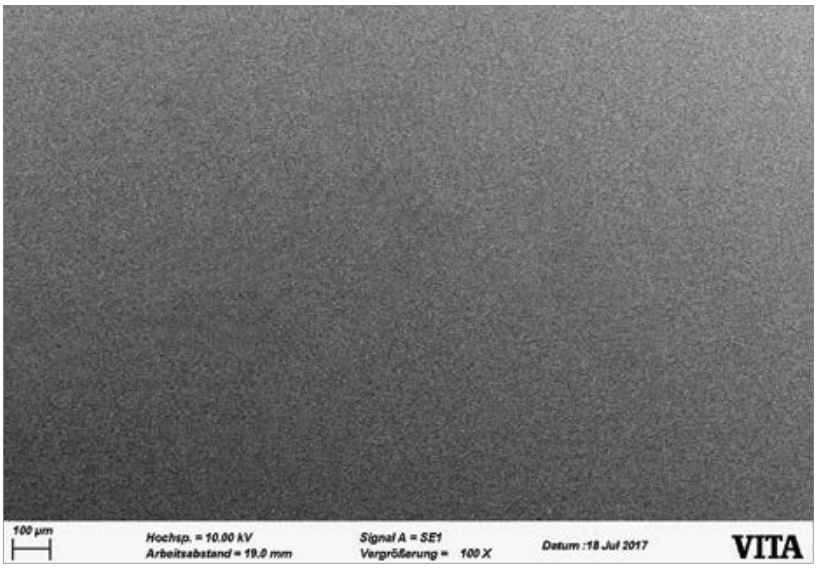


Figure 5: SEM image of PMMA, 100x magnification; source VITA R&D

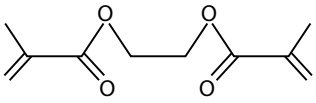


Figure 3: Structural formula of EGDMA

1. Description of the material

1.2 Description of MRP composite

In contrast to classic PMMA denture teeth, VITA denture teeth manufactured from MRP composite (MRP = Microfiller Reinforced Polymer matrix) consist of a highly crosslinked polymer matrix with homogeneously distributed inorganic microfillers polymerized into the matrix. The silicon fillers (SiO2/pyrogenic silica) are surface modified or silanized at VITA in a special process to ensure excellent bonding to the PMMA matrix. The SiO_2 filler acts as an additional crosslinking agent during polymerization. The results of reinforcing the polymer matrix is to ensure excellent wear resistance and durable surfaces (see, e.g., tests, pages 11, 12). MRP composite, used for the first time in 1983, now forms the material basis for the majority of VITA denture teeth and has since proven its reliability a million times over.

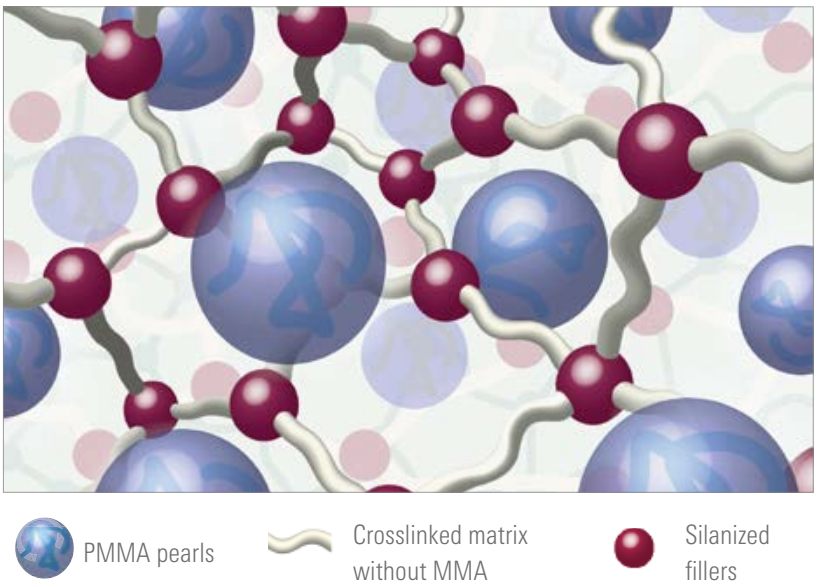


Figure 6: Schematic structure of MRP composite; source VITA R&D

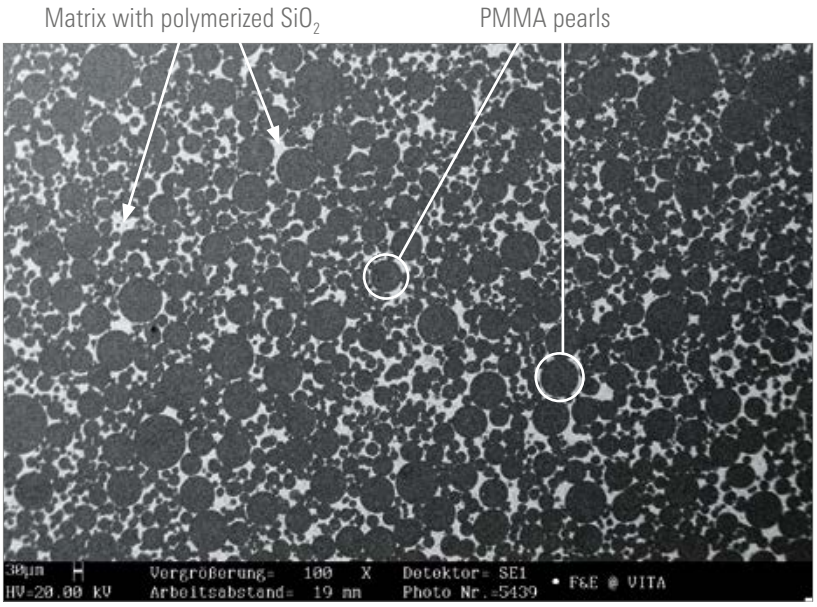


Figure 7: SEM image of MRP composite, 100x magnification; source VITA R&D

2. Manufacturing procedure

2. Manufacturing procedure

2.1 Central processing stages

MRP composite is manufactured under constant quality control, according to a special procedure developed at VITA Zahnfabrik. VITA denture teeth, made from MRP composite, are manufactured exclusively in Germany at the headquarters of VITA Zahnfabrik, according to the highest production and quality standards – ensuring consistently reliable prosthetics. Specially trained, skilled personnel produce the denture teeth using automated processes, as well as customized manual production. Figure 8 shows the principle process from receiving the raw materials to finished denture tooth.

Figure 8: Manufacturing process of VITA denture teeth; source VITA R&D

2. Manufacturing procedure

2.2 Tooth manufacturing procedure

Today, high-quality denture teeth are built up layer-by-layer from different types of material. By specifically varying the material composition in the individual layers— for example, in terms of filler content, pigments or monomers, it is possible to achieve a natural shade effect and translucency in the denture teeth. The layering of a new generation tooth is illustrated using the example of VITAPAN EXCELL® (Fig. 9).

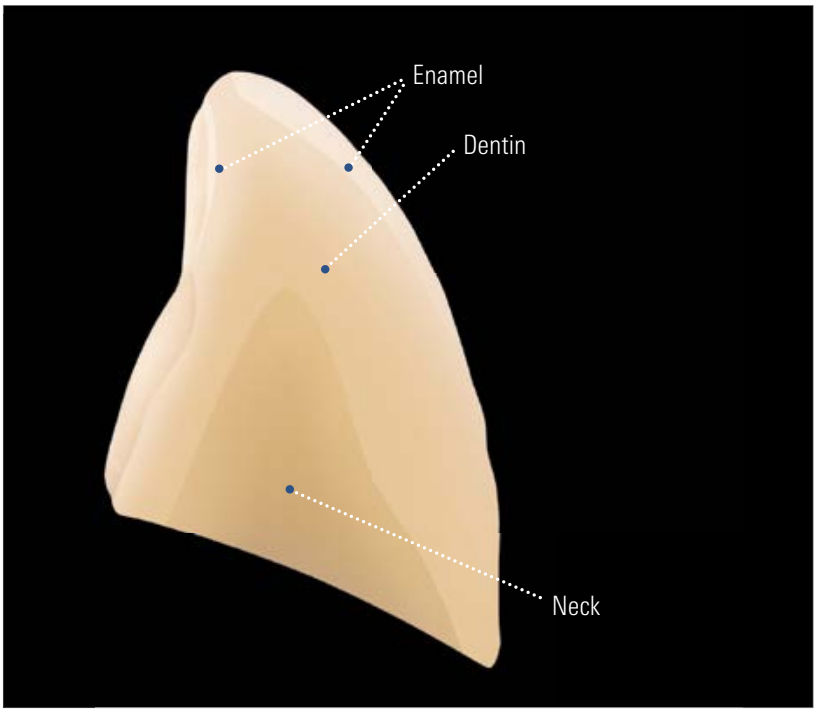


Figure 9: Schematic layering of VITAPAN EXCELL®

There are fundamental differences in tooth manufacture, depending on the material base. The following is intended to explain and demonstrate these differences in the manufacture of denture teeth fabricated from base materials containing MMA, compared with those fabricated using MRP composite (Figs. 10 a,b/11).

2.2.1 Procedure with MRP composite denture teeth

With VITA denture teeth made from MRP composite, the various shaded materials for enamel, counter mould enamel, dentin and cervical area are packed successively into the tooth mould. The mould is only closed when it is completely filled with material. The material is compressed and cured under the influence of pressure and heat in a special heating press. The denture tooth is then completely polymerized in a single step. During this process, the marginal layers of the individual materials interlock, creating a gap-free and porous-free bond (see Fig. 10 b).

Figure 10 a: Schematic representation of the manufacturing procedure of denture teeth made from MRP composite; source VITA R&D

Sectional view of denture tooth made from MRP composite

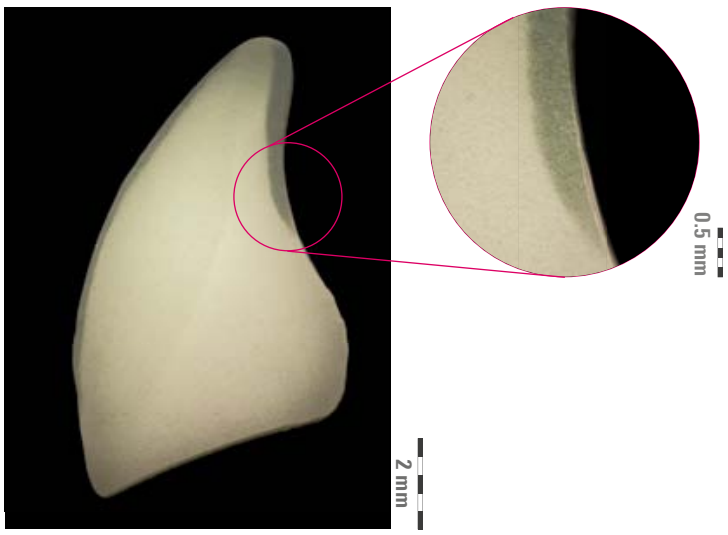


Figure 10 b: Light microscope image of the sectional view of a VITA denture tooth (VITAPAN EXCELL®) made from MRP composite; Source VITA R&D

2. Manufacturing procedure

2.2.2 Procedure with (P)MMA denture teeth

According to the layering concept, tooth materials mixed with MMA are inserted or pressed successively in the tooth moulds, beginning with the enamel. In the process, each individual layer is fixed in position by heating under pressure (i.e., initially polymerized), to ensure that the mould can be opened for introducing the next layer. After pressing the last layer, final polymerization follows, which fully polymerizes the material.

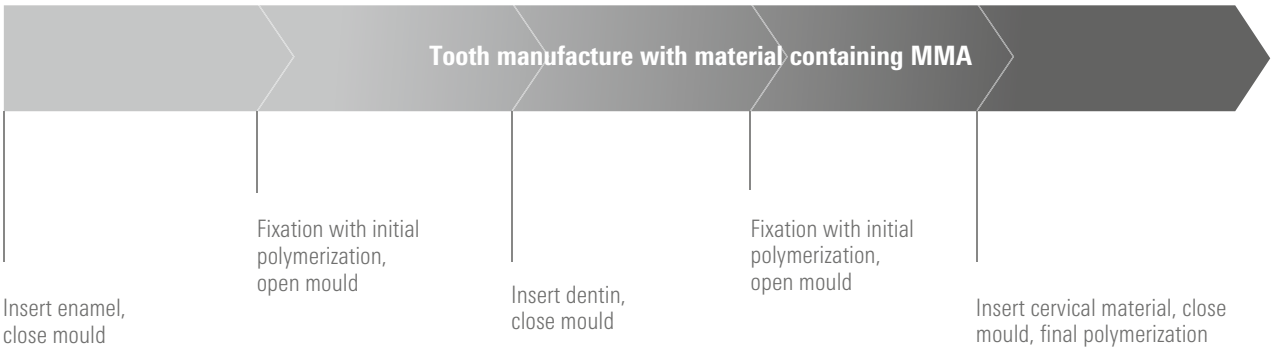


Figure 11: Schematic illustration of manufacturing procedure of (P)MMA denture teeth; source VITA R&D

3. Technical data of denture teeth

3. Technical data of denture teeth made from MRP composite

3.1. Overview of MRP composite material tooth range

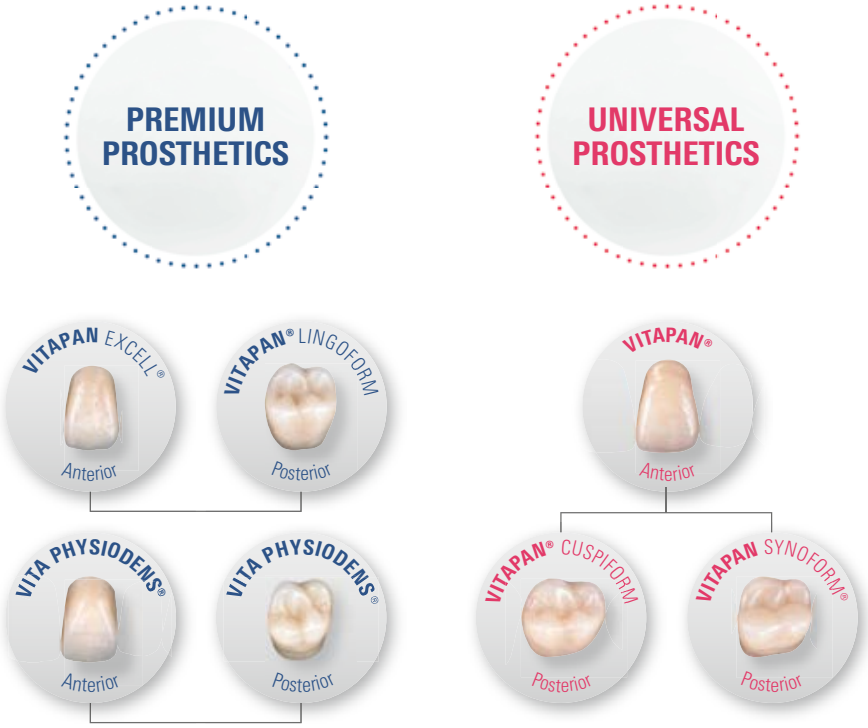


Figure 12: Illustration of the VITA MRP composite anterior/posterior range structure

3. Technical data of denture teeth

3.2 Physical properties

Microfiller **R**einforced **P**olymer matrix (MRP composite)

Bending strength	MPa	80
Modulus of elasticity	MPa	4,350
Vickers hardness HV 0,5/30	MPa	275
Water absorption	µg/mm^3	26.1
Solubility in water	µg/mm^3	1.2

3.3 Chemical composition

Microfiller **R**einforced **P**olymer matrix (MRP composite)

Components	**Percentage by weight**
PMMA	84 – 86
Silicon dioxide	14 – 15
Pigments	< 1

4. Wear behavior

4. Wear behavior

a) Materials and methods

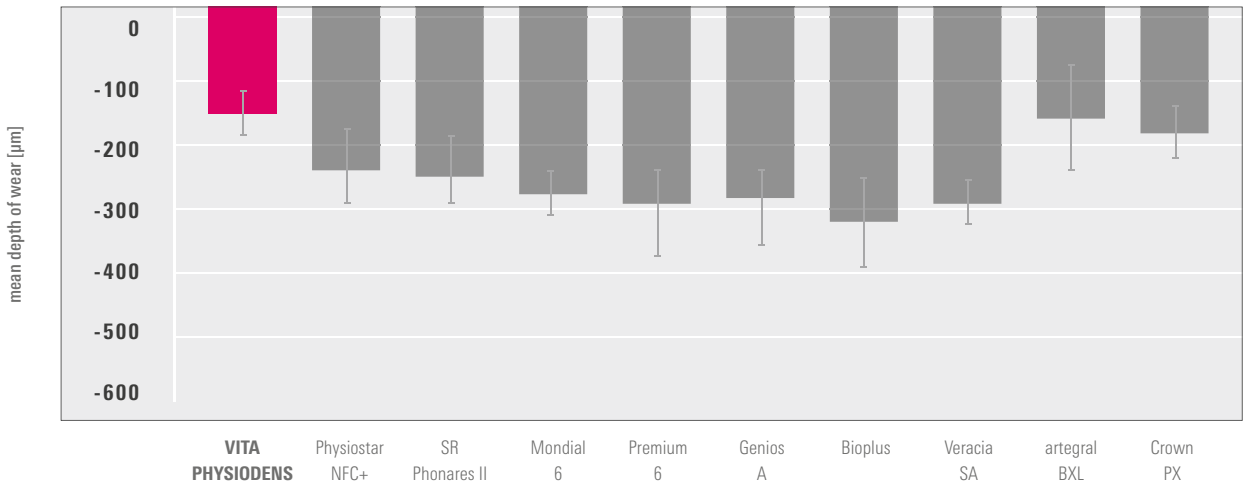
For determining the wear and abrasion behavior of the tooth lines mentioned below, a Pin-on-block wear test was performed in a mastication simulator, each with eight specimen per tooth line and using the following parameters: steatite ball as antagonist; 50 N loading force; 1.2 x 105 cycles; 1.2 Hz and 830 thermocycles at 5 – 55° C.
At the end of mastication simulation, the depth of the wear mark was measured.
The result graph shows the mean depth of the wear mark for each tooth line.

b) Source

University of Regensburg, Prof. M. Rosentritt, Test Report No. 280_2,
Report 11/15 ([2] cf. 13. References)

c) Result

Wear study



d) Conclusion

VITA PHYSIODENS® was used as the example for VITA denture teeth made from MRP composite and showed the lowest wear depth in the above wear test. As a result, denture teeth manufactured using this material can be expected to have a high clinical wear resistance and abrasion stability.

5. Vickers hardness

5. Vickers hardness

a) Materials and methods

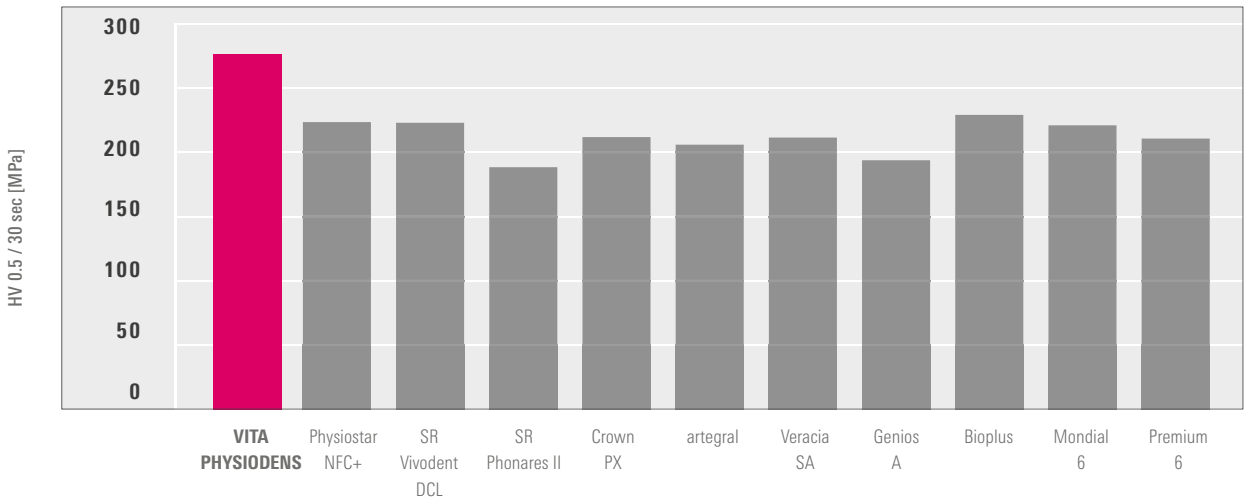
One denture tooth from each of the tooth lines mentioned below was cut through the middle, and one half each embedded in epoxy resin and then polished to a high luster. Three hardness indentations were applied to each polished tooth section in the test machine, using a testing force of 5 Newton (N) for 30 seconds. After measuring the indentation diagonals, the hardness was calculated in megapascals (MPa). This test was carried out in accordance with ISO 6507-1. The result graph shows the mean values from the three measurements for each tooth line.

b) Source

Internal study, VITA R&D, report 02/17 ([1] cf. 13. References)

c) Result

Vickers hardness (HV)



d) Conclusion

Representing all VITA denture teeth made from MRP composite, VITA PHYSIODENS® showed the highest mean value in the Vickers hardness test. The Vickers hardness values calculated for individual tooth lines built up from different materials may vary by approx. 25 percent, depending on the layer of material.
With VITA tooth lines made from MRP composite, all layers consist of this special composite. The test results indicate that these products have high mechanical resistance.

6. Shade match with VITA classical A1–D4®

6. Shade match with VITA classical A1–D4® shade standard

a) Materials and methods

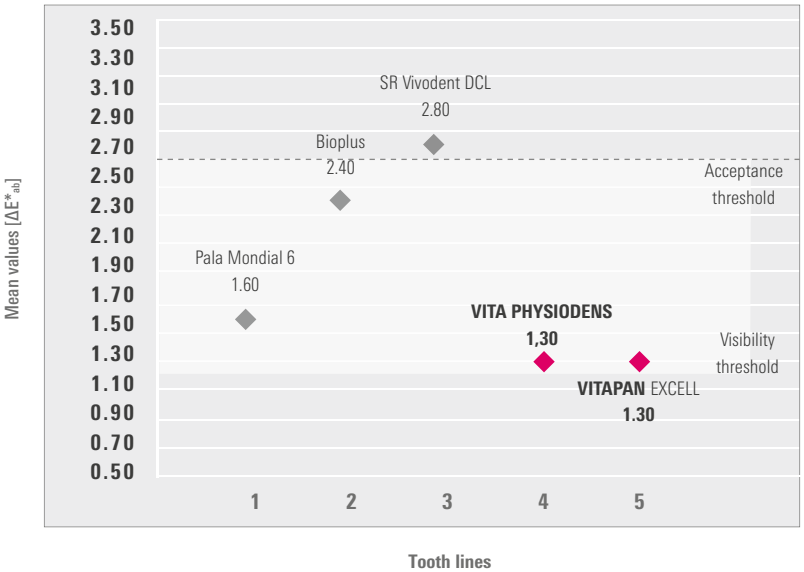
In this test, the match of the tooth lines shown below were investigated with the VITA classical A1–D4® shade guide. In the first step, teeth 21 and 22 were fixed in a custom-built holder from randomly selected anterior sets of teeth in shades A1, A2 and A3. In the second step, five measurements were taken for each tooth and shade using an electronic tooth shade measurement device. A mean value was determined for each set and then a total mean value was calculated across the three shades. Five measurements were also taken on the reference shade guide (VITA classical A1–D4®, VITA Zahnfabrik) for each shade guide piece and the mean values formed. The result graph shows the mean values of the determined shade deviation (ΔE^*_{ab}) for each line of teeth or set of teeth to the reference shade guide (A1, A2, A3)

b) Source

Johannes Gutenberg University of Mainz, Dr. M.Sc. Christopher Igiel,
Report 05/17 ([3] cf. 13. References)

c) Result

Shade match of the tooth lines to the VITA classical A1–D4® shade standard
Overall mean values (ΔE^*_{ab}) for each tooth line (all sets of teeth in A1, A2, A3)



Specification of the tooth lines tested:

- SR Vivodent DCL; geometry: A14
- Bioplus; geometry: L68
- Pala Mondial 6; geometry: R455
- VITA PHYSIODENS®; geometry: T2S
- VITAPAN EXCELL®; geometry: T46

6. Shade match with VITA classical A1–D4®

d) Conclusion

The test results indicate that the VITAPAN EXCELL® and VITA PHYSIODENS® anterior teeth tested, exhibit on average, an excellent shade guide to the VITA classical A1–D4® in shades A1, A2 and A3. A mean of ΔE^*_{ab} 1.3 was determined from all measurements (A1, A2 and A3) for each of the two tooth lines.
In ISO/TR 28642:2016, the perceptibility threshold for differences in shade between dental materials is given as ΔE^*_{ab} 1.2. This means metrologically determined shade deviations often (50% of cases) cannot be perceived when visually assessed by dental experts.

Shade deviations up to a ΔE^*_{ab} of 2.7 (acceptance threshold) are assessed as tolerable, according to ISO/TR 28642:2016. However, the results only allow an initial statement to be made about the trend, as shades can deviate, depending on the geometry and production batch of the respective tooth line.

7. Bond quality to base materials

7. Bond quality to base materials (cold-curing acrylic)

a) Materials and methods

One test piece each was fabricated from designated cold-curing acrylics (FuturaGen, Schütz Dental; ProBase Cold, Ivoclar Vivadent; PalaXpress, Kulzer) and VITA PHYSIODENS® denture teeth for testing the bond strength in accordance with ISO 22112. For the test, the denture teeth were roughened basally and coated with an adhesion promoter (VITACOLL, VITA Zahnfabrik). The base materials were then poured and cold cured. Finally, the specimens were loaded until failure and the fracture surfaces were assessed visually in accordance with ISO 20795-1 and ISO 22112.

b) Source

Internal study, VITA R&D, report 06/16 ([1] cf. 13. References)

c) Result

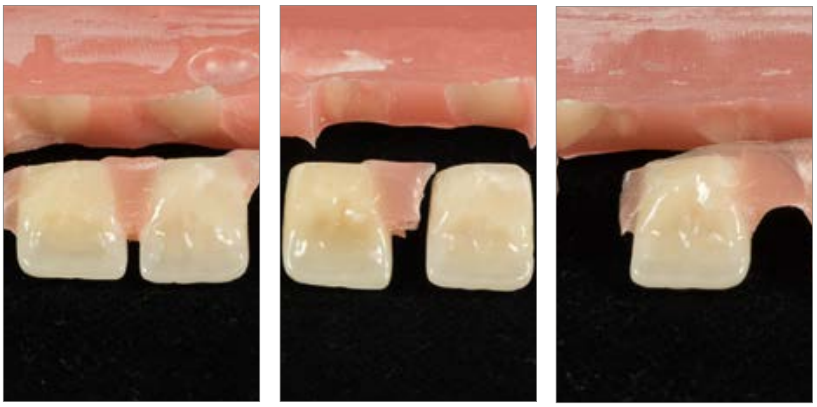


Figure 13 a – c: Typical fracture pattern after bond testing of VITA PHYSIODENS with the base materials named above (Base material from left to right: FuturaGen, ProBase Cold, PalaXpress)

d) Conclusion

No failure was observed in the bonding zone during testing of the bond strength with cold-curing acrylics according to ISO 22112. A cohesive fracture pattern was observed in analysis of the fracture surfaces. Both tooth fragments are stuck to the base material and fragments of the base material are stuck to the teeth. This means that both the denture base material and tooth material failed. A very good bond can be demonstrated between VITA denture teeth made of MRP composite and the base materials mentioned above. On top of that, a good bond to heat-curing acrylic is also guaranteed, as regular internal tests demonstrate.

8. Influence of pretreatment

8. Influence of conditioning on the bond quality

a) Materials and methods

Four specimens were fabricated using PalaXpress (Kulzer) and VITA PHYSIODENS® for testing the bond strength in accordance with ISO 22112. To determine the influence of conditioning on the bond strength, the denture teeth were conditioned basally in different ways before pouring the base material and polymerizing it. In accordance with ISO 20795-1 and ISO 22112, the specimens were loaded until failure and the fracture surfaces were assessed visually.

b) Source

Internal study, VITA R&D, report 03/17 ([1] cf. 13. References)

c) Result

Figure 14 a: Fracture pattern; tooth base was sandblasted and coated with bonding agent

Figure 14 b: Fracture pattern; no surface treatment of the tooth base was performed

Figure 14 c: Fracture pattern; tooth base was only conditioned by sandblasting

Figure 14 d: Fracture pattern; tooth base was only coated with bonding agent

d) Conclusion

After conditioning the contact surfaces according to the manufacturer's recommendations (sandblasting the basal surfaces and coating with VITACOLL adhesion promoter), an excellent bond can be achieved between cold-curing acrylic and VITA denture teeth made from MRP composite (here in this test, VITA PHYSIODENS), as the cohesive fracture pattern shows (Fig. 14 a). Failure to condition, or if conditioning is not carried out completely, then this can lead to failure in the bonding zone, so that the "smooth" denture teeth break out (see Fig. 14 b to 14 c).

9. Manual processability

9. Manual processability

a) Materials and methods

The objective of this test was to determine how precisely and reliably VITA denture teeth made from MRP composite can be trimmed using tungsten carbide instruments, without material chipping occurring in the margin or edge regions. A retention recess was prepared as an example in the palatal surfaces of ten VITAPAN EXCELL® anterior teeth using a tungsten carbide cutter (HM 486GX 023 cross-cut, standard, Hager & Meisinger GmbH, Neuss, Germany), as is typical for CoCr restorations. The retention was prepared using a motor speed of 20,000 rpm and the manual pressure usually applied for this type of preparation (approx. 0.3 to 2 N). The prepared surfaces of the specimens were then examined both visually and using a stereo microscope (Leica MZ6).

b) Source

Internal study, Technical Service VITA Zahnfabrik, Report 06/17
([4] see 13. References)

c) Result

Figure 15 a: Inserting a retention recess in VITAPAN EXCELL® using a tungsten carbide cutter

Figure 15 b: Positioning the prepared VITAPAN EXCELL® on the CoCr framework

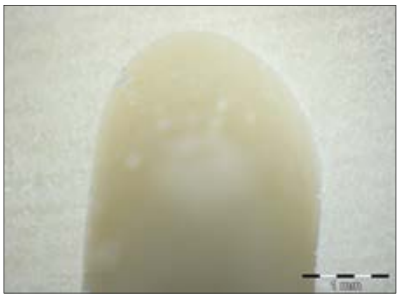


Figure 15 c: Light microscope image of the retention recess in the palatal surface

d) Conclusion

Assessment of the prepared palatal surface of the denture tooth made from MRP composite using a light microscope (Fig. 15 c) shows precise margins in the area of the incorporated retention, without any marginal chipping. As a result, reliable processability with edge stability can be expected for VITA MRP composite denture teeth.

10. Shade stability after trimming

10. Shade stability after trimming

a) Materials and methods

Sets of anterior teeth with the same geometry in shade A2 were selected from the tooth lines below, and the respective denture tooth 12 was manually trimmed palatally using a cross-cut tungsten carbide cutter for testing the shade stability of denture teeth after trimming. The palatal side was trimmed in three steps. The respective denture tooth was reduced during trimming to wall thicknesses of 2.0 mm, 1.5 mm and 1.0 mm. After each step, the shade stability of the denture teeth was assessed and the result photographically documented. Documentation shows tooth 11 of the set of teeth each time as a shade reference.

b) Source

Internal study, Technical Service VITA Zahnfabrik, Report 06/17 ([4] cf. 13. References)

c) Result

Tooth line, Manufacturer	Wall thickness 2.0 mm	Wall thickness 1.5 mm	Wall thickness 1.0 mm
VITA PHYSIODENS®, VITA Zahnfabrik			
SR PHONARES II, Ivoclar Vivadent			
PhysioStar NFC+, Candulor			
PREMIUM 6, Kulzer			

Figure 16: Photographic documentation of palatally trimmed denture teeth in wall thicknesses 2.0, 1.5 and 1.0 mm

d) Conclusion

In this test, VITA PHYSIODENS® made from MRP composite in the selected geometry exhibited comparatively good shade stability after trimming. The same aspect applied for all tooth lines: The lower the wall thickness, the lower the chromaticity of the denture teeth. However, the basic shade can be restored by using tooth-colored acrylic during fabrication of the denture (see partial/ hybrid dentures). The results only allow an initial statement to be made about the trend for the above mentioned tooth lines, as the shade fidelity can deviate after trimming, depending on the geometry of the tooth.

11. Shade stability after storage

11. Shade stability after storage

a) Materials and methods
VITA PHYSIODENS® were stored for six months in tea, coffee and red wine for testing the shade stability of denture teeth made from MRP composite. The storage media were heated to 20°C and stirred. The stored denture teeth were removed at regular intervals and cleaned under running water using a toothbrush. At the end of the storage period, the specimens were removed, cleaned and visually compared with the retained sample.

b) Source
Internal study, VITA R&D, report 07/17 ([1] cf. 13. References)

c) Result before and after six months storage

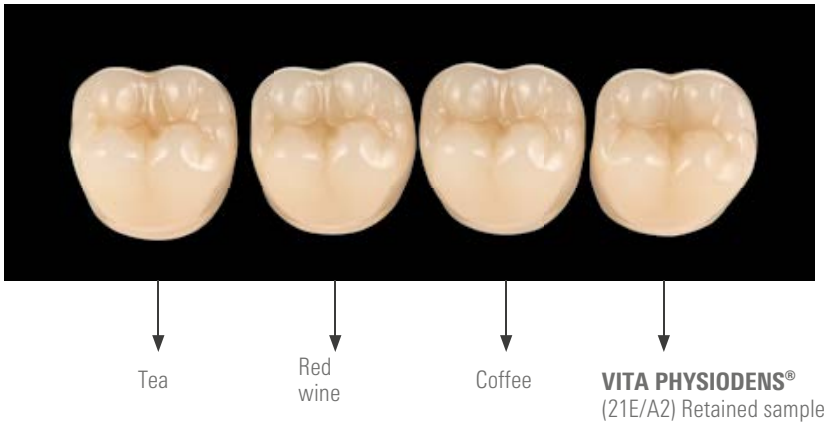


Figure 17: Photographic documentation of retained sample and stored specimen (six months)

d) Conclusion
Visual comparison of retained sample and specimens after the six-month storage period showed very good shade stability for the VITA denture teeth made from MRP composite (here using the example of VITA PHYSIODENS®). No discoloration was detected during visual inspection.

12. Biocompatibility

12. Biocompatibility

During the manufacture of VITA denture teeth, partly firm, partly liquid base materials are transformed into solid, insoluble MRP composite. During this process, both the aggregate state of the material changes, as well as the bioavailability for the denture wearer. Fully polymerized MRP composite can be considered inert and cannot enter the human organism. Various tests were performed on extracts to assess possible risks from elutable substances from MRP composite.

12.1 Cytotoxicity

The invitro cytotoxicity of MRP composite was tested on extracts of VITA denture teeth in accordance with ISO 10993-5. During the tests, no indication of cell lysis or toxicity was detected.1

12.2 Irritation and skin sensitization

The potential of MRP composite to cause skin sensitization was tested in accordance with ISO 10993-10. The tested material did not show any significant sensitization potential during this test.2

12.3 Chemical characterization of materials

The MRP composite was tested and assessed for possible soluble biologically active residue in accordance with ISO 10993-18. The assessment showed that the material is biologically safe.

12.4 Conclusion

The present chemical analysis, biological tests and many years of market observation demonstrate that MRP composite is a biocompatible material, which if used properly, does not pose a health risk for patients, dental technicians or dental personnel.

Bibliography:
NAMSA Lab No. 08G_50865_01 "Summary Report and Biological Risk Assessment"
eurofins Expert statement VITA Polymer teeth No. 019-00265A

[1)] NAMSA Project no. 08T_41116_07, 2007
[2)] RCC Project no. 283973
RCC Project no. 283926/RCC Project no. 283950

13. References

13. References

1. **Internal studies, VITA R&D:**
   VITA Zahnfabrik H. Rauter GmbH & Co. KG
   Research and Development Division
   Spitalgasse 3
   79713 Bad Säckingen
   Dr. Stefan Aechtner, Project Manager for Material Development, Bad Säckingen

2. **Abrasion studies, University of Regensburg, Germany**
   Prof. Dr.-Ing. Martin Rosentritt, Forschungsbereichsleiter,
   Universitätsklinikum Regensburg, Poliklinik für Zahnärztliche Prothetik,
   Regensburg; Bericht: Testreport Nummer 280_2, 11/15

3. **Shade measurements for prosthetic teeth, University of Mainz**
   Dr. M.Sc. Christopher Igiel, Research Associate,
   Johannes Gutenberg-University of Mainz, Polyclinic for Prosthetics,
   Mainz; Report: 05/2017

4. **Internal study, Technical Service VITA Zahnfabrik**
   VITA Zahnfabrik H. Rauter GmbH & Co. KG
   Sales Division
   Spitalgasse 3
   79713 Bad Säckingen
   ZT Andreas Buchheimer, Head of Application Technology, Bad Säckingen

Suitable solutions for processes.

Shade determination

VITA Easyshade V / VITA Easyshade LITE

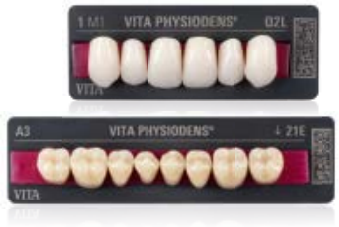
or VITA Shade Guides

Shape determination

Tooth storage or lifelike mould chart

Denture teeth

VITA PHYSIODENS Anterior & Posterior
VITAPAN EXCELL Anterior
VITAPAN LINGOFORM Posterior
VITAPAN Anterior
VITAPAN CUSPIFORM Posterior
VITAPAN LINGOFORM Posterior



Bonding

VITACOLL and VITAFOL

Characterization

VITA VM LC *flow* and VITA AKZENT LC

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VITAPAN® product family, VITA PHYSIODENS®

MD

Additional information on VITA prefabricated teeth
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VITA DENTURE TEETH

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