

## Clinical and scientific differences

# 1-piece and 2-piece ceramic dental implants

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Ceramic dental implants have long ceased to be hype, on the contrary, they can offer a significant addition to the daily dental implant practice. Not only their favourable aesthetics play a significant role, but also their ability to work completely metal-free is of added value, surely for patients with a proven allergy for grade 5 titanium, containing the hyperreactive components vanadium and aluminium.

The fact that furthermore peri-implantitis seems to appear only incidentally, is an important supporting argument for their use as well.

Whereas the original design of zirconia implants was formerly always of a 1-piece/1-

phase structure (monobloc design), nowadays also 2-piece/2-phase designs (hybrid concept) are widely utilised to restore missing teeth.

This article will compare the advantages and disadvantages of 1-piece versus 2-piece ceramic implants based on clinical, scientific, and patient related criteria.

Finally, some general recommendations towards the use of ceramic dental implants in daily practice will be formulated.

## Introduction

Ceramic dental implants are a relatively new type of dental implants made from the ceramic material zirconia (zirconium dioxide— $ZrO_2$ ).<sup>1</sup> In the past, ceramic implants were predominantly made of aluminium oxide ( $Al_2O_3$ ), which was a far too brittle material for oral rehabilitation, which led to multiple implant fractures, causing a widespread rejection in their application, leading to a global stigmatisation of ceramic dental implants.<sup>2</sup>

Recently, ceramic dental implants are becoming increasingly popular again due to their aesthetic appeal and biocompat-

ibility.<sup>3,4</sup> Unlike traditional titanium implants, ceramic implants have a whitish colour, making them virtually indistinguishable from natural teeth, especially when the patient presents with a thin gingival biotype.<sup>5</sup> In such cases, the hint of grey titanium in combination with a high smile line, is an aesthetic letdown.

Additionally, ceramic implants are hypoallergenic, making them a suitable option for patients with metal allergies.<sup>6</sup> Actually titanium allergy can be detected in dental implant patients, even though its estimated prevalence is quite low (0.6%). A higher risk of positive allergic reaction was found in patients showing post-op allergy compatible responses (allergic symptoms) after implant placement or unexplained implant failures.<sup>7</sup>

These implants also have a lower thermal conductivity compared to metal implants, which can reduce sensitivity and discomfort in the mouth often experienced as unpleasant by the patient.<sup>8</sup>

Whereas ceramic implants are still relatively new, research has shown promising results in terms of their long-term success rates and durability.



**Fig. 1:** A 1-piece and a 2-piece ceramic dental implant (Z-Systems: Z5m & Z5-BL).

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The choice between a 1-piece/1-phase implant versus a 2-piece/2-phase implant is a more recent phenomenon. At the early days of ceramic dental implants, all these implants were produced as a monobloc, i.e. an implant with an integrated abutment<sup>9</sup> (Fig. 1).

In the dental implant community, there is still a lot of discussion on the place of ceramic dental implants in the rehabilitation of (partial) edentulous patients. A majority still considers zirconia implants as a transient phenomenon, whereas others consider it as the ultimate breakthrough in implant dentistry.<sup>10</sup> Scientific research has however shown that ceramic implants can be a valuable alternative to titanium implants.

On 1-piece/1-phase implants, there are more studies published since they are already much longer on the market. Already in the seventies, Sammy Sandhaus and Thomas Driskell were publishing groundbreaking work. Both proved separately the great opportunities of working with ceramic 1-piece implants.<sup>11,12</sup>

Only more recently 2-piece/2-phase ceramic implants entered the dental implant market (Table 1).

Due to their later release on the market, these 2-piece/2-phase implants have less scientific data available, and the existing data span up to ten years.<sup>13,14</sup> Although the medium-term results are excellent after 5 to 6 years, the German Association of Oral Implantology (DGI), made a warning in their recent S3 guideline.<sup>15,16</sup> Thiem and co-workers confirm the feasible use of one-piece zirconia implants as an addendum/alternative to titanium implants. However, no conclusion regarding the application of two-piece ceramic implant systems can be drawn based on the existing data. So, they suggest recommending these implants only after the patient has been informed in detail about the lack of long-term clinical data.

### Criteria

Based on eight different criteria, the differences and advantages/disadvantages

between 1-piece and 2-piece ceramic dental implants will be discussed.

### 1. Design

With a 1-piece implant, the implant and the abutment are fused to one simple monobloc. Therefore, there can't be any bacterial leakage between the implant and the abutment because there is no joint as with the 2-piece implants, where there is always a gap detected between the implant and the abutment.<sup>17</sup> This means furthermore that the temporary or final crown finally must be cemented on top of the implant. There is a wide range of these implants commercially available (Table 2).

The more complex 2-piece implants consist of two or three parts: the implant body itself, the abutment, and the abutment retention screw. In case of a cementable abutment, there is of course no abutment screw. The retention screw can be fabricated out of titanium, gold, carbon, or zirconia (Fig. 2).

It's important to follow the manufacturer instructions for applying to correct torque on these screws: titanium screw is 25 Ncm; carbon screw is 25 Ncm; zirconia screw is 12 Ncm; gold screw is 15 Ncm! Currently, there is only a limited number of 2-piece implants on the dental market (Table 2).

### 2. Surgery

The first stage surgical procedure for both implant types is identical, although for 1-piece implants a flapless approach can be appropriate. The flapless technique for 1-piece implants shows however statistically significantly more bone loss which might be indicative for future problems.<sup>18</sup>

Only in a 2-stage approach for 2-piece implants, a second surgery is necessary, connecting the healing abutment to the implant. Healing abutments are mostly made from PEEK or PEKK.

Because it is not always allowed to prep 1-piece zirconia implants (always carefully look at the manufacturer recommendations!), their immediate correct surgical positioning is of utmost importance.<sup>19</sup>

BRAND	PRODUCT	CEMENTED ABUTMENT	SCREWED ABUTMENT	SCREW MATERIAL
Z-Systems	Z5-BL/Z5-TL	no	yes	ceramic or titanium
Zeramex	XT/P6	no	yes	carbon
Nobel Biocare	NobelPearl	no	yes	carbon
Straumann	Pure	no	yes	titanium
Zircon Medical	Patent	yes	no	–
WITAR	AWI	no	yes	direct*
Neodent	Zi	no	yes	titanium
Camlog	Ceralog	no	yes	titanium or gold
SDS	Bright/Value	yes	yes	peek
TAV	W	no	yes	titanium

\*Ceramic abutment directly screwed into the implant (no additional screw).

**Table 1:** Detailed overview of the 2-piece/2-phase ceramic implants and their components.

Therefore, it can be advantageous to initially use guided surgery for these procedures, helping to avoid incorrect inclination of the abutment component of the implant.<sup>20</sup> For 2-piece implants this problem is less significant, since most commercial brands offer angulated or preparable abutments in their portfolio.

Whether 1-piece or 2-piece implants are installed, always low drilling speeds should be applied, surely when ceramic implant drills are applied. Drills made of ceramics don't conduct the warmth, leading to overheating of the bone in the osteotomy.<sup>21</sup> The latter doesn't lead to implant failure but induces significant crestal bone loss during healing and a final lower percentage of bone-to-implant contact.<sup>22</sup> These drilling speeds start around 800rpm for the first drills, reducing to 400rpm for the last drills. The advised tapping for D1-D2 (and D3) bone should be performed at 15rpm.<sup>23</sup>



**Fig. 2:** Different abutment retention screws: titanium (Neodent)—carbon (Zeramex)—zirconia (Z-Systems)—gold (Camlog).

It is of utmost importance to check the individual recommendations of the manufacturer before using the respective drill sequences.

### 3. Loading

Since for ceramic implants almost always bone tapping is utilised, the primary stability of these implants is often insufficient for direct loading.<sup>24</sup> Therefore, delayed, or late loading are mostly recommended for 2-piece implants. Moreover, in the aesthetical front area, a 2-phase technique can help to improve the gingival aesthetic outcome as shown by Suchetha and co-workers.<sup>25</sup>

1-piece implants are due to their design anyway directly loaded. To reduce these immediate loading forces, most brands offer silicone or PEEK protection caps to place over the abutment after installing the implant. These shock absorbers also protect for gingival overgrowth during the required healing time (Fig. 3).

### 4. Prosthetics

The prosthetic procedure of a 1-piece implant is almost completely identical to the prosthetic process for natural teeth. Both, analogue and digital impression are possible. Due the high affinity of the soft tissue towards zirconia, often excess gingiva must get reduced by retraction cords or (diode) laser.<sup>26</sup> Implant analogues are not really required in this method.

For 2-piece implants, the procedures are identical as for titanium 2-piece implants:

1-PIECE CERAMIC IMPLANTS	2-PIECE CERAMIC IMPLANTS
Z-Systems: Z5m/Z5m(t)	Z-Systems: Z5-BL/Z5-TL
Straumann: Pure Monotype	Straumann: Pure
Camlog: Ceralog Monobloc	Camlog: Ceralog Hexalobe
Zircon Medical: Patent 1-piece	Zircon Medical: Patent 2-piece
SDS: Bright	SDS: Bright/Value
TAV: W-1	TAV: W-2
Witar: AWI 1-piece	Witar: AWI 2-piece
ZiBone	ZiBone
Medical Instinct: Bone Trust	Neodent: Zi
Fair Implant: Fair White	Zeramex: XT/P6
Ceraroot	Nobel Biocare: NobelPearl
Tree Oss Ceramic	SIC: SIC White
Bredent: WhiteSky	

**Table 2:** Overview of 1-piece and 2-piece ceramic dental implants.



**Fig. 3:** PEEK protection caps for 1-piece implant (Z-Systems, Z5m).

analogue or digital impression, open or closed tray. Different brand-related scan bodies are available and here an implant analogue is always needed for the further laboratory handling. It is still of the highest importance to use the original components, delivered by the respective manufacturers, since printing of these individual components does not offer the same accuracy yet.<sup>27</sup>

## 5. Sizes

The offer in diameters and lengths is rather limited for 1-piece as for 2-piece ceramic implants. Table 3 shows the ranges in diameters and lengths of the actual most common used ceramic dental implants.

The available diameter ranges from 3.3 (Straumann) to 7 mm (SDS). The lengths range from 6 (SDS) to 16 mm (bredent). The average diameter is 4.2 mm and the average length is 10.8 mm. With these sizes almost all indications are properly covered.

Considering design there are parallel and tapered implants available. Most of the implants are not self-tapping. Therefore, almost in all situations, bone tapping is advised before implant installation.

For the 2-piece implants there is large variety of internal connections. Not every connection offers the same stability (Fig. 4).

## 6. Costs

The use of 1-piece implants is relatively less expensive since there is only need for a full ceramic crown that can be cemented on top of the implant–abutment complex. For 2-piece implants, there is always the need for extra components: ceramic abutments and abutment retention screws. These extra components mean not only an extra cost in their purchase from the manufacturer, but also an extra cost in the laboratory handling, making the final cost of a 2-piece ceramic implant substantially higher.

## 7. Complications

The main complication for oral implants is the absence of lack of osseointegration. With the actual ceramic materials, the success rates of zirconia implants are comparable with those of titanium implants. After all, zirconia and titanium implants show a similar soft and hard tissue integration capability. Titanium however, tended to demonstrate an accelerated initial osseointegration compared to zirco-

nia. It is meanwhile also clear that zirconia implants against that do not show better clinical results as titanium implants.<sup>28,29</sup> So both systems seem to have comparable clinical outcomes.

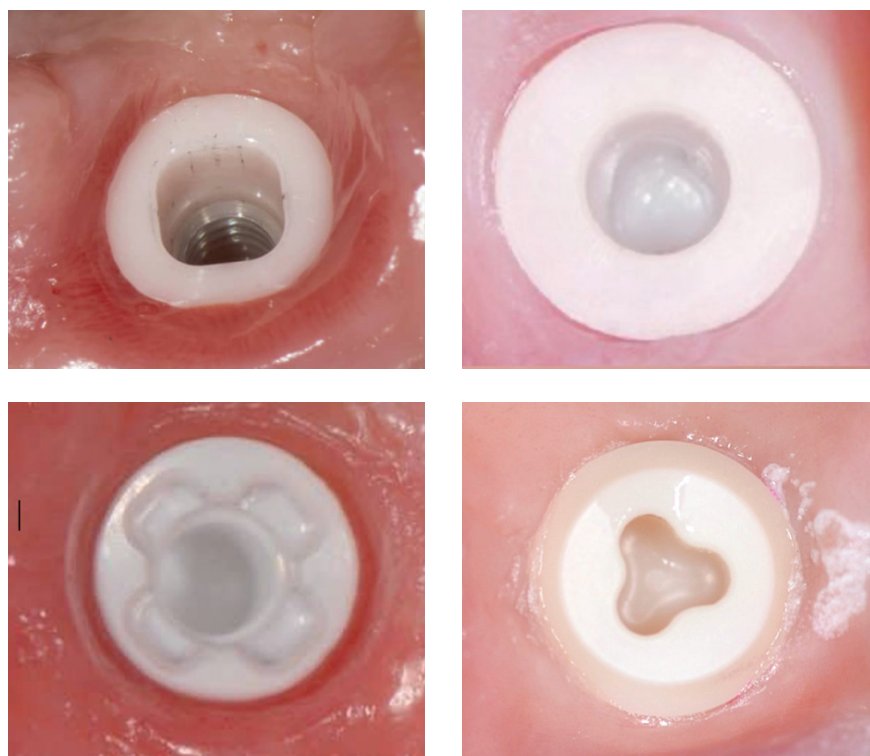
With 1-piece implants, the cementation of the crown can cause cement rests that can remain present subgingival. These toxic cement rests can easily induce peri-implantitis.<sup>30</sup> Therefore, the meticulous removing of all excess cement after cementation of the crown, is of utmost importance.<sup>31</sup>

As mentioned before, the wrong positioning (i.e. inclination) of a 1-piece implant that may not be grinded post-operative, is a major problem. Here the only solution is explantation.

2-Piece ceramic implants can offer different complications. Abutment screw loosening and abutment screw fracture are the main problems.<sup>32</sup>

Therefore, it is essential to apply the exact prescribed torque value when installing the abutment or the crown. The more components used, the higher the risk for complications.

As far as actual scientific literature concerns, there seems to be less peri-implantitis



**Fig. 4:** Different internal connections of different ceramic implant brands (clockwise): Pure (Straumann)—Z5c (Z-Systems)—Patent (Zircon Medical)—Zeramex (DentalPoint).

around ceramic implants in comparison with titanium ones.<sup>33,34</sup> A peer explanation on this phenomenon is still waiting for now.

## 8. Patients perspective

Probably this is an underestimated and neglected factor in daily clinical decision making. Patients prefer minimal invasive therapy, minimal morbidity, minimal number of appointments and minimal costs. When comparing 1-piece and 2-piece implants, it is obvious that patients will

prefer their therapy with 1-piece implants, because this concept offers the most advantages for them.

Moreover, the recent S3 guideline on ceramic implants by the German Association of Oral Implantology, advises all practitioners to warn their patients that there is still insufficient scientific data to support the unlimited use of 2-piece ceramic dental implants.<sup>16</sup> The latter should therefore in fact always be consented before applying 2-piece implants in practice.

## Conclusions

In implant dentistry, it can be stated that 1-piece implants offer meanwhile the same prognosis as 2-piece implants. Moreover, recent studies indicate clearly that 1-piece as well as 2-piece ceramic implants show excellent clinical results. However, 2-piece ceramic dental implants don't offer sufficient long-term scientific substantiation yet to support their overall use in daily practice. Therefore, always an extended informed consent should be offered to patients receiving a therapy with 2-piece zirconia implants.

The use of 2-piece zirconia implants will increase since they offer much more versatility than 1-piece implants. This higher versatility will unfortunately result in a raise of the costs for the practitioners and consequently for the patients.

Future randomised controlled trials will have to confirm the promising results of 2-piece zirconia implants.

BRAND	RANGE OF DIAMETERS	RANGE OF LENGTHS
Z-Systems	3.6–5 mm	8–12 mm
Zeramex	3.5–5.5 mm	8–14 mm
Straumann	3.3–4.8 mm	8–14 mm
Nobel Biocare	3.5–5.5 mm	8–14 mm
Camlog	4 mm	8–12 mm
Zircon Medical	4.1–5 mm	7–13 mm
SDS	3.2–7 mm	6–14 mm
TAV	3.6–4.8 mm	8–14 mm
bredent	3.5–4.5 mm	8–16 mm
ZiBone	3.6–5 mm	8–14.5 mm
Tree Oss	3.7–4.3 mm	10–13 mm
Ceraroot	3.5–6.5 mm	8–14 mm
Neodent	3.75–4.3 mm	10–13 mm
WITAR	3.9–6 mm	8–14 mm
Fair Implant	3.5–5 mm	8–13 mm
Medical Instinct	4–5 mm	10–13 mm
SIC	3.5–5.5 mm	8–14 mm

**Table 3:** Range in diameters and lengths of different commercially available ceramic dental implant systems.

Literature



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