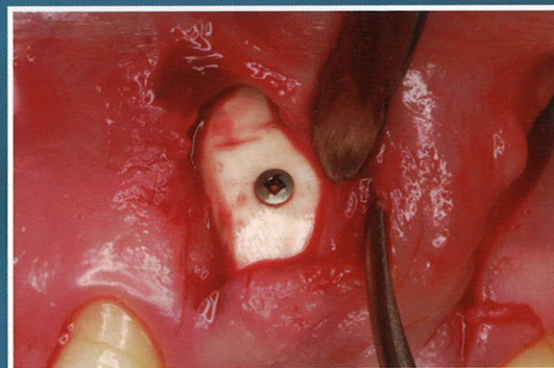
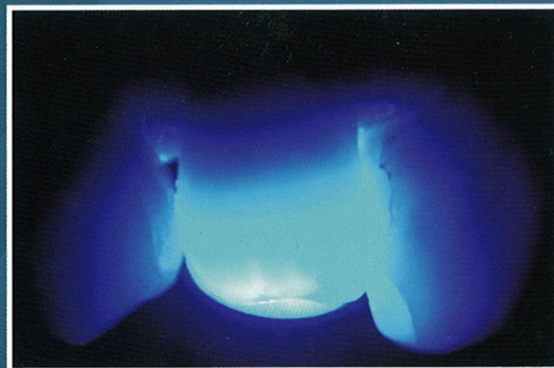


Fundamentals of  
**Esthetic  
Implant  
Dentistry**

**Abd El Salam El Askary**

 **Blackwell  
Munksgaard**





# Contents

List of Contributors, viii

Foreword, ix

Preface, x

Acknowledgments, xii

About the Author, xiv

Chapter 1 Introduction, 3

Chapter 2 Diagnostic Considerations for Esthetic Implant Therapy, 13

Chapter 3 Contemporary Facial Evaluation, 79

Chapter 4 Multidimensional Esthetic Implant Positioning, 109

Chapter 5 Intraoral Plastic Soft Tissue Surgery, 127

Chapter 6 Immediate Esthetic Implant Therapy, 179

Chapter 7 Socket Augmentation: Rationale and Technique, 209

Chapter 8 The Interimplant Papilla, 225

Chapter 9 Tissue Engineering in Maxillofacial Surgery, 255

Chapter 10 Prosthetic Technologies and Techniques Beyond the Mere Fixture, 263

Chapter 11 The Art and Science of Shade Matching in Esthetic Implant Dentistry, 275

Chapter 12 Treatment Complications in the Esthetic Zone, 301

Index, 329

# List of Contributors

## Main author:

Abd El Salam El Askary, B.D.S  
39 Abdelsalam aref. St.  
Elbostan  
Alexandria, Egypt  
E-mail: askary@dataxpres.com.eg  
Phone: +2 012 214 8642  
Fax: +2 03 5850770

## Co-authors:

### Chapter 7

Hom-Lay Wang, D.D.S., M.S.D.  
Professor and Director of Graduate Periodontics  
Department of Periodontics and Oral Medicine  
University of Michigan School of Dentistry  
1011 North University Avenue  
Ann Arbor, Michigan 48109-1078, USA  
Phone: 734-763-3383  
Fax: 734-936-0374  
E-mail: homlay@umich.edu

Rodrigo F. Neiva, D.D.S.  
Clinical Assistant Professor  
Department of Periodontics and Oral Medicine  
University of Michigan School of Dentistry  
Ann Arbor, Michigan 48109-1078, USA

### Chapter 9

Dr. Dritan Turhani  
AKH-General Hospital of Vienna  
Department of Cranio-Maxillofacial and Oral Surgery  
Waehringer Guertel 18-20  
1090 Vienna, Austria  
E-mail: dritan.turhani@gmail.com

Elisabeth Stein, Martina Weinßenböck, and Rolf Ewers  
also contributed

### Chapter 10

Dr. Peter Gehrke  
Bismarck str.27  
67059 Ludwigshafen  
Germany  
Phone: 49 62 21 68124456  
Fax: +49 621 68124469  
Email: Dr-gehrke@dr-dhom.de

### Chapter 11

Stephen J. Chu, DMD, MSD, CDT, MDT  
150 East 58th Street, Suite 3200  
New York, New York 10155  
Phone: 212-752-7937  
Fax: 212-980-9647  
E-mail1: schu@csdny.com  
E-mail2: schudmd@aol.com

## Chapter 10

# Prosthetic Technologies and Techniques Beyond the Mere Fixture

*Peter Gehrke*

An accurate and systematic approach is required to evaluate, diagnose, and resolve esthetic problems predictably. Tooth color is obviously essential for the final result, but esthetic treatment planning should never be focused on shade improvements alone. The ultimate goal is achieving a pleasing smile architecture considering the proper proportion and relation according to established principles (Chiche and Pinault 1994, Magne and Belser 2002, Salama et al. 2002, Garber and Salama 2000).

Predictable osseointegration has taken implant dentistry beyond the mere restoration of function for the compromised edentulous case to esthetic single-tooth implant-supported restorations in the anterior region. Today, implants are a viable treatment option for partial edentulism. Consequently, sacrificing sound tooth structures for fixed bridgework can be prevented, and specific problems related to removable partial dentures can be eliminated.

However, to be the preferred treatment choice, implant-supported restoration should, cosmetically, be equal to or surpass that of conventional fixed prosthesis. This necessitates developing an implant recipient site in both hard and soft tissue for optimal placement of the implant and emergence of the restoration. Implants should not be limited by the osseous topography, which can compromise the final restoration, but implant placement should rather be restoration driven (Garber 1996). In addition, all restorative techniques available and adjunctive periodontal soft tissue procedures need to be applied to compensate for anatomical irregularities at the site and of the adjacent teeth. This allows for an implant restoration that mimics that of a natural tooth.

The increasing predictability and longevity of porcelain laminate veneers offer a beneficial asset to the esthetic modification of implant-adjacent teeth (Garber and Adar 1997, Fradeani et al. 2005). They allow for alteration of shade and tooth shape and convey the illusion of changes in tooth position. Smile design, restoration durability, and color conformity of natural and replaced teeth are prerequisites for a highly esthetic

restoration. Although metal implant abutments have inherent esthetic disadvantages, they are most widely considered to be a standard treatment option for implant-supported restorations. The art of looking natural, however, has been perfected by ceramics. Their application in prosthodontics has opened up a new era in esthetic tooth replacement.

## Zirconium Dioxide

Improved material characteristics, complying with clinicians' and patients' increased demands for highly esthetic results, have contributed significantly to the development of a new generation of implant abutments made from zirconium. These abutments are noted for their tooth-like color, high load strength, tissue tolerability, and intrasulcular design enhancement (Filser et al. 2001, Tinschert et al. 2001, Ichigawa et al. 1992, Yildirim et al. 2000, Yildirim et al. 2003, Sadoun and Perelmuter 1997, Brodbeck 2003). The phenomenon of transformation toughening of zirconium dioxide results in extremely high component strength and extraordinary bending capability and tensile strength, as well as fracture and chemical resistance (Gehrke and Kielhorn 2004, Gehrke et al. 2006). Oxide ceramics are equal to metals from a mechanical standpoint, but they are biologically stronger (Covacci et al. 1999, Ferraris et al. 2000).

Zirconium was introduced to material science in 1975 (Garvie et al. 1975), followed by its medical application in total hip replacements in the mid-1980s (Christel 1989). The use of zirconium dioxide for implant abutments has been introduced recently due to its high fracture resistance shown when comparing zirconium dioxide to aluminum oxide and other dental ceramics (Tinschert et al. 2001, Ichigawa et al. 1992, Yildirim et al. 2000, Yildirim et al. 2003, Gehrke and Kielhorn 2004, Gehrke et al. 2006). So far, only little data are available on the survival rate and average life times of zirconium implant restorations (Döring et al. 2004).



The word "zirconium," as used in our habitual language, represents a simple form of the chemically correct name "zirconium dioxide." The German chemist M.H. Klaproth discovered zirconium dioxide in 1789 by heating zirconium rocks (Hoppe et al. 1987). The name zircon is derived from the Persian word *zargon*, which means "gold color." The main material used for the extraction of zirconium dioxide is the mineral zircon ( $\text{ZrSiO}_4$ ), which is found in volcanic rocks (granites, syenites, and gneisses). The majority of zircon is mined in Australia, the United States, India, and South Africa. Zirconium oxide is gained by melting coke with lime and zircon. A highly purified raw product must be used to develop high-performance ceramics. For this reason, a special synthesis method was developed to obtain highly pure zirconium oxide. (See Figures 10.1A–N.)

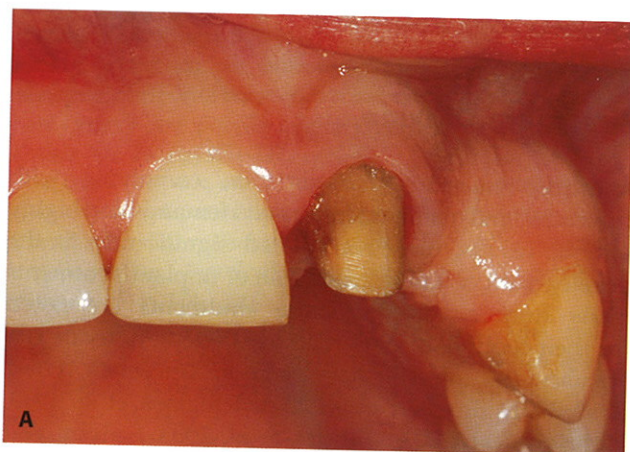


Figure 10.1A. Preoperative labial view after continuous decementation of fixed restoration with distal cantilever.

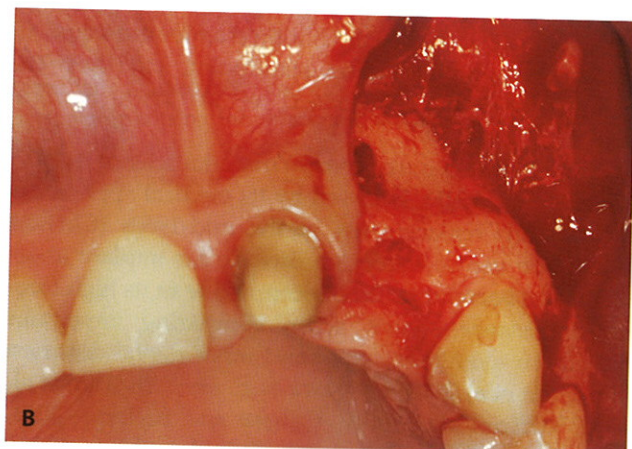


Figure 10.1B. Incision and elevation of mucoperiosteal flap. Note labial bone depression and fenestration. (Surgery: Dr. Orcan Yüksel).

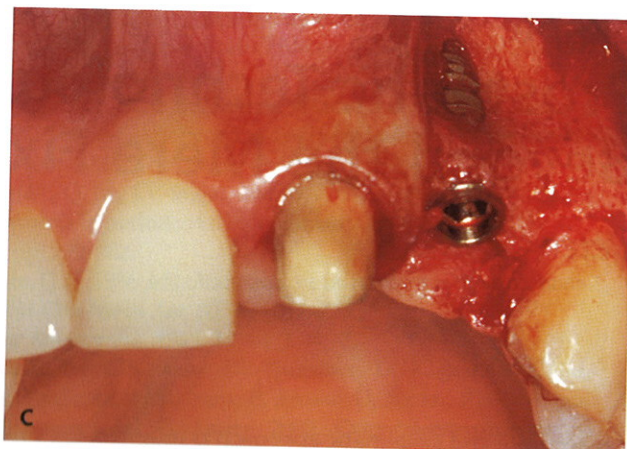


Figure 10.1C. XiVE Implant (DENTSPLY Friadent, Mannheim, Germany), 3.8 mm in diameter and 11 mm in length. Additional augmentation with FRIOS Algipore (Friadent, Mannheim, Germany) and Bio-Gide Membrane (Geistlich Pharma AG, Wolhusen, Switzerland).



Figure 10.1D. Labial view immediately after implant placement, augmentation, and flap closure.

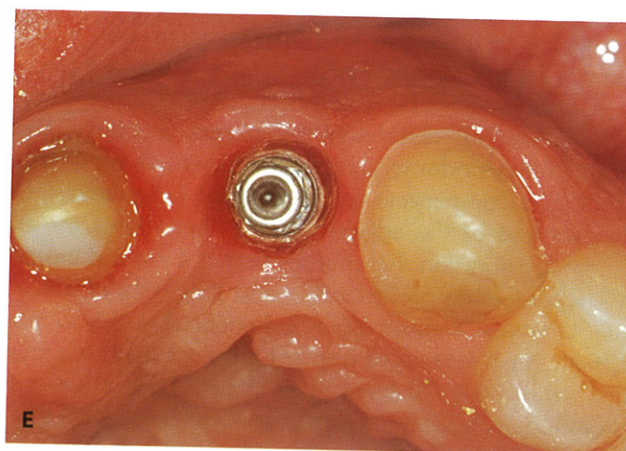
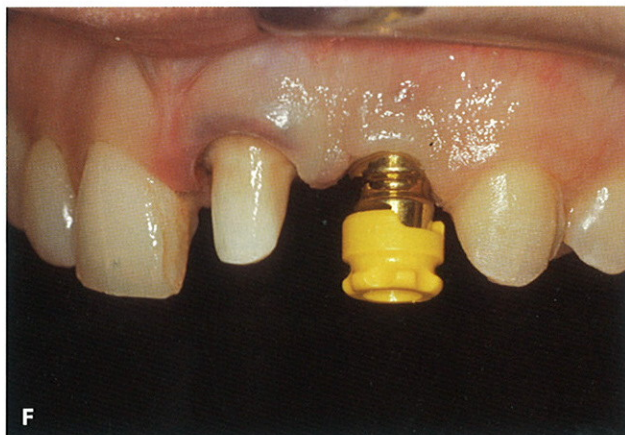


Figure 10.1E. Occlusal view 6 months after implant placement. Preparation of left canine for porcelain laminate veneer.

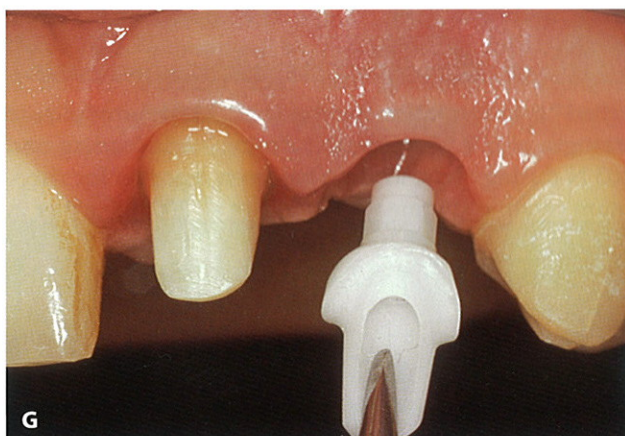




**Figure 10.1F.** Labial view after insertion of implant transfer coping with Transfer Cap and placement of retraction cord around central incisor for impression taking.



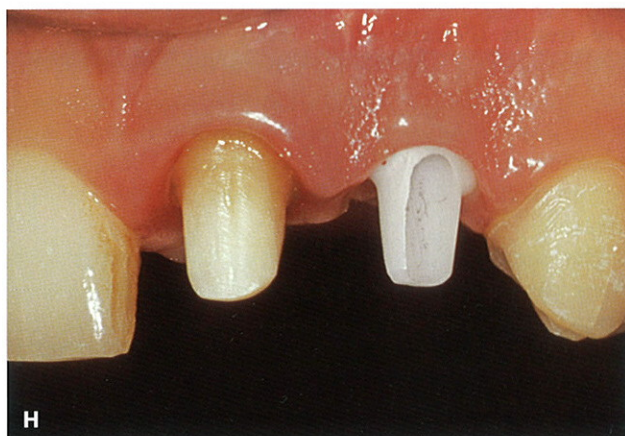
**Figure 10.1I.** Laboratory: Porcelain laminate veneer for canine. Full-ceramic crowns for central incisor and implant abutment.



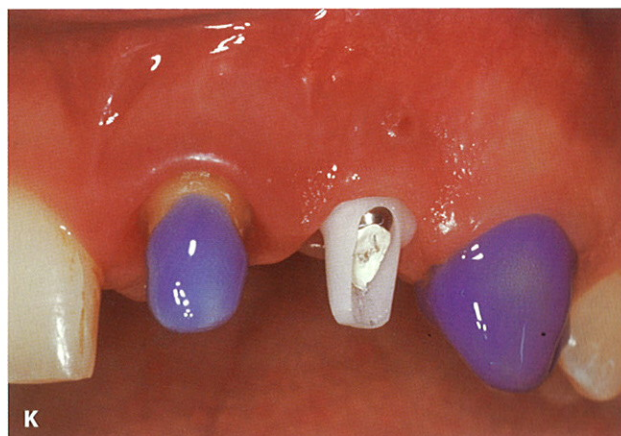
**Figure 10.1G.** Try-in of customized CERCON® zirconium abutment with hexagonal connection.



**Figure 10.1J.** Full-ceramic restorations and porcelain laminate veneer on master cast.

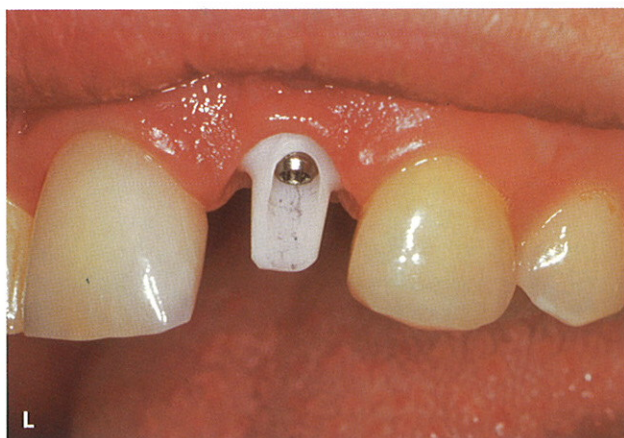


**Figure 10.1H.** Labial view of inserted zirconium abutment in situ.



**Figure 10.1K.** Conditioning of left central incisor and canine for bonding of ceramic restorations.

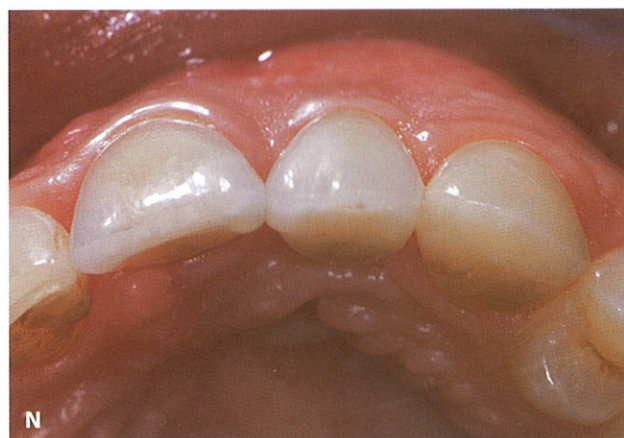




**Figure 10.1L.** Labial view after bonding of ceramic restorations to implant-adjacent teeth.



**Figure 10.1M.** Pleasing smile architecture with proper relation of implant restoration to adjacent teeth. Labial view of final restoration. (In collaboration with Dr. Orcan Yüksel)



**Figure 10.1N.** Occlusal view of final restoration displaying compensated irregularities of buccal contour and overlying tissue.

## Transformation Toughening

Zirconium dioxide has “self-repairing” properties, preventing crack propagation (Gehrke and Kielhorn 2004). It exists in three crystal conditions, even if the chemical composition is identical. This material characteristic is called *polymorphism*. At temperatures exceeding 2300°C, zirconium oxide is found in the cubic crystal phase; it changes into a tetragonal crystal phase when it cools down. Zirconium oxide transforms into a monoclinic phase at temperatures below 1200°C. The transformation from tetragonal to monoclinic is completed with a volume increase of approximately 3–5%.

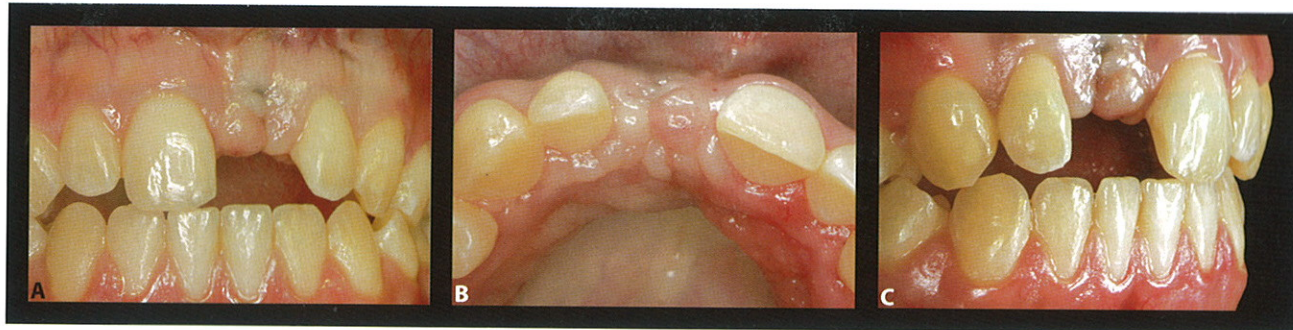
These volume changes lead to very high inner-structure tensions and component fracture. For this reason, oxide additives (e.g., magnesium oxide, calcium oxide, or yttrium oxide) are necessary to completely or partially stabilize the high-temperature phases (cubic or tetragonal) down to room temperature. This reduces compression stress within the structure to a controlled level and prevents component destruction while cooling. The phenomenon of preventing microcrack propagation resulting from high material tension is called “transformation toughening.” Maximum fracture strength of 672 Newtons (N) during static loading and 403 N during cyclic loading has been reported for zirconium ceramic abutments (Gehrke et al. 2006). Further in vitro and in vivo studies are necessary to prove that this claim can be accurate in clinical situations. (See Figures 10.2A–Z.)

## Biocompatibility

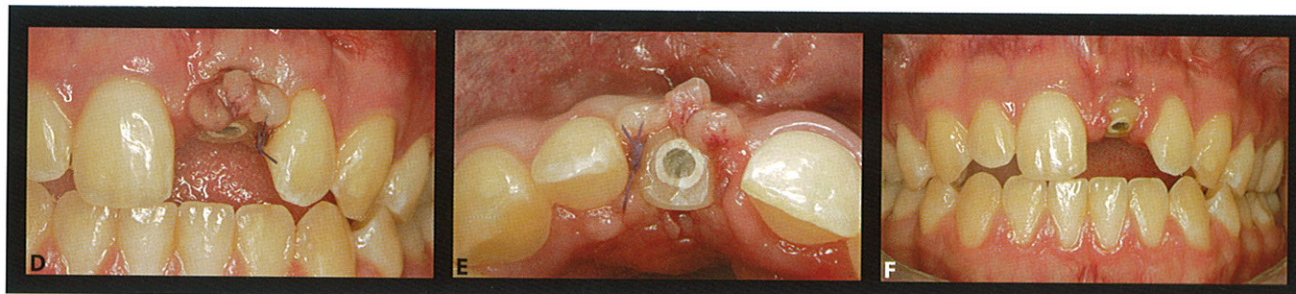
Numerous studies have documented the biological safety of zirconium dioxide (Covacci et al. 1999, Ferraris et al. 2000). No toxic effects occurred at the interface of zirconium dioxide with bone or soft tissue. Tests of the mutagenic effects (chromosome aberration test) and carcinogenic effects (Ames test) yield the same positive results (Ferraris et al. 2000). An intact implant restoration requires the effective maintenance of the peri-implant margins, including low plaque adhesion to the implant abutment. Inadequate soft tissue attachment may lead to bacterial penetration, resulting in peri-implantitis and progressive loss of hard and soft tissues.

The degree of adhesion between bacteria and abutment depends on the abutment's and bacteria's free surface energy, the roughness of the surface, and the saliva's ionic conductivity (Quirynen and Bollen 1995). Recent studies by Scarano and others (2004) confirmed a 40% reduction in bacterial adhesion on zirconium oxide compared to titanium with comparable roughness.





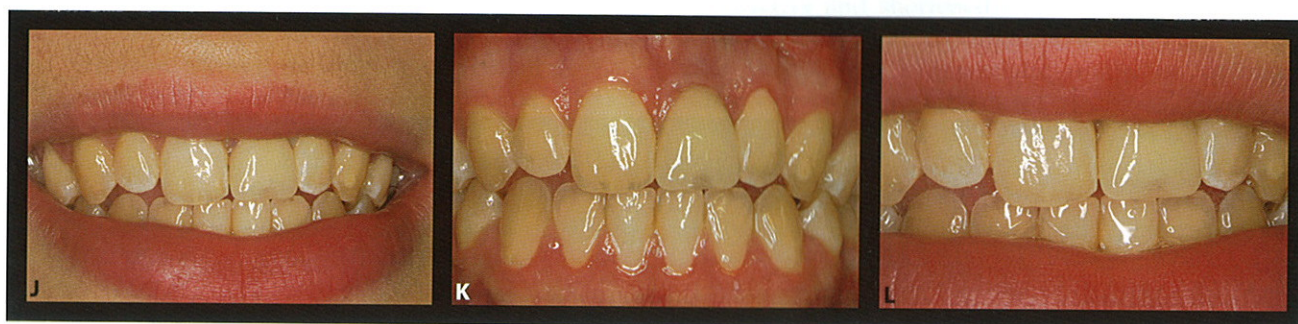
**Figure 10.2.** A. Tissue healing in region of left central incisor 8 months' post implant placement and guided tissue regeneration/membrane. Note unfavorable scar tissue and exposure of membrane tack. B. Occlusal view of soft tissue conditions in region of left central incisor. C. Labial view of soft tissue conditions in region of left central incisor.



**Figure 10.2.** D. Labial view after pedicle soft tissue graft. (Surgery Prof. Dr. Günter Dhom). E. Occlusal view of pedicle soft tissue graft around acrylic anatomically contoured gingival former (FRIADENT, EsthetiCap). F. Situation 10 days after implant recovery and guided soft tissue management.



**Figure 10.2.** G. Impression taken with transfer coping and cap for fabrication of long-term provisional restoration. H. Incisally screw-retained provisional crown on acrylic abutment (FRIADENT, ProTect). I. Labial view of provisional acrylic crown on master cast prior to delivery.



**Figure 10.2.** J. Smile line after delivery of provisional single restoration for left central incisor. K. Intraoral view of screw-retained provisional after closing of incisal access hole with acrylic. L. Close-up of smile line with provisional acrylic restoration.



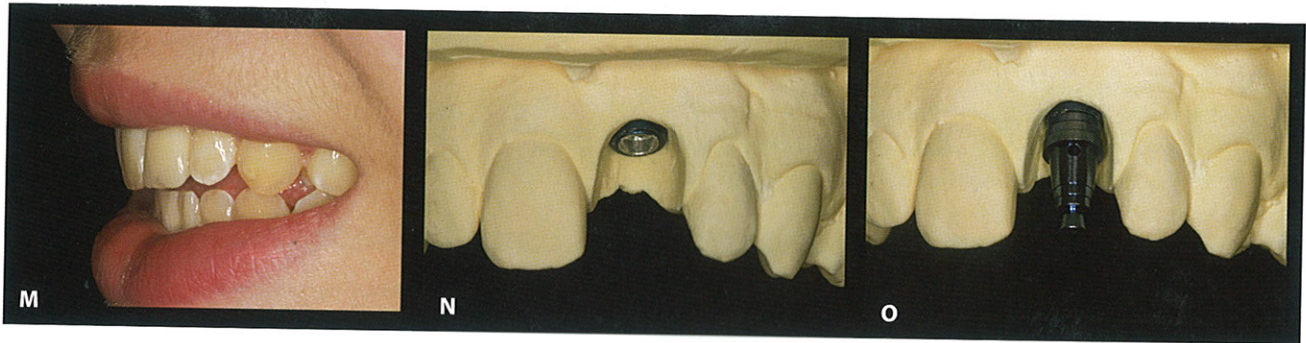


Figure 10.2. M. Lateral view of smile line in temporary stage. N. The gingival profile is checked and gingival height with select abutment on master cast. O. Selection of the abutment size & height.



Figure 10.2. P. Selection of the abutment angulation. Q. CAD/CAM fabricated Zirconium abutment in place. R. CAD/CAM fabricated zirconium copings in place.

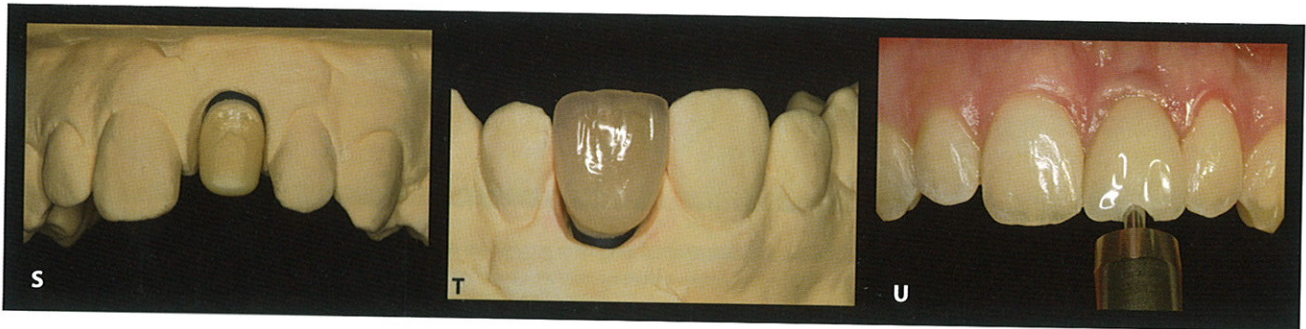


Figure 10.2. S. Zirconium copings after customization. T. Final full ceramic crown prior to delivery. U. Removal of provisional screw-retained crown.



Figure 10.2. V. Incisal view if the Soft tissue condition. W. Labial view of the emergence profile 3 months after implant recovery. X. Clinical try-in with titanium abutment that shows the difference from the zirconium abutment.



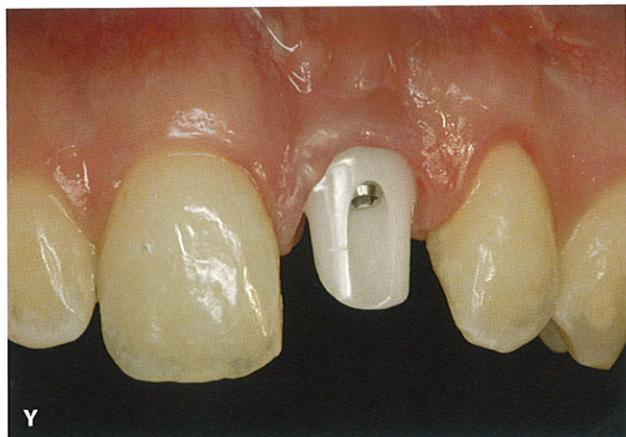


Figure 10.2Y. The zirconium abutment intra-orally.



Figure 10.2Z. Intraoral view of final full ceramic restoration in situ.

Most infections in the oral cavity are due to the initial adhesion of bacterial colonization. These start on surface irregularities, such as grooves or abrasive defects, and extend gradually over the entire abutment. Bacteria are inaccessible to mechanical removal in the subperi-implant region, which allows bacteria to attach strongly to the abutment. The adhesion of bacteria directly correlates to the roughness and the number of surface defects. Abutments with low roughness values show a significant reduction in plaque adhesion and plaque growth. Poortinga and others (2001) demonstrated the significant influence of energy on bacterial adhesion, besides surface roughness. Bacteria absorbing and passing electrons from the fluid substrate adhere in stronger and greater numbers compared to bacteria only receiving electrons. These results prove that the electron transfer between bacteria and their substrate also influences the adhesion and thus plaque formation.

A comparative immunohistochemical evaluation of vascular growth factor, inflammatory infiltrate, proliferative activity expression, and microvessel density in the peri-implant soft tissues surrounding titanium and zirconium dioxide healing caps revealed statistically decreased values for zirconium dioxide (Degidi et al. 2006). Consequently, zirconium actively contributes to peri-implant tissue protection. The ideal synergy of mechanical, functional, biological, and esthetic features contributes significantly to the esthetic result of a full-ceramic implant restoration. Conventional titanium abutments can produce a bluish, metal shimmer at the restoration margin, especially in cases of thin soft tissue. This results in a significant loss of esthetic quality and may contribute to an unsatisfactory treatment outcome, particularly for patients with a high smile line. Zirconium ceramics

appear to be an alternative abutment material for these cases.

Restorations in the esthetically demanding anterior region present significant challenges in both the surgical and prosthetic stages of implant dentistry. Titanium has been established as the material of choice for endosseous implants, resulting in a high degree of predictability. Zirconium dioxide appears to be a suitable material for manufacturing implant abutments with a high fracture strength and low bacterial colonization potential. Ceramic abutments also minimize the gray color associated with metal components shining through the peri-implant tissues. Their durability and color conformity are prerequisites for highly esthetic implant restorations.

### Using Prefabricated Zirconium Copings on Corresponding Implant Abutments

New implant restorative treatment protocols aim for an effective and shortened treatment concept, both in the laboratory and chairside. The following clinical case summarizes a systematic restorative approach using a novel premanufactured zirconium abutment/coping system in partially edentulous patients. The prosthetic and laboratory procedures for an implant-supported single-tooth replacement in the esthetic region are addressed and illustrated in a step-by-step approach.

After osseointegration and stage-two soft tissue healing, a zirconium dioxide abutment (CERCON®, DENTSPLY Friadent, Mannheim, Germany) was attached to an implant (XiVE®, DENTSPLY Friadent, Mannheim, Germany) replacing the right lateral incisor. (See Figures 10.3A–N.) After placing the abutment, a





Figure 10.3G. Impression with polyether material and picked-up cap.

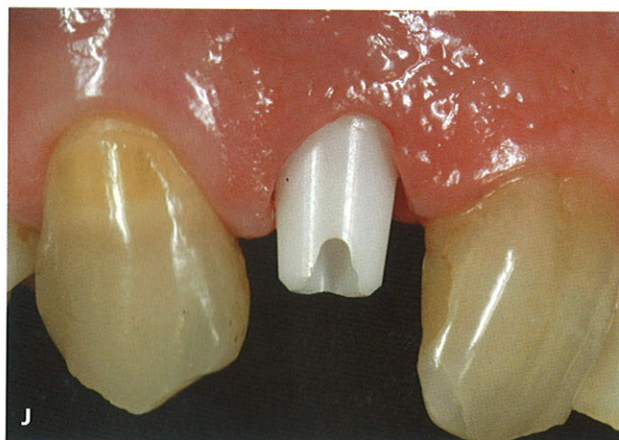


Figure 10.3J. Finalized full-ceramic restoration in the laboratory. Premanufactured coping serves as foundation for porcelain crown.

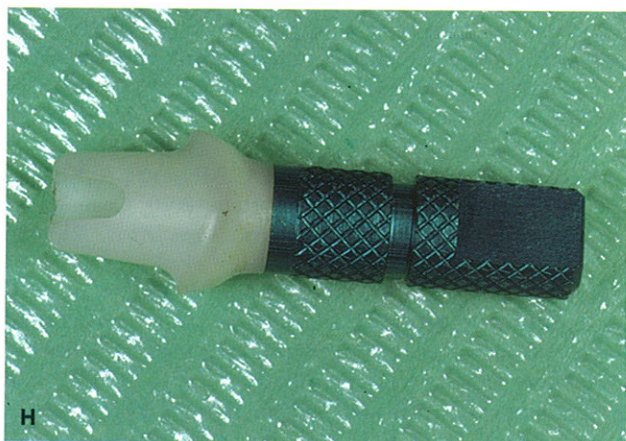


Figure 10.3H. Zirconium abutment connected to an implant analogue.



Figure 10.3K. Seating of zirconium ceramic abutment.

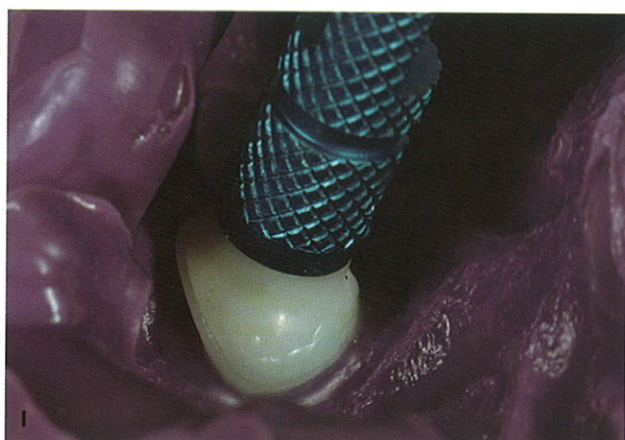


Figure 10.3I. Reseating of implant analogue/abutment unit into impression.



Figure 10.3L. Try-in of full ceramic crown.





Figure 10.3G. Impression with polyether material and picked-up cap.

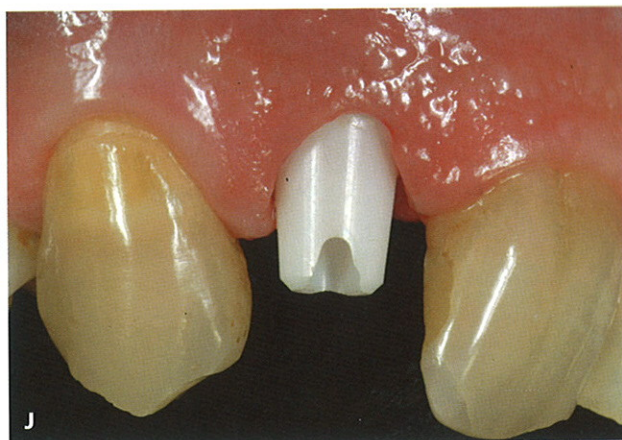


Figure 10.3J. Finalized full-ceramic restoration in the laboratory. Premanufactured coping serves as foundation for porcelain crown.

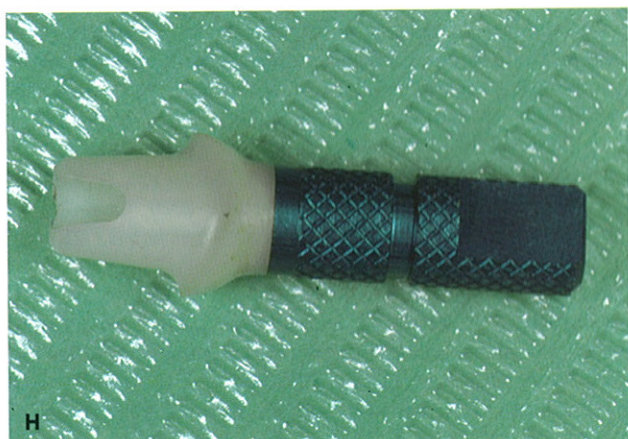


Figure 10.3H. Zirconium abutment connected to an implant analogue.



Figure 10.3K. Seating of zirconium ceramic abutment.

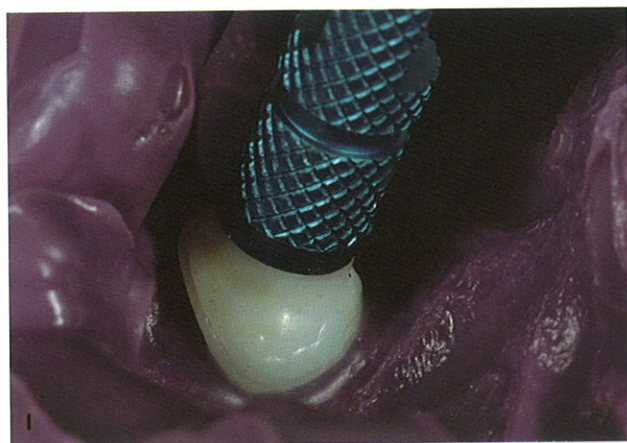


Figure 10.3I. Resealing of implant analogue/abutment unit into impression.



Figure 10.3L. Try-in of full ceramic crown.





Figure 10.3M. Crown in situ immediately after cementation.

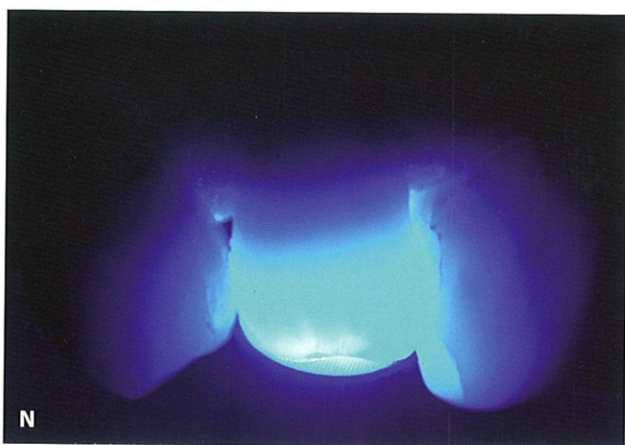


Figure 10.3N. Labial view of full ceramic implant restoration with polymerization light.

premanufactured corresponding zirconium coping was seated and an impression was taken for the fabrication of a master cast. The ceramic coping served as an impression transfer cap, to be picked up directly with the impression. Before pouring the cast, the zirconium abutment was connected to an implant analogue and securely resealed into the cap. No additional modifications were required, and porcelain was applied directly to the ceramic coping to complete a full-ceramic crown. The coping served as the foundation for the porcelain applied by the laboratory to create the final restoration. No additional ceramic crown or wax-up was necessary. The full ceramic crown, based on the zirconium cap was delivered and subsequently luted with resin cement. The clinical results indicate that the investigated zirconium restorative system allows an expedited and systematic treatment to resolve esthetic challenges with a premanufactured ceramic abutment/coping system in partially edentulous patients.

## References

- Brodbeck, U. 2003. The ZiReal post: A new ceramic implant abutment. *J Esthet Restor Dent*, 15, (1), pp. 10–24.
- Chiche, G.J., and A. Pinault. 1994. *Esthetics of anterior fixed prosthodontics*. Textbook, Quintessence Publishing Co, Inc., Chicago, pp. 13–31.
- Christel, P.S. 1989. Zirconia: the second generation of ceramics for total hip replacement. *Bull Hosp Jt Dis Orthop Inst.*, 49, (2), pp. 170–177.
- Covacci, V., N. Bruzzese, G. Maccauro, C. Andreassi, G.A. Ricci, C. Piconi, E. Marmo, W. Burger, and A. Cittadini. 1999. In vitro evaluation of the mutagenic and carcinogenic power of high purity zirconia ceramic. *Biomaterials*, 20, (4), pp. 371–376.
- Degidi, M., L. Artese, V. Pernotti, P. Gehrke, and A. Piattelli. 2006. Inflammatory infiltrate, microvessel density (MVD), nitric oxide synthase (NOS) expression, vascular endothelial growth factor (VEGF) expression, and proliferative activity (Ki-67) in the peri-implant soft tissues around titanium and zirconium oxide healing caps. *J Periodontol*, 77, pp. 73–80.
- Döring, K., E. Eisenmann, and M. Stiller. 2004. Functional and esthetic considerations for single-tooth ANKYLOS implant-crowns: 8 years of clinical performance. *J Oral Implantol*, 30, pp. 198–209.
- Ferraris, M., E. Verne, P. Appendino, C. Moisesescu, A. Krajewski, A. Ravaglioli, and A. Piancastelli. 2000. Coatings on zirconia for medical applications. *Biomaterials*, 21, (8), pp. 765–773.
- Filser, F., P. Kocher, F. Weibel, H. Lüthy, P. Schärer, and L.J. Gauckler. 2001. Reliability and strength of all-ceramic dental restorations fabricated by direct ceramic machining (DCM). *Int J Comput Dent*, 4, (2), pp. 89–106.
- Fradeani, M., M. Redemagni, and M. Corrado. 2005. Porcelain laminate veneers: 6- to 12-year clinical evaluation—A retrospective study. *Int J Periodontics Restorative Dent.*, Feb, 25, (1), pp. 9–17.
- Garber, D.A. 1996. The esthetic dental implant: letting restoration be the guide. *J Oral Implantol.*, 22, (1), pp. 45–50.
- Garber, D.A., and P. Adar. 1997. Securing the position of ceramic veneers in dentistry, *Summer*, 4, (2), pp. 2–4.
- Garber, D.A., and M. Salama. 2000. The Aesthetic Smile: Diagnosis and Treatment. *Periodontology*, 1996, 11, pp. 18–28.
- Garvie, R.C., R.H. Hannink, and R.T. Pascoe. 1975. Ceramic steel. *Nature*, 258, (5537), pp. 703–704.
- Gehrke, P., and J. Kielhorn. 2004. CERCON~ implant abutments: Beauty follows function. *International Magazine Oral Implantol*, 5, (3), pp. 6–13.
- Gehrke, P., G. Dhom, J. Brunner, D. Wolf, M. Degidi, and A. Piattelli. 2006. *Zirconium Implant Abutments: Fracture Strength and Influence of Cyclic Loading on Retaining-Screw Loosening*. Quintessence Int, 37, pp. 19–26.
- Hoppe, G., F. Damaschun, and G. Wappler. 1987. An appreciation of Martin Heinrich Klaproth as a mineral chemist. (Article in German). *Pharmazie.*, Apr, 42, (4), pp. 266–267.
- Ichigawa, Y., Y. Akagawa, H. Nikai, and H. Tsuru. 1992. Tissue compatibility and stability of a new zirconia ceramic in vivo. *J Prosthet Dent*, 68, pp. 322–326.



- Magne, P., and U. Belser. 2002. *Bonded porcelain restorations*. Textbook, Quintessence Publishing Co, Inc., Berlin, pp. 58–96.
- Poortinga, A.T., R. Bos, and H.J. Busscher. 2001. Charge transfer during staphylococcal adhesion to TiNoX coatings with different specific resistivity. *Biophys Cem*, 91, (3), pp. 273–279.
- Quirynen, M., and C.M.L. Bollen. 1995. The influence of surface roughness and surface-free energy on supra- and subgingival plaque formation in man. A review of the literature. *J Clin Periodontol*, 22, (1), 1–14.
- Sadoun, M., and S. Perelmutter. 1997. Alumina-zirconia machinable abutments for implant-supported single-tooth anterior crowns. *Pract Periodontics Aesthet Dent*, 9, (9), pp. 1047–1054.
- Salama, M., H. Salama, and D.A. Garber. 2002. Guidelines for Aesthetic Restorative Options and Implant Site Enhancement. *Pract Proced Aesthet Dent*, (14), 2, pp. 125–130.
- Scarano, A., M. Piattelli, S. Caputi, G.A. Favero, and A. Piattelli. 2004. Bacterial adhesion on commercially pure titanium and zirconium oxide disks: An in vivo human study *J Periodontol*, 75, (2), pp. 292–296.
- Tinschert, J., G. Natt, W. Mautsch, M. Augthun, and H. Spiekermann. 2001. Fracture resistance of lithium disilicate-, alumina-, and zirconia-based three-unit fixed partial dentures: A laboratory study. *Int J Prosthodont*, 14, (3), pp. 231–238.
- Yildirim, M., D. Edelhoff, O. Hanisch, and H. Spiekermann. 2000. Ceramic abutments—A new era in achieving optimal esthetics in implant dentistry. *Int J Periodontics Restorative Dent*, Feb, 20, (1), pp. 81–91.
- Yildirim, M., H. Fischer, R. Marx, and D. Edelhoff. 2003. In vivo fracture resistance of implant-supported all-ceramic restorations. *J Prosthet Dent*, 90, (4), pp. 325–331.