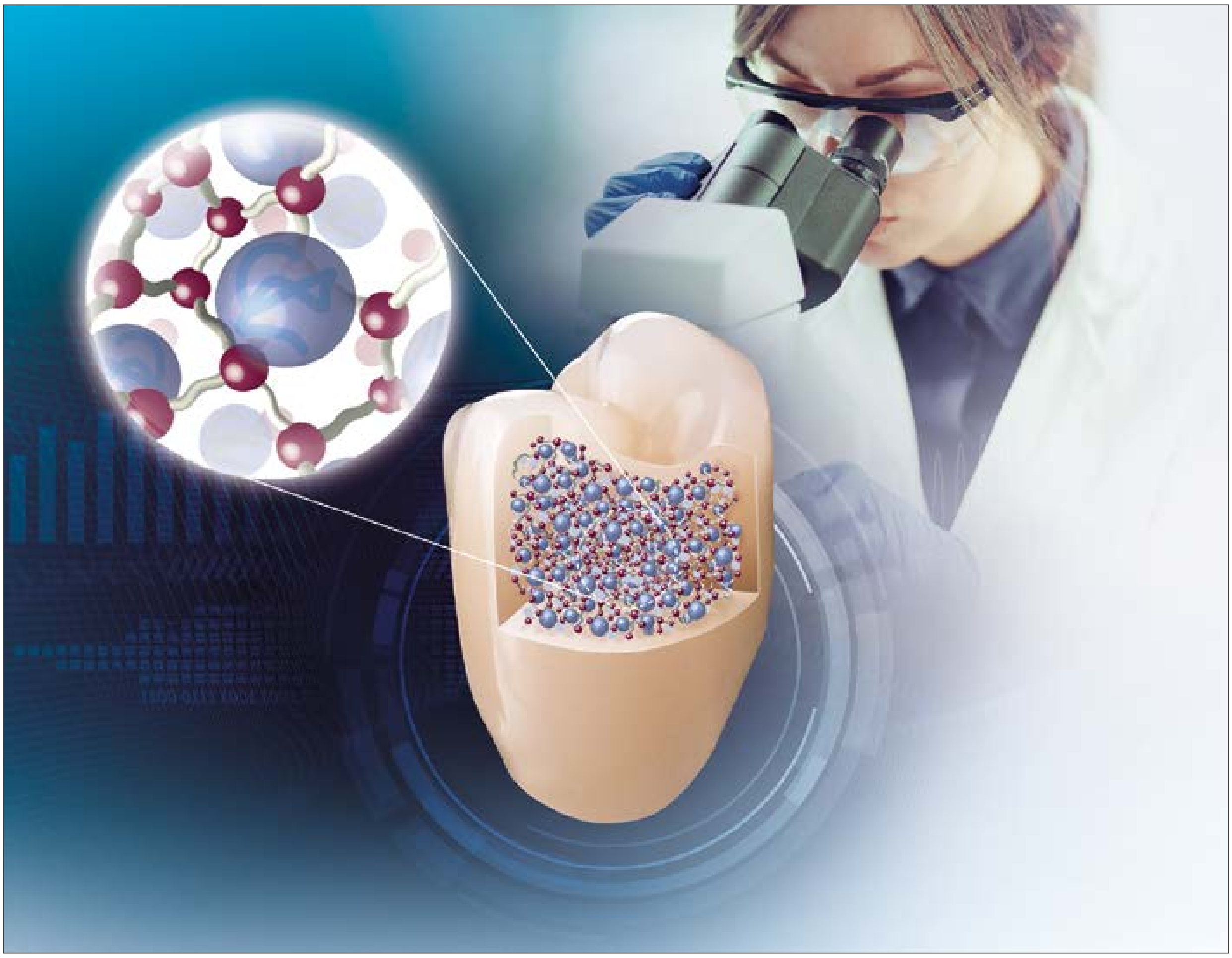
VITA Denture Teeth

Technical and scientific documentation



VITA shade determination | VITA shade communication | VITA shade reproduction | VITA shade control

Date of issue: 2023-02

VITA – perfect match.

VITA

1. Introduction

As a pioneer in the manufacture of denture teeth, VITA Zahnfabrik has over 90 years of experience in the dental prosthetics sector. Starting in 1926, porcelain teeth (Helios denture teeth) with natural enamel-dentin layering were manufactured by VITA. In 1956, VITA introduced the first vacuum-fired VITA LUMIN® VACUUM denture teeth with the accompanying LUMIN VACUUM shade guide. At the same time, the first standard for systematic classification of natural tooth shades was also created (13 shades). This system formed the basis for the worldwide established VITA classical A1–D4® shade standard.
With the development of polymethyl methacrylate (PMMA) in the first half of the twentieth century, a material was available that could be used for more than just the manufacture of denture teeth, but also for many other dental applications. The next major development step was the introduction of VITAPAN® denture teeth in 1983. These were the first VITA MRP composite denture teeth, manufactured from a highly cross-linked PMMA matrix with an inorganic filler, polymerized into the matrix. These denture teeth were initially supplied in the shades of the VITA classical A1–D4® shade standard.
A new denture tooth generation was presented at IDS 2017 with VITAPAN EXCELL®. Thanks to its unique layering structure, VITAPAN EXCELL enables the natural play of light and is characterized by "golden" proportions and an excellent shade match to the VITA classical A1–D4® shade guide.

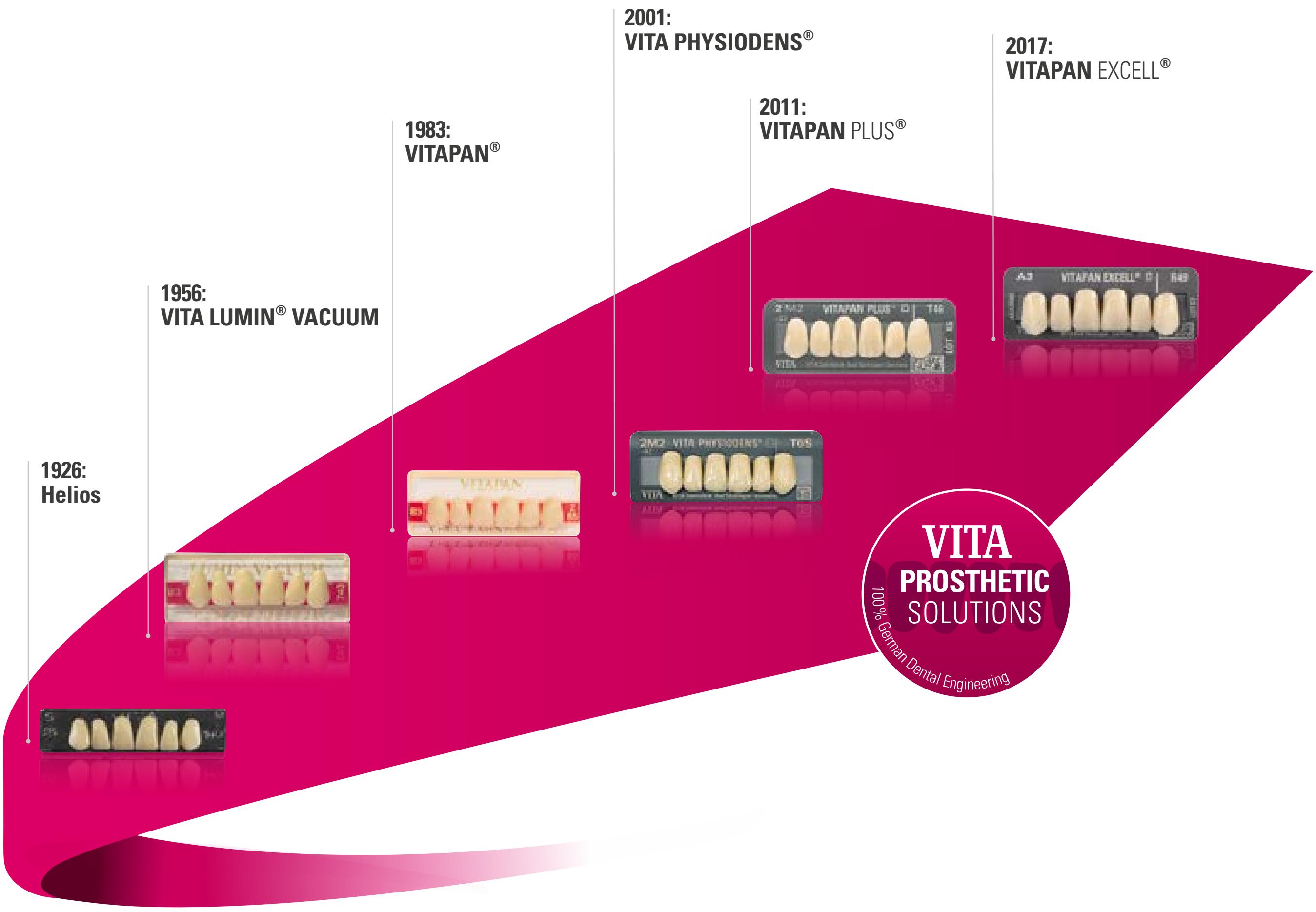


Figure 1: Key milestones in the development of VITA denture teeth

2. Description of the material

2.1 Description of PMMA

Denture teeth available on the market today are primarily manufactured from polymethyl methacrylate. The smallest molecular single component of PMMA, the monomer, is the liquid methyl methacrylate (MMA). During the manufacture of the teeth, PMMA, which is in the form of small spheres, and MMA are mixed together homogeneously with pigments, crosslinked monomers, (e.g., ethylene glycol dimethacrylate (EGDMA)), as well as with 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 cross-linked monomers.

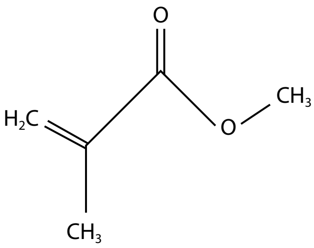


Figure 2: Structural formula of MMA

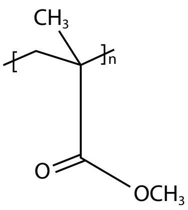


Figure 3: Structural formula of PMMA

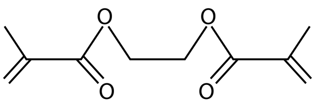


Figure 4: Structural formula of EGDMA

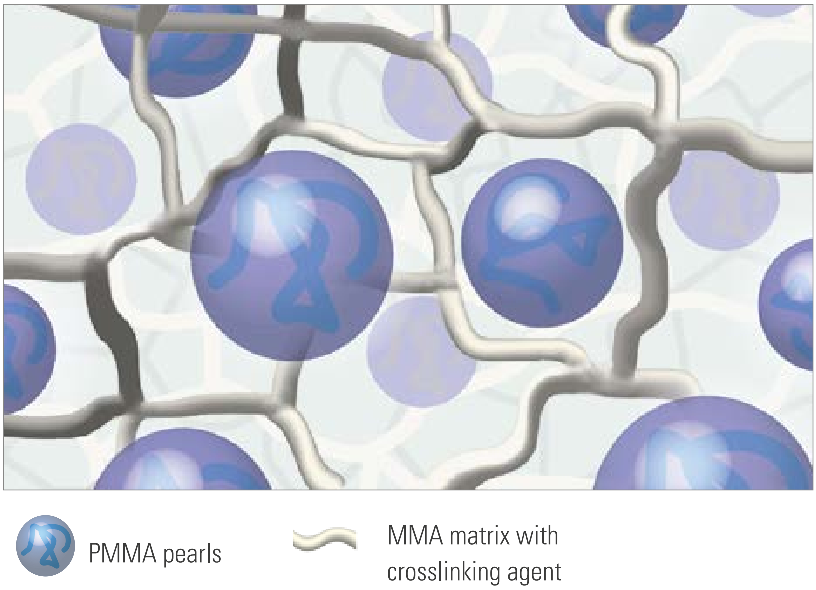


Figure 5: Schematic structure of PMMA; source VITA R&D

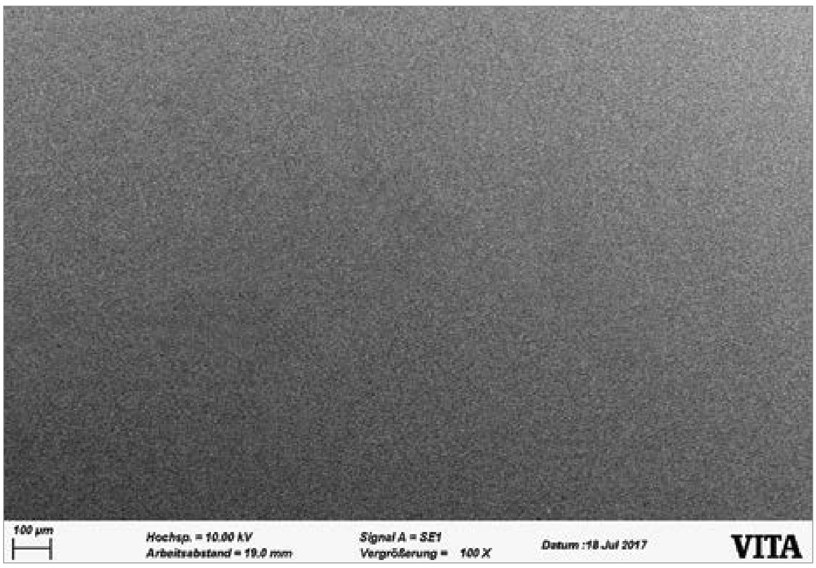


Figure 6: SEM image of PMMA, 100x magnification; source VITA R&D

2.2 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 silicone fillers (SiO_2/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 result of reinforcing the polymer matrix is to ensure excellent wear resistance and durable surfaces (cf., e.g., tests, Page 14, 15). MRP composite, used for the first time in 1983, now forms the material basis for the majority of VITA teeth and has proven its reliability a million times over.

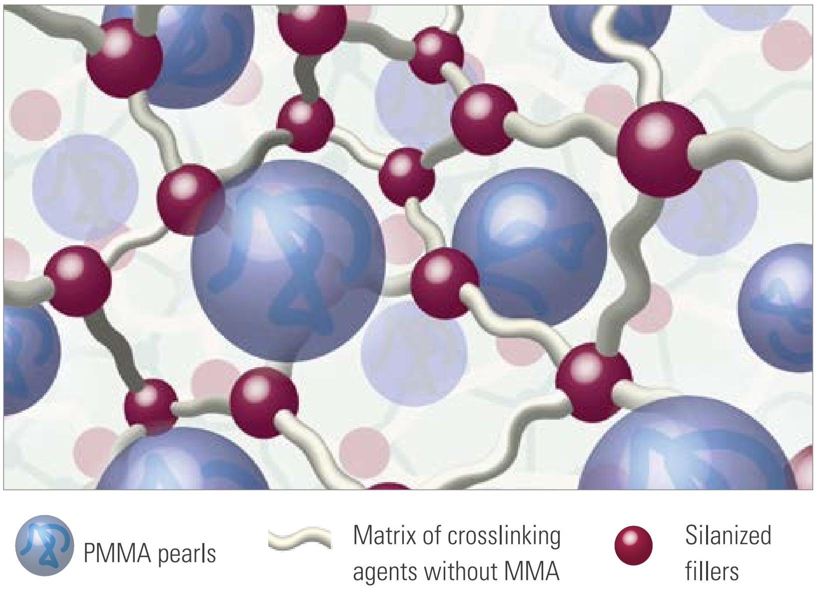


Figure 7: Schematic structure of MRP composite; source VITA R&D

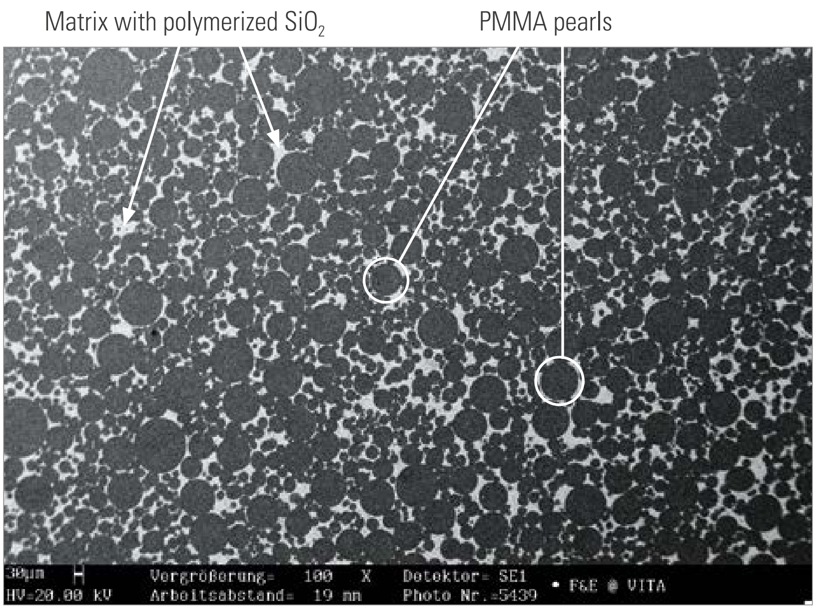


Figure 8: SEM image of MRP composite, 100x magnification; source VITA R&D

3. Manufacturing procedure

3.1 Central processing stages

MRP composite is manufactured under constant quality control, according to a procedure developed in-house at VITA Zahnfabrik. VITA denture teeth, made from MRP composite, are manufactured exclusively in southern 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 9 shows the general process from receiving the raw materials to finished denture tooth.

Figure 9: Manufacturing process of VITA denture teeth; source VITA R&D

3.2 Tooth manufacturing procedure

Today, high-quality denture teeth are built up layer-by-layer from different types of material. A natural shade effect and translucency of the denture teeth can be achieved by varying the material composition (e.g., filler content, pigments or monomers). The layering of a new generation tooth is shown using the example of VITAPAN EXCELL® (Fig. 10).

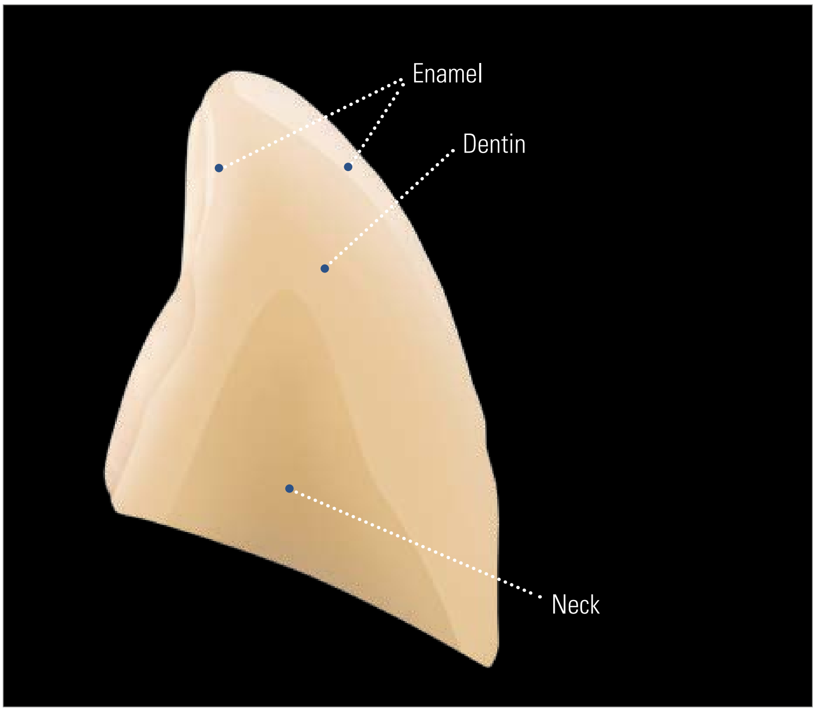


Figure 10: Schematic layering of VITAPAN EXCELL®

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. 11-12).

3.2.1 Procedure with MRP composite denture teeth

With VITA denture teeth made from MRP composite, the different 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 completely polymerized in a single step. During polymerization, the marginal layers of the individual materials interlock, resulting in a gap-free and porous-free bond (Fig. 11b)

Insert enamel, dentin and cervical material, close mould

Polymerization under the influence of heat and increasing pressure

Figure 11a: 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

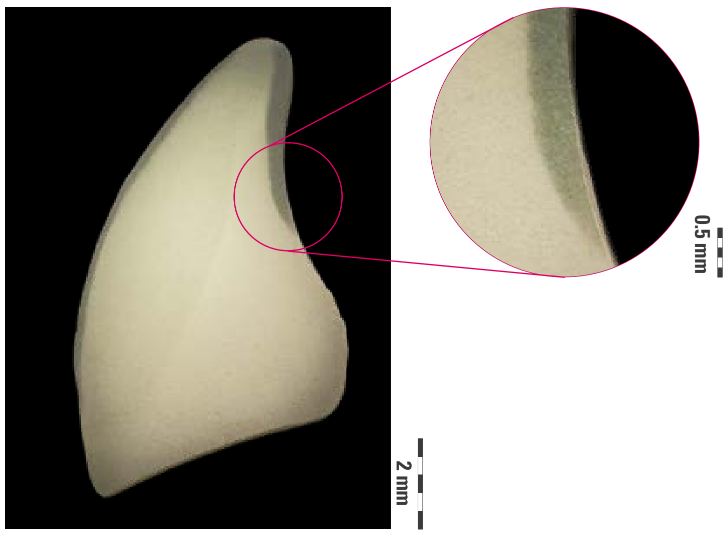


Figure 11b: Light microscope image of the sectional view of a VITA denture tooth made from MRP composite (VITAPAN EXCELL®); source VITA R&D

3.2.2 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.

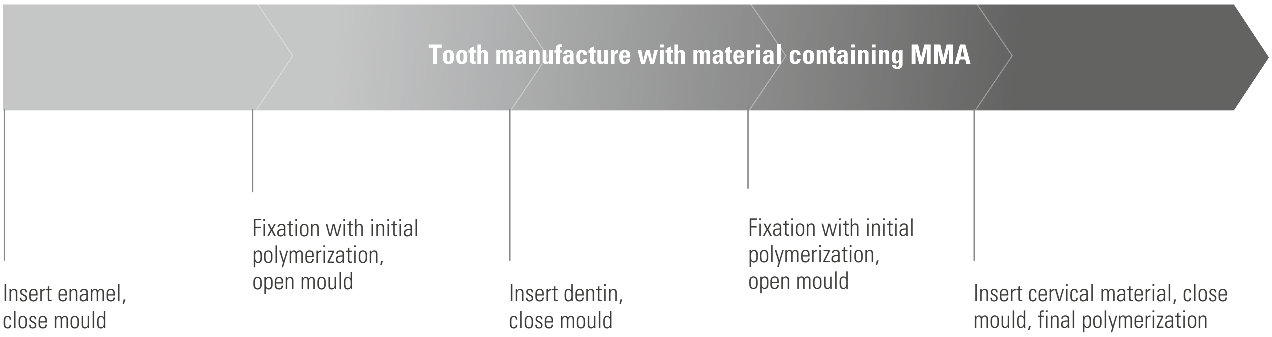


Figure 12: Schematic illustration of manufacturing procedure of (P)MMA denture teeth; source VITA R&D

4. Technical data of denture teeth made from MRP composite

4.1. Overview of MRP composite material tooth range

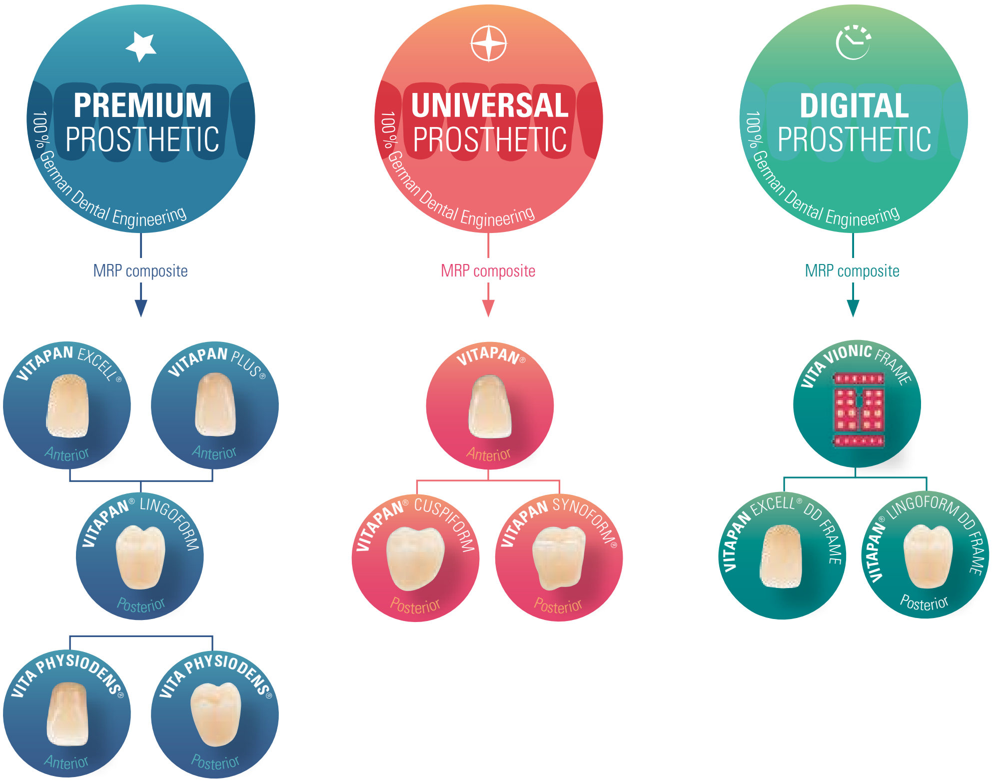


Figure 13: Illustration of the VITA MRP composite anterior/posterior range structure

4.2 Physical properties

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

Flexural strength	MPa	80
Modulus of elasticity	MPa	4,350
Vickers hardness HV 0,5/30	MPa	275
Water absorption	µg/mm³	26.1
Solubility in water	µg/mm³	1.2

4.3 Chemical composition

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

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

5. Wear behavior

a) Materials and methods

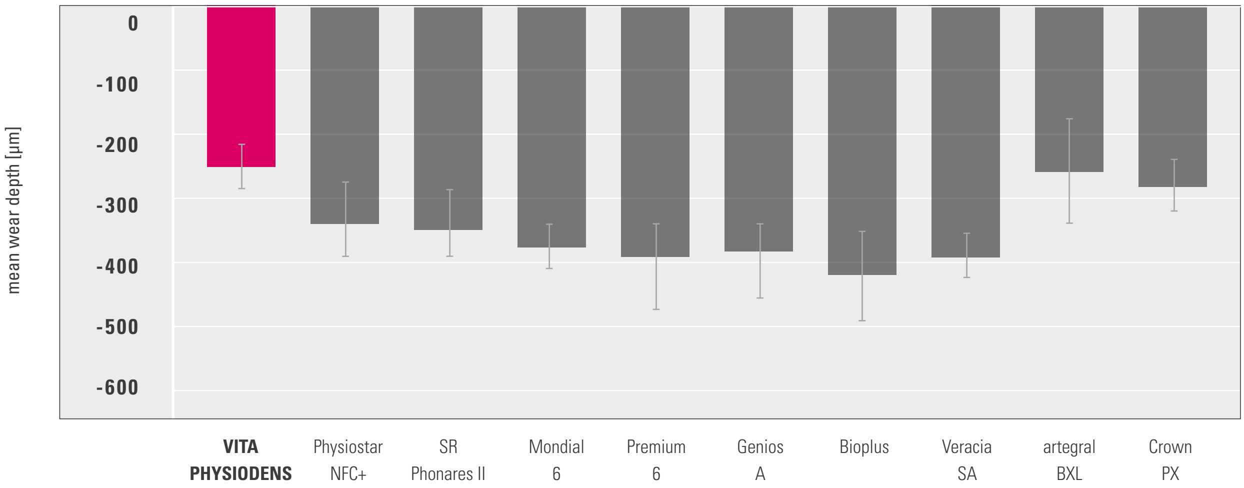
For determining the wear and abrasion behavior of the tooth lines below, a Pin-on-block wear test was performed in a mastication simulator, each with eight specimen per tooth line and using the following parameters: steatite ball as antagonist; 50 N loading force; 1.2 x 10^5 cycles; 1.2 Hz and 830 thermocycles 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, Germany, Prof. Dr. M. Rosentritt, Test Report No. 280_2, Report 11/15 ([2] cf. 14. 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, good clinical wear resistance and abrasion stability can be expected from denture teeth manufactured using this material.

6. Vickers hardness

a) Materials and methods

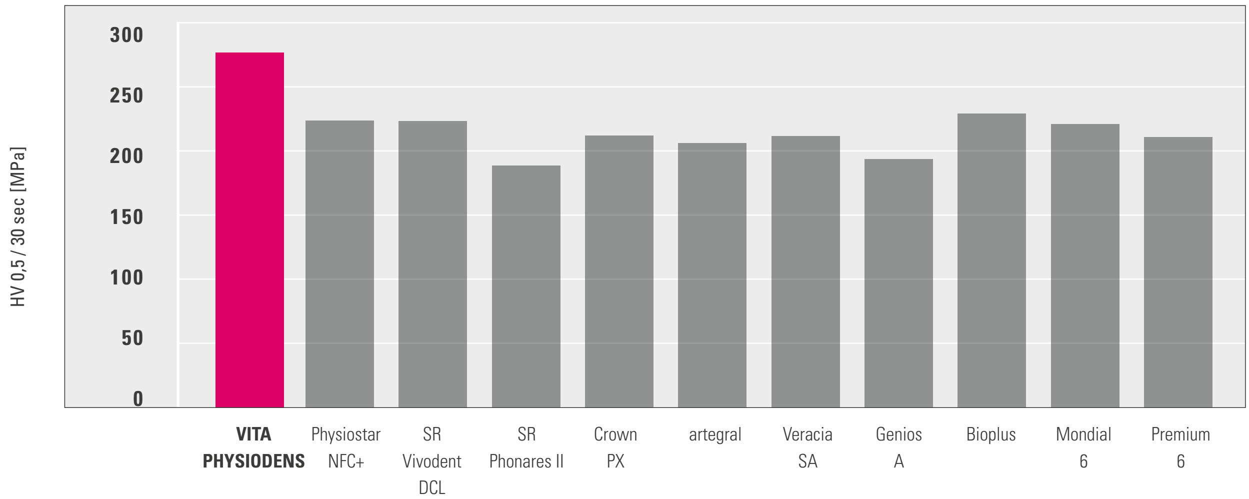
One denture tooth from each of the tooth lines below was cut through the middle and one half each embedded in epoxy resin and then polished to a high luster. Three hardness indentations were applied to each polished tooth section in the test machine using a testing force of 5 Newton (N) for 30 seconds. 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. 14. 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 mean 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 achieved with VITA MRP composite denture teeth show a high mechanical resistance.

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

a) Materials and methods

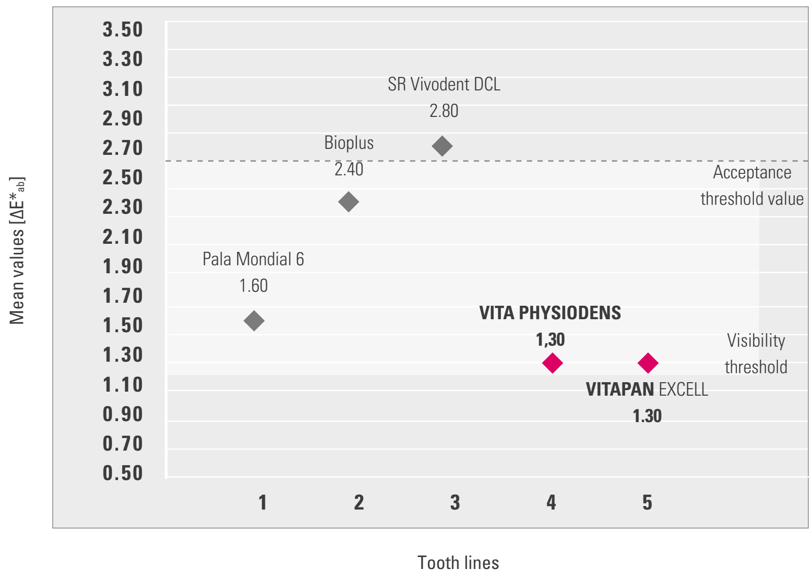
This test investigated the match of the tooth lines shown below with the VITA classical A1–D4® shade guide. In the first step, teeth 21 and 22 from randomly selected anterior sets of teeth in shades A1, A2 and A3 were fixed in a custom-built holder. In the second step, five measurements were taken for each tooth and shade using an electronic dental spectrophotometer (Shadepilot, DeguDent), a mean was determined for each set and then an overall mean calculated over the three shades. Five measurements were also taken on the reference shade guide (VITA classical A1–D4®, VITA Zahnfabrik) for each shade test 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. 14 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

d) Conclusion

The test results indicate that the VITAPAN EXCELL® and VITA PHYSIODENS® anterior teeth tested, exhibit on average, an excellent shade match to the VITA classical A1–D4® in shades A1, A2, 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.

8. 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. 14. References)

c) Result

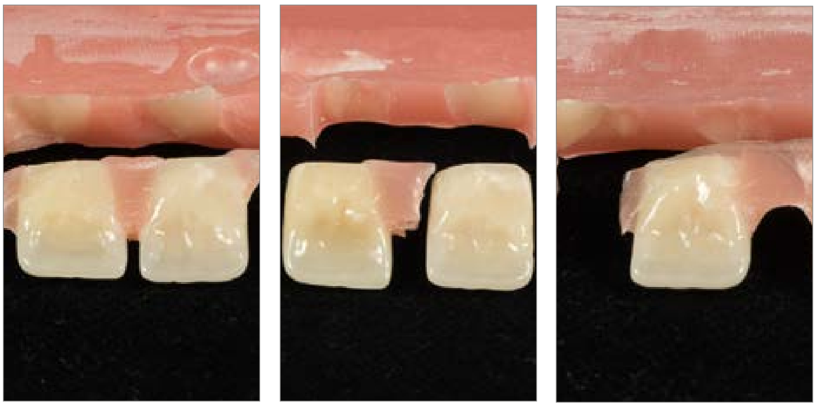


Figure 14 a – c: Typical fracture pattern after bond testing of VITA PHYSIODENS with the base materials named above (Base material from left to right: FuturaGen, ProBase Cold, PalaXpress)

d) Conclusion

No failure was observed in the bonding zone during testing of the bond strength with cold-curing acrylics in accordance with ISO 22112. A cohesive fracture pattern was observed in analysis of the fracture surfaces. Tooth fragments were adhering to the base material and fragments of the base material were also adhering to the teeth. This means that both the denture base material and tooth material failed. This proved that there was a very good bond between the VITA denture teeth made from MRP composite and the base materials named above. In addition, a good bond to heat-curing acrylic is also guaranteed, as regular internal tests demonstrate.

9. 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.
The specimens were loaded until failure and the fracture surfaces assessed visually in accordance with ISO 20795-1 and ISO 22112.

b) Source

Internal study, VITA R&D, Report 03/17 ([1] cf. 14. References)

c) Result

Figure 15 a: Fracture pattern; tooth base was sandblasted and coated with bonding agent

Figure 15 b: Fracture pattern; tooth base was not surface - conditioned

Figure 15 c: Fracture pattern; tooth base was only conditioned by sandblasting

Figure 15 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 the test VITA PHYSIODENS), as the cohesive fracture pattern shows (Fig. 15 a). Failure to condition or incomplete conditioning can lead to failure in the bonding zone, so that denture teeth break out completely (Fig. 15 b - 15 c).

10. 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 14. References)

c) Result

Figure 16 a: Inserting a retention recess in VITAPAN EXCELL® using a tungsten carbide cutter

Figure 16 b: Positioning the prepared VITAPAN EXCELL® on the CoCr framework

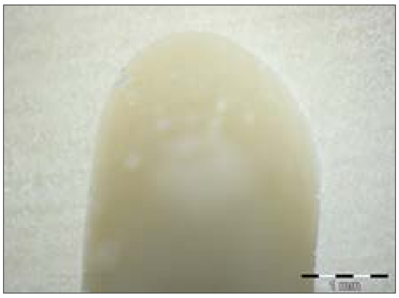


Figure 16 c: Light microscope image of the retention recess in the palatal surface

d) Conclusion

Assessment of the prepared palatal surface of the denture tooth made from MRP composite using a light microscope (Fig. 16 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.

11. Shade stability after trimming

a) Materials and methods

Sets of anterior teeth with the same geometries 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, 1.5 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] see 14. References)

c) Result

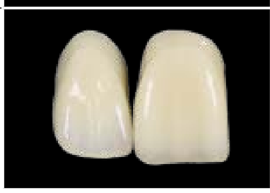
Tooth line, Manufacturer	Wall thickness 2.0 mm	Wall thickness 1.5 mm	Wall thickness 1.0 mm
VITA PHYSIODENS®, VITA Zahnfabrik			
SR PHONARES II, Ivoclar Vivadent			
PhysioStar NFC+, Candulor			
PREMIUM 6, Kulzer			

Figure 17: 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 tooth lines, as the shade fidelity can deviate after trimming, depending on the geometry of the tooth.

12. 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. 14. References)

c) Result before and after six months storage

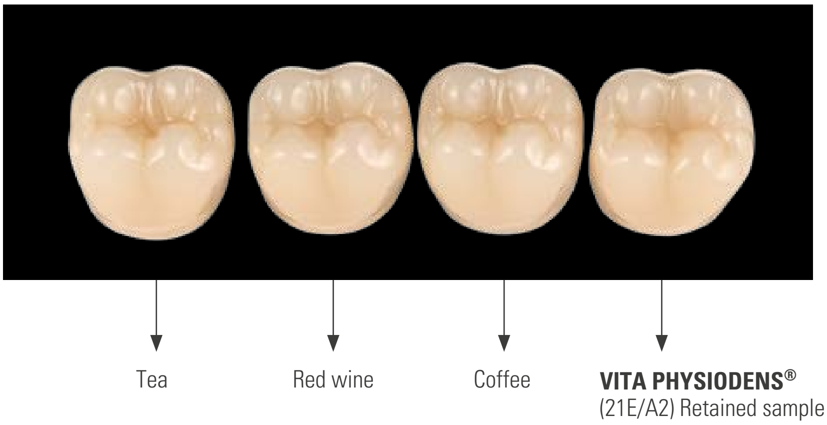


Figure 18: Photographic documentation of retained sample and stored specimen (six months)

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 could be established during visual inspection.

13. 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.

13.1 Cytotoxicity

The in-vitro 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.[1,2]

13.2 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.3

13.3 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.

13.4 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"
RCC Project No. 343462 (1993) and 401613, (1993)

[1)] RCC Project No. 343462 (1993) and 401613, (1993)
[2)] NAMSA Lab No. 08G_50865_01 "Summary Report and Biological Risk Assessment"
[3)] RCC Project No.283950 (1990), 283926 (1990)

14. References

1. **Internal studies, VITA R&D:**
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2. **Abrasion studies, University of Regensburg, Germany**
   Prof. Dr.-Ing. Martin Rosentritt, Forschungsbereichsleiter,
   Universitätsklinikum Regensburg, Poliklinik für Zahnärztliche Prothetik,
   Regensburg; Report: Testreport Nummer 280_2, 11/15

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

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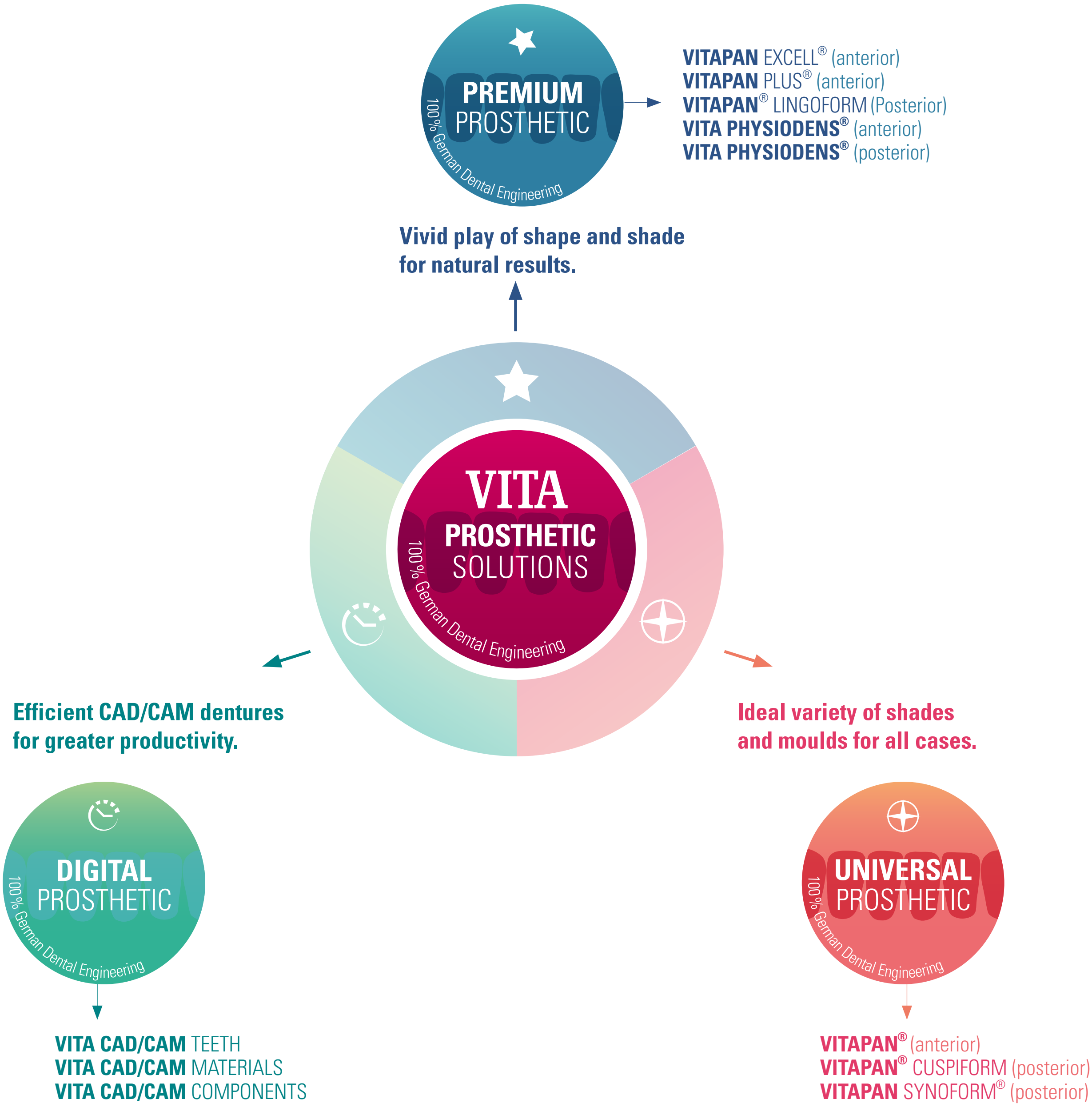

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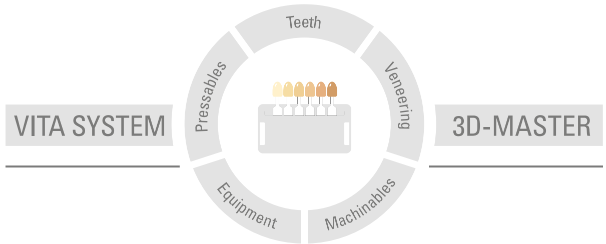

Please note: Our products must be used in accordance with the instructions for use. We accept no liability for any damage resulting from incorrect handling or usage. The user is furthermore obliged to check the product before use with regard to its suitability for the intended area of applications. We cannot accept any liability if the product is used in conjunction with materials and equipment from other manufacturers that are not compatible or not authorized for use with our product and this results in damage. The VITA Modulbox is not necessarily a component of the product. Date of issue of this information: 2023-02

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VITA Zahnfabrik has been certified and the following products bear the mark CE 0124:

VITAPAN® product range, **VITA PHYSIODENS®**, **VITA VIONIC®** FRAME dental solutions

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