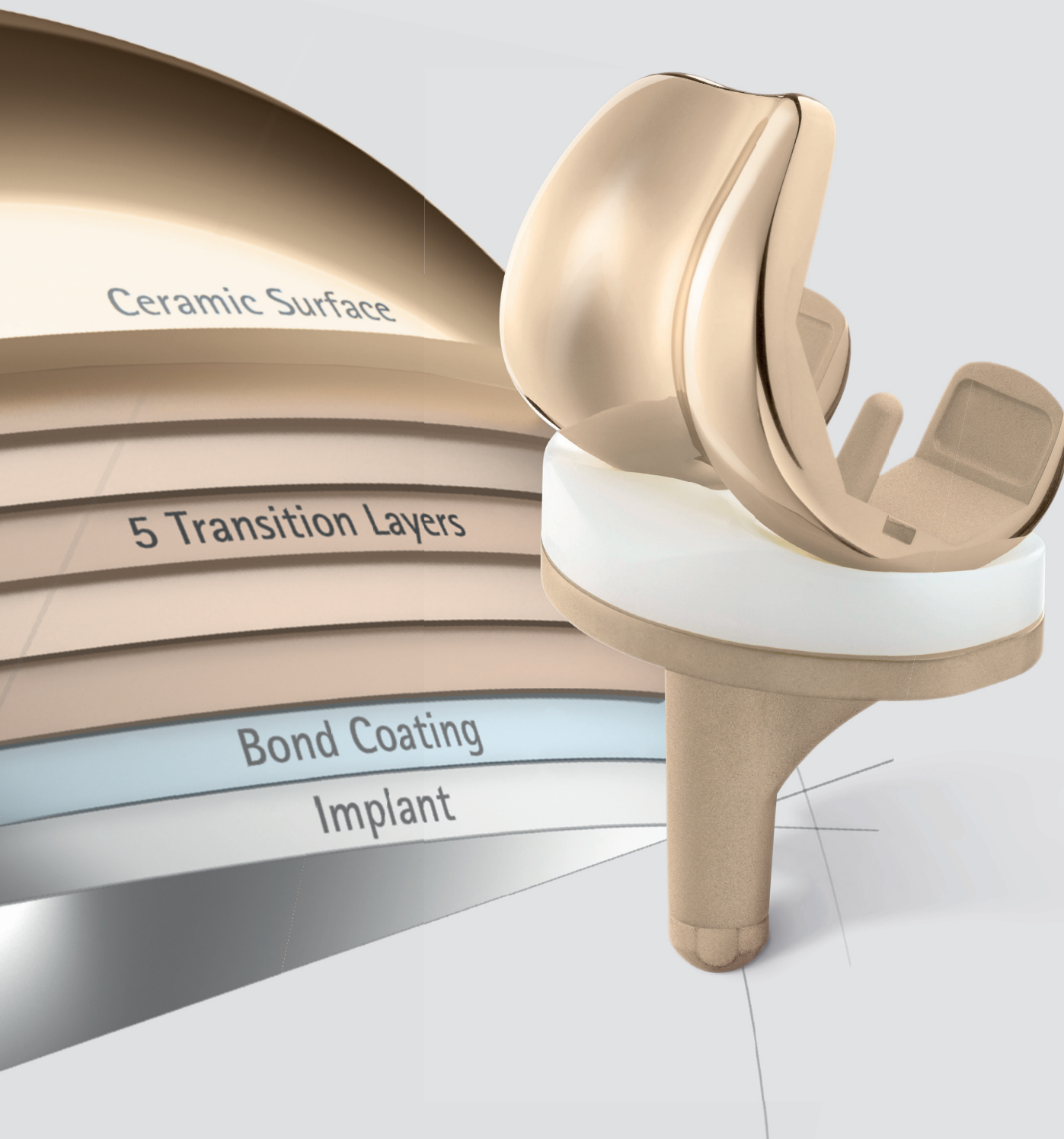


# AESCULAP® AS Advanced Surface

7 layers for protection



# AESCULAP® AS Advanced Surface Technology

Your chance for better results in Knee Arthroplasty

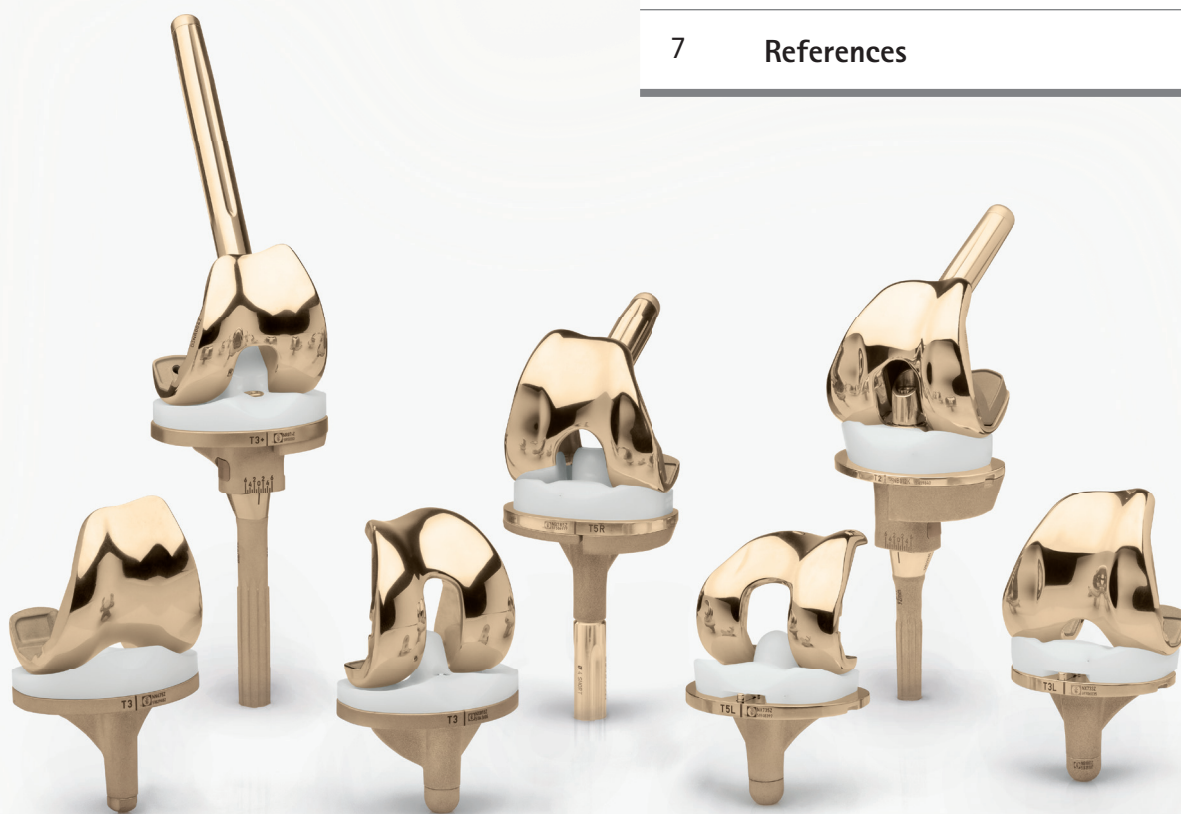
## AS Advanced Surface Technology

The 7-layer coating offers enhanced protection against wear of the implant components and reduces the metal ion release in the body.

With improved mechanical properties and convincing results in biocompatibility it is a perfect solution to prevent complications in primary and additional risks in revision surgery.

## Contents

1	Challenges in TKA	3
2	AS Advanced Surface Technology	4
3	Wear solution	6
4	Enhanced biocompatibility	8
5	Multilayer vs. Monolayer coating	12
6	AS implant portfolio	14
7	References	16



AESCULAP® AS Family

# Challenges in Total Knee Arthroplasty

10% of patients are unsatisfied after Total Knee Arthroplasty Surgery (1).

## Implant failures

Aseptic loosening, infection and wear of the polyethylene are the main prosthesis-related reasons for implant failure (2). One of the main goals for the further development of implant materials and designs in Total Knee Arthroplasty is to reduce polyethylene wear. Improvements in surgical technique and implants lead to less problems after TKA and fewer revisions (2).

Aseptic loosening

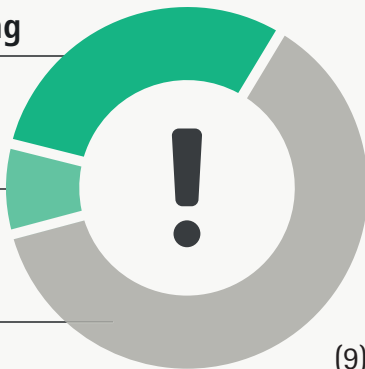
29.8%

Wear

8.2%

Other problems

62%



(9)



## Metal hypersensitivity

It has been discovered that a possible contact allergy to implant materials may lead to implant intolerance. Endoprostheses are known to release metal ions into the human body. This can lead to immune reactions in patients who are at risk of hypersensitivity. The metal hypersensitivity prevalence among the general population is relatively high at 13% (3). 60% of patients with complications after metal implants are sensitive to metals (4). Reduction of the metal ion release is therefore another main goal in the further TKA development.



60% of patients with poorly functioning total joint are **sensitive to metal ions** on the skin (4).

# AESCULAP® AS Advanced Surface Technology

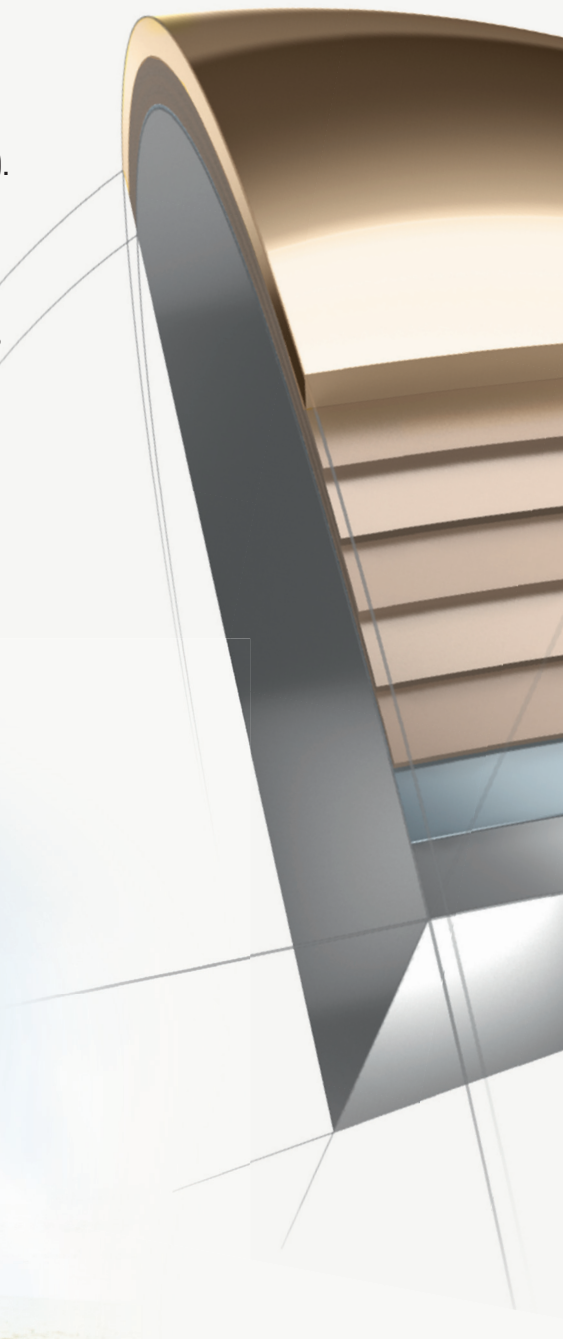
Our answer to the top prostheses-related reasons for implant failure

## Designed for performance

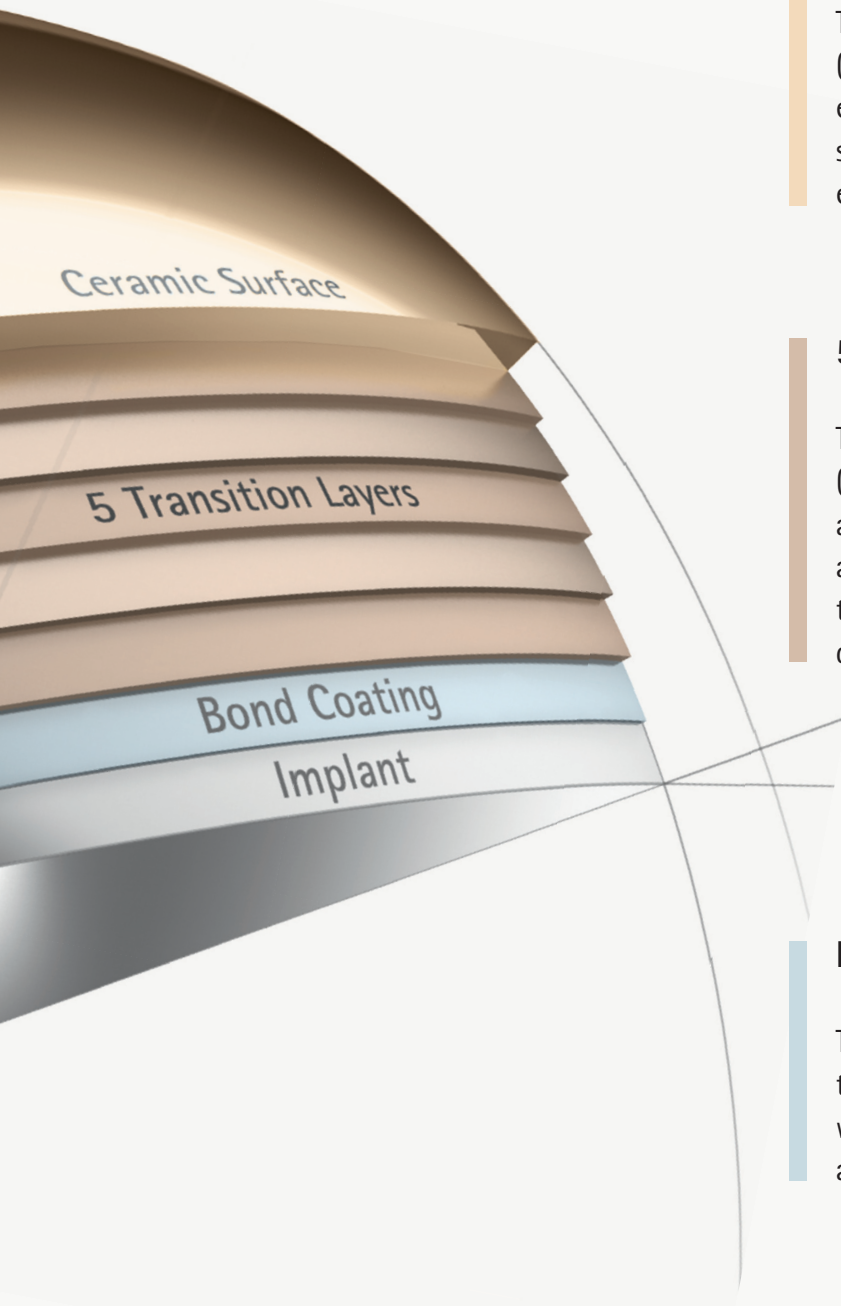
The Advanced Surface multilayer structure provides the coating with high elasticity. The 5 transition layers - with Chrome Nitride and Chrome Carbon Nitride alternating - improve the molecular structure of the coating and therefore prevent an eggshell effect of the top layer Zirconium Nitride coating. Titanium Nitride monolayer coatings show defects such as pinholes, small titanium droplets and blisters with delaminated coating (5). Besides multidirectional slight scratching also grey discoloration could be detected in studies (6).

The Zirconium Nitride top layer is applied with latest generation technologies showing a polycrystalline cubic formation with a fine and very dense structure. It has a high capacity to withstand high stresses, strains and corrosive environment (7, 8). Ideal for articulating structures like knee joints.

The specific architecture of the multilayer coating system evidences a very good bonding durability. Test results show a reduction of wear of approximately 60% compared to the uncoated implants. Also Ion concentrations were lower than those measured in reference tests on uncoated components (7).



## 7 layers for protection



### Ceramic Surface

The top layer is made from Zirconium Nitride (ZrN), a hard ceramic material. It offers exceptionally high wear resistance. A hard surface increases scratch resistance (7) and ensures lower polyethylene wear.

### 5 transition layers

The five transition layers Chrome Nitride (CrN) and Chrome Carbon Nitride (CrCN) alternately provide stability and create a barrier effect. These layers prevent the release of metal ions and bridge the difference in hardness.

### Bond coating

The bonding layer between CoCrMo and the transition coating forms an alloy compound with the base material promoting superior adhesion.

# Wear solution

Essential for longevity: reduction of wear

The wear of the polyethylene is directly linked to aseptic loosening due to osteolysis triggered by polyethylene wear particles. Aseptic loosening is the most common reason for revisions in TKA (9, 10). The interaction of components is therefore very important for the results of a knee surgery and the patient's well being.

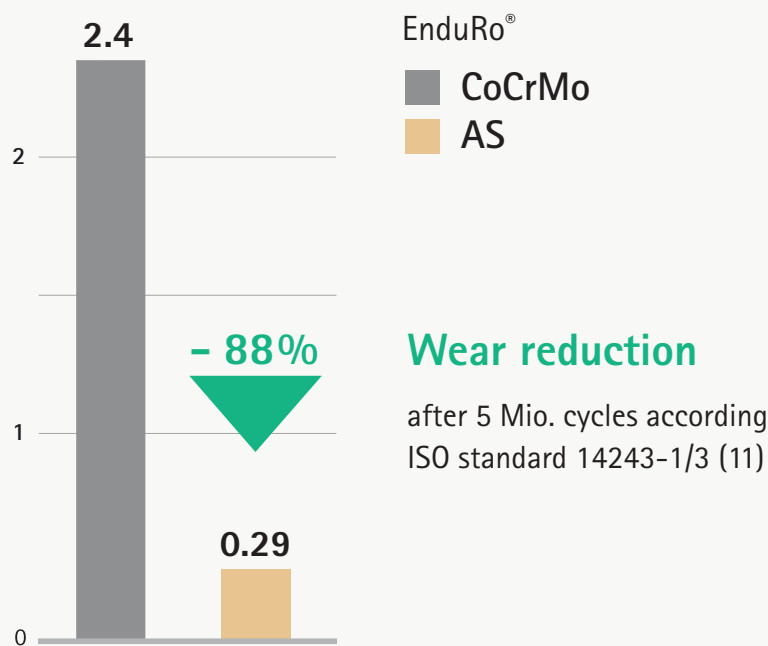
## Excellent wear rates

The Zirconium Nitride top coat yields superior surface hardness that is unmatched in the market place. The wear rate in an EnduRo knee is reduced by up to 88% compared to uncoated implants. This ceramic surface layer stands for improved scratch resistance, good wettability and for better articulation between bearing surfaces.

↓ 88%

AS knee implants demonstrate up to 88% reduction in wear compared to CoCrMo prosthesis (11).

Wear rate (mg/Mc)



AESCULAP®  
AS EnduRo

# Wear under highly demanding activity testing – HDA

Because of the high importance of wear, we developed additional test methods that exceed the common ISO test procedure. One of them is the so called HDA testing. With parameters for high demanding activities we want to continuously analyse and improve the realistic wear behavior of our knee implant components. Basis of the HDA testings are the monitoring of the implant during activities like stair climbing, squat performing or

level walking from a profile that represents a patient with a weight of 100 kg.

The same 5 million cycles represent a clinical usage between 15 to 30 years in vivo. In comparison, the ISO standard tests represent an in vivo usage of 3 years with only level walking from a 75 kg patient. With the HDA testing method wear and delamination can be shown in the PE like in a in vivo retrieval of a conventional PE (20).

## Wear simulation – HDA



100 kg patient  
5 million cycles  
which represents  
**15 to 30 years of  
clinical usage**



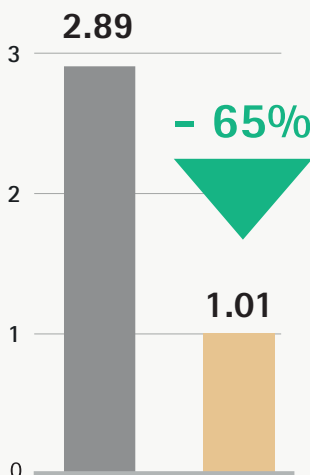
## Wear simulation – ISO



75 kg patient  
5 million cycles  
which represents  
**3 years of clinical  
usage**



## Wear rate (mg/Mc)



Columbus® DD  
■ CoCrMo  
■ AS

## Wear reduction

after 5 Mio. cycles  
according HDA testing

# ↓ 65%

In our HDA test setting the standard version of Columbus® shows low wear results with 2.89 milligrams per Million cycles. For the version with 7-layer AS coating a reduction of 65% compared to the cobalt chromium implant could be reached (21). Convincing results for our coated implants.

# Enhanced biocompatibility

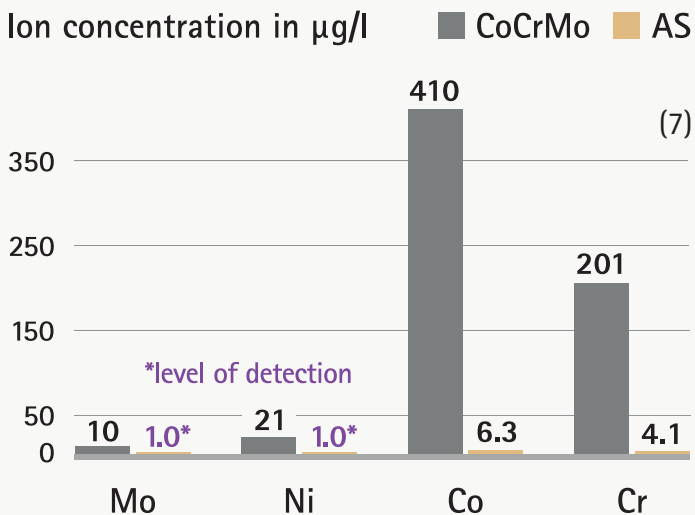
Take care in advance

All metals corrode inside the body. When metals such as Nickel (Ni), Cobalt (Co) and Chromium (Cr) - that are used in Orthopaedic implants - corrode, they release metal ions that can trigger a cascade of adverse reactions in certain patients.

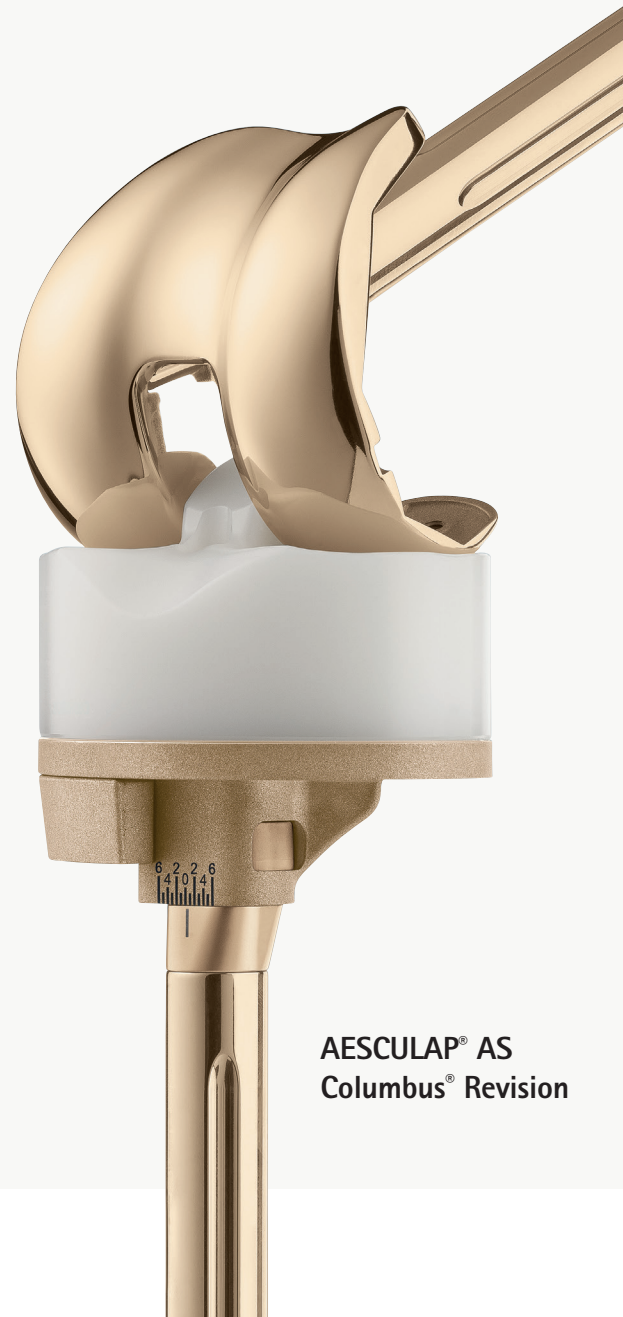
AESCULAP® Advanced Surface Technology is designed to provide a strong barrier to the potential release of metal ions, such as Nickel, Cobalt and Chromium, with exceptional resistance to wear.

## ↓ Less metal ion release

With AS Technology, metal ion concentration is near the level of detection and below biological threshold (7). The material with excellent biocompatibility seals the metallic components, providing an effective metal ion barrier.



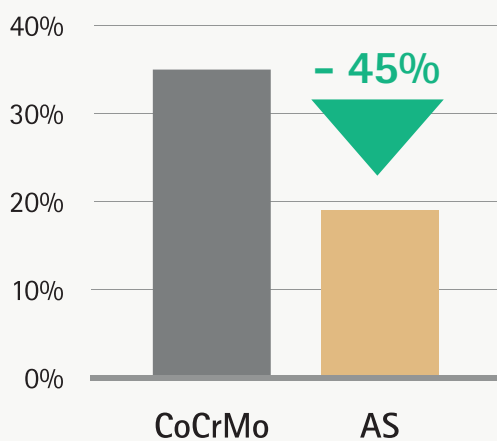
The results confirm that even under extreme wear stress, Advanced Surface Technology constitutes an effective barrier against the potential diffusion of metal ions from the base material. TKA patients revised after hypersensitivity to metal ions improved significantly with AS coated implants.



AESCULAP® AS  
Columbus® Revision



Quantification of covered area (%)

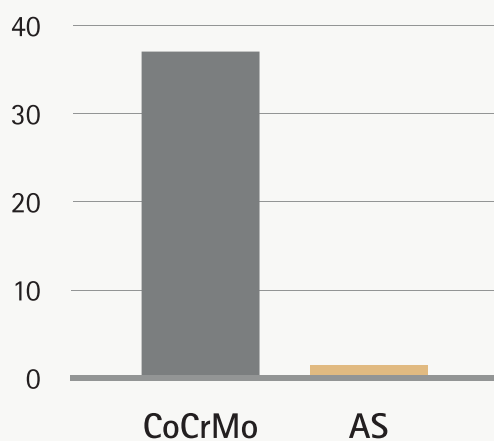


↓ 45%

## Lower biofilm formation

One of the most commonly identified pathogens responsible for orthopaedic implant infection is *Staphylococcus epidermidis*, which can form biofilms on surfaces and lead to medical problems. The AS surface with Zirconium Nitride top coat showed 45% lower biofilm formation compared with standard uncoated CoCrMo implants (13).

Interleukin level IL-8 (pg/ml)



↓ Less triggering of immune system

Interleukins (IL-x) are endogenous messenger substances of the cells of the immune system. Elevated levels of interleukin in the blood indicate the presence of an inflammatory reaction. Using implants with Advanced Surface Technology means no additional pro-inflammatory triggering (14).

# Enhanced biocompatibility

Take care in advance



**The clinical performance is very important** – not only for the surgeon who aims for a good result after surgery, but also for the patient who needs the confidence to make the right choice for his/her health.

There are many different studies and papers to prove the effectiveness and advantages of AS Advanced Surface Technology.

[Link to the literature database](#)

## Ceramic coating resolves symptoms after revision

Another study could show the effectiveness of the AS Technology. Metal and cement allergy affects a small subset of patients, causing severe pain and often systemic reaction after TKA. In this study 28 patients with the history of clinically documented severe metal allergy, severe pain, swelling, and effusion after primary TKA were treated differently: 17 received a ceramic coated revision implant – seven of them with Advanced Surface coating –, 4 received a standard chrome implant and 7 remained untreated. Symptoms resolved in the 17 patients revised with ceramic-coated components (15).



“As it happens, I was a candidate for a knee replacement, and I chose Advanced Surface Technology, which I use on every single patient. Why should I use a lesser item for my patients?”

**Ronald Gene Hood, MD**

St. Francis Health System, Muskogee, USA



# Multilayer vs. Monolayer coating

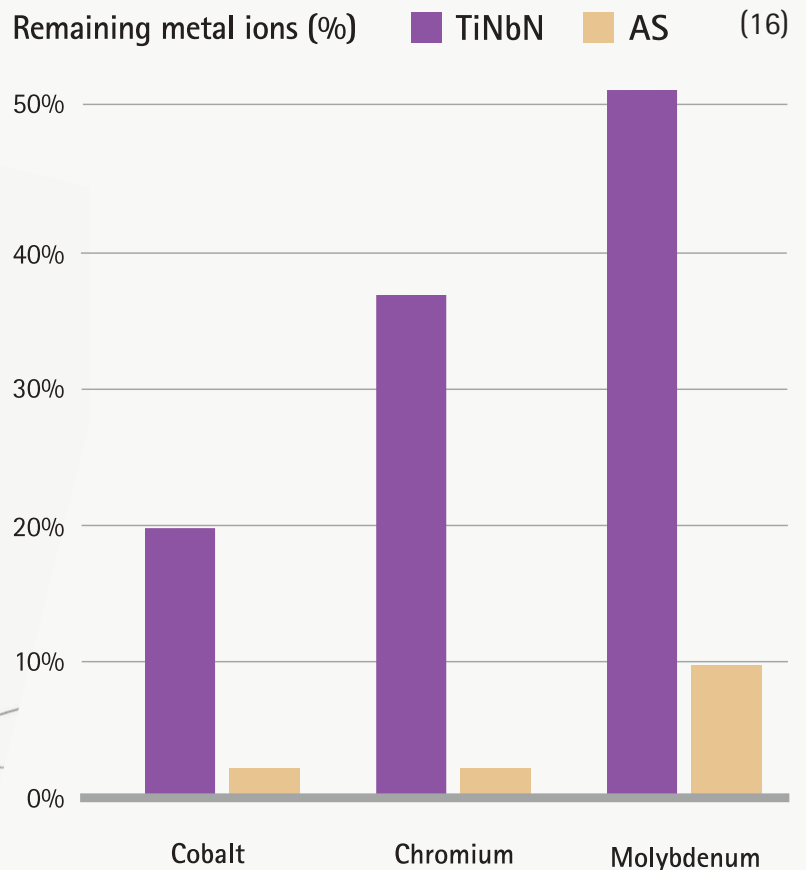
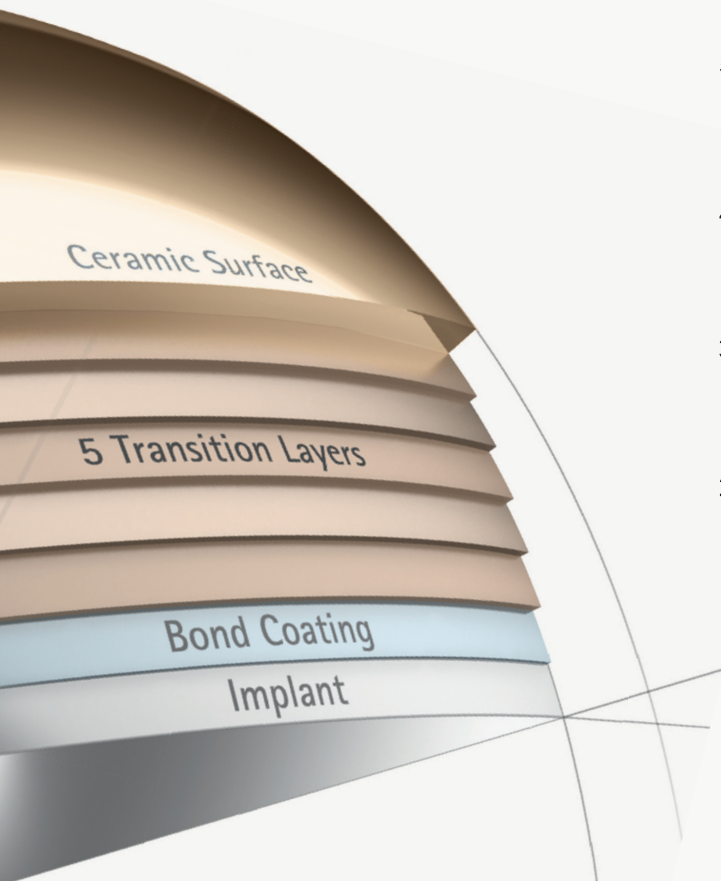
7 layers for protection

## AS coating outperforms Monolayer surfaces

Unlike monolayer coatings, the AS 7-layer coating with Zirconium Nitride surface (ZrN) has a buffer zone which compensates the changes in surface hardness and results in more resilient elastic properties. In addition, the transition layers act as an improved metal ion barrier and offer a more efficient metal ion reduction than monolayer coatings with Titanium Niobium Nitride surface (TiNbN) (7, 16).

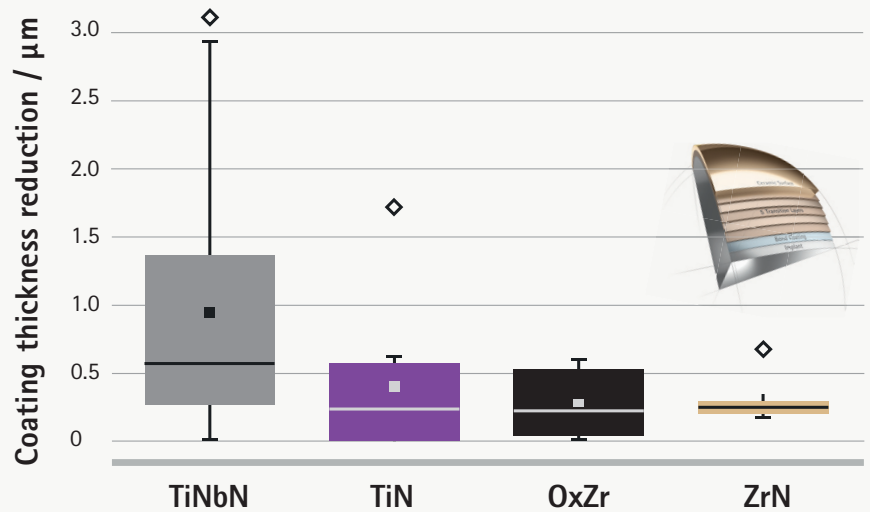


AESCULAP®  
AS VEGA System®



## Reduced coating abrasion

Almost no thickness reduction: AS is best in class! A study with 37 retrievals shows after 4,2 years in-situ: The AS coating is most stable. In comparison with other Monolayer coatings the AS Multilayer coating showed the lowest reduction in coating thickness (18).



## 98% survival rate after 10 years

A randomized-controlled trial was initiated to show safety of a new multilayer hypoallergenic coating system. Serum metal ion levels, patient-reported outcomes and implant survival were evaluated. 120 patients without hypersensitivity to metals were randomized to receive a coated or standard TKA of the same knee system. Excellent implant survival was observed in both groups (19).



AESCULAP®  
AS Columbus®

Get in touch with our experts

[Link to contact form](#)



# Implant portfolio

Complete protection - from primary to revision



The AS coating technology can be applied to all metal implant components. It is important for us to let you decide for your preferred AESCULAP® knee implant system – with the option in AS.

**Find out which knee system is matching your needs.**



## Suitable solutions for different patient needs

The interchangeable and anatomically-designed Columbus® Knee prosthesis offers proper physician choice and patient specificity. Columbus® has comprehensive options to cover all bicondylar indications and intraoperative situations.

[Link to product webpage](#)



## Precise modularity in revision surgery

Today revision surgery represents already around 15 percent of knee replacement surgeries. Due to more and more earlier implantations and more severe bone defects, the numbers continuously rise. Based on the very successful design of the Columbus® knee endoprotheses, the development of the Columbus® Revision System was just a logic consequence.

[Link to product webpage](#)



### Posterior stabilized system for natural rotation

The posterior stabilized VEGA System® was developed to fulfill the modern requirements of patients and surgeons with a modern knee implant system. The following objectives were considered in its design: Natural kinematics through a rollback and a pivotal motion around the medial condyle.

[Link to product webpage](#)



### Mobile platform system offering advantages in wear and kinematics

The e.motion® knee endoprosthesis system offers the surgeon a number of implant options depending on the soft-tissue conditions and the extent of the bone defect – a system for many indications. This modularity is achieved through compatibility among the e.motion® products. The mobile platform offers high congruency with all its advantages for wear and kinematics.

[Link to product webpage](#)



### Safety for stable conditions in hinged implant revisions

Revision operations will continue to play a significant role in the future. The particular challenges of hinged implant revisions require an implant that performs the functions of the collateral ligamentous apparatus without restricting essential joint functions such as flexion and rotation. The design of the implant optimises the bone loss.

[Link to product webpage](#)

# References

- (1) DeFrance, M. J., & Scuderi, G. R. (2023). Are 20% of patients actually dissatisfied following total knee arthroplasty? A systematic review of the literature. *The Journal of Arthroplasty*, 38(3), 594-599.
- (2) Dalury DF, Pomeroy DL, Gorab RS, Adams MJ. Why are total knee arthroplasties being revised? *J Arthroplasty*. 2013 Sep;28(8 Suppl):120-1. doi: 10.1016/j.arth.2013.04.051. Epub 2013 Jul 23. PMID: 23886410.
- (3) Schäfer T, Böhler E, Ruhdorfer S, Weigl L, Wessner D, Filipiak B, Wichmann HE, Ring J. Epidemiology of contact allergy in adults. *Allergy*. 2001 Dec;56(12):1192-6.
- (4) Hallab N, Merritt K, Jacobs JJ. Metal sensitivity in patients with orthopaedic implants. *J Bone Joint Surg Am*. 2001 Mar;83-A(3):428-36.
- (5) Łapaj, Ł., Wendland, J., Markuszewski, J., Mróz, A., & Wiśniewski, T. (2016). Retrieval analysis of titanium nitride (TiN) coated prosthetic femoral heads articulating with polyethylene. *Journal of the Mechanical Behavior of Biomedical Materials*, 55, 127-139.
- (6) Raimondi MT, Pietrabissa R. The in-vivo wear performance of prosthetic femoral heads with titanium nitride coating. *Biomaterials*. 2000 May;21(9):907-13.
- (7) Reich J, Hovy L, Lindenmaier HL, Zeller R, Schwiesau J, Thomas P, Grupp TM. Präklinische Ergebnisse beschichteter Knieimplantate für Allergiker [Preclinical evaluation of coated knee implants for allergic patients]. *Orthopade*. 2010 May;39(5):495-502.
- (8) Santana AE. Relating hardness-curve shapes with deformation mechanisms in TiAlN thin film indentation. *Materials Science and Engineering A* 406(2005) 11-18.
- (9) Sadoghi P, Liebensteiner M, Agreiter M, Leithner A, Böhler N, Labek G. Revision surgery after total joint arthroplasty: a complication-based analysis using worldwide arthroplasty registers. *J Arthroplasty*. 2013 Sep;28(8):1329-32
- (10) Australian National Joint Replacement Registry 2022.
- (11) Grupp TM, Giurea A, Miehke RK, Hintner M, Gaisser M, Schilling C, Schwiesau J, Kaddick C. Biotribology of a new bearing material combination in a rotating hinge knee articulation. *Acta Biomater*. 2013 Jun;9(6):7054-63.
- (12) Blömer W, Lohrmann E. Verschleißbeständigkeit von UHMWPE-Artikulationen in der Hüftgelenkendoprothetik. In: Weller S, Braun A, Eingartner C, Maurer F, Weise K, Winter E, Volkmann R. *Das BICONCONTACT Hüftendoprothesensystem 1987-2007*. Stuttgart: Georg Thieme Verlag; 2007. p. 94-100.
- (13) Pilz M, Staats K, Tobudic S, Assadian O, Presterl E, Windhager R, Holinka J. Zirconium Nitride Coating Reduced Staphylococcus epidermidis Biofilm Formation on Orthopaedic Implant Surfaces: An In Vitro Study. *Clin Orthop Relat Res*. 2019 Feb;477(2):461-466.
- (14) Thomas P, Hisgen P, Kiefer H, Schmerwitz U, Ottersbach A, Albrecht D, Summer B, Schinkel C. Blood cytokine pattern and clinical outcome in knee arthroplasty patients: comparative analysis 5 years after standard versus "hypoallergenic" surface coated prosthesis implantation. *Acta Orthop*. 2018 Dec;89(6):646-651.
- (15) Whiteside LA. Clinical Results of Revision TKA in Patients With Presumed Metal and Cement Allergy. *J Arthroplasty*. 2022 Jun;37(6S):S250-S257.



- (16) Ragone V, Canciani E, Biffi CA, D'Ambrosi R, Sanvito R, Dellavia C, Galliera E. CoCrMo alloys ions release behavior by TiNbN coating: an in vitro study. *Biomed Microdevices*. 2019 Jul 4;21(3):61.
- (17) Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR). *Hip, Knee & Shoulder Arthroplasty: 2021 Annual Report*, Adelaide; AOA, 2021: 258.
- (18) Therese Bormann, Simeon Kraenzler, Sebastian Jaeger, Daniel Kluess, Wolfram Mittelmeier, Tobias Renkawitz, J. Philippe Kretzer, Stability of ceramic coatings on retrieved knee prostheses, *Journal of the Mechanical Behavior of Biomedical Materials*, Volume 144, 2023, 105997, ISSN 1751-6161.
- (19) Lützner J, Beyer F, Lützner C, Tille E, Postler AE. A Novel Multilayer-Coating for Total Knee Arthroplasty Implants is Safe – 10-Year Results From a Randomized-Controlled Trial. *J Arthroplasty*. 2023 Jan;38(1):90-95.e1. Jun;37(6S):S250-S257.
- (20) Schwiesau, J., Schilling, C., Kaddick, C., Utzschneider, S., Jansson, V., Fritz, B., ... & Grupp, T. M. (2013). Definition and evaluation of testing scenarios for knee wear simulation under conditions of highly demanding daily activities. *Medical engineering & physics*, 35(5), 591-600.
- (21) Puente Reyna AL, Fritz B, Schwiesau J, Schilling C, Summer B, Thomas P, Grupp TM. Metal ion release barrier function and biotribological evaluation of a zirconium nitride multilayer coated knee implant under highly demanding activities wear simulation. *J Biomech*. 2018 Oct 5;79:88-96.

## Proven clinical results

On our clinical evidence website you will find all published studies on our knee systems, including the number of implantations, as well as biomechanical data and global registry results.

[Link to clinical data](#)



# AESCULAP® – a B. Braun brand

Aesculap AG | Am Aesculap-Platz | 78532 Tuttlingen | Germany  
Phone +49 7461 95-0 | Fax +49 7461 95-2600 | [www.bbraun.com](http://www.bbraun.com)

The main product trademark "AESCULAP" and the product trademarks "Columbus", "e.motion", "VEGA System" and "EnduRo" are registered trademarks of Aesculap AG.

Subject to technical changes. All rights reserved. This brochure may only be used for the exclusive purpose of obtaining information about our products. Reproduction in any form partial or otherwise is not permitted.