The goal of this prospective clinical study is to evaluate a new all-ceramic implant abutment made from zirconium oxide during the immediate load of dental implants placed in the block grafted anterior maxilla. This new zirconia abutment gives the clinician the opportunity to provide the patient with an all-ceramic restorative system (abutment and crown) for an optimum esthetic result and a high level of patient satisfaction. A total of 9 hydroxyapatite-coated dental implants were surgically placed in 9 patients and were immediately loaded 5 to 7 days later with a custom composite provisional restoration that was placed out of functional occlusion. Each prefabricated, natural colored zirconia abutment was shaped and connected to the implant with a titanium screw. Provisional restorations were cemented to the zirconia abutment with the use of temporary cement. Twelve weeks later, the provisional restoration was replaced with an all-ceramic restoration. Over a 52-week observation period, no abutment fractures occurred, and no abutment screw loosening was observed. No implants failed. All 9 patients reported total satisfaction regarding esthetic quality of the all-ceramic restorative system (abutment and implant). Preliminary results of this clinical study indicate that this new zirconia abutment offers the clinician and the patient exceptional strength, optimal esthetics, and simplicity. It is of important clinical significance that use of this all-ceramic abutment eliminates the well-known disadvantages of metal abutments.

Key Words: Zimmer Contour ceramic abutment, zirconia abutment, zirconium oxide, all-ceramic restorative system.
formation of mineralized tissue at the interface of dental implants before functional restoration.\textsuperscript{1,2} It was theorized that early or immediate loading would promote fibrous tissue formation around the implants rather than around the bone.\textsuperscript{3} Because of improved surgical instrumentation, implant design, and surface topography, this concept has been challenged. Over the past 5 years, the author (C.Y.S.L.) has routinely implemented the immediate load protocol in the bone grafted anterior maxilla to replace missing incisor teeth. Esthetics is always an issue with regard to patient satisfaction, and use of ceramometal restorations in the esthetic zone is unpredictable. In some instances, the final outcome can prove disappointing to both the clinician and the patient.

To date, few published articles have described the simultaneous use of provisional restorations on implants immediately placed into fresh or healed extraction sites.\textsuperscript{4–12} The purpose of immediate implant placement after tooth extraction with simultaneous provisionalization is to maintain the soft tissue architecture.\textsuperscript{7} When a provisional restoration is immediately placed on the implant, studies have showed that this technique can maintain the gingival outline and the dimensions of the papilla (Figure 1) during the osseointegration period.\textsuperscript{4–12}

To our knowledge, there is a paucity of information in the dental implant literature regarding immediate load of implants placed in the reconstructed anterior maxilla that required block bone grafts followed by implant surgery with immediate provisionalization.\textsuperscript{13} Further, no published clinical reports have described the use of all-ceramic abutments and, specifically, the use of the Zimmer Contour ceramic abutment (Zimmer Dental, Carlsbad, Calif) in immediate load cases of the grafted anterior maxilla. This new zirconia internal hexagonal connection abutment (Zimmer Dental) is manufactured from high-strength zirconium oxide (1150 MPa).\textsuperscript{14} As a biomaterial for use in dentistry, zirconia possesses high flexural strength (900 to 1200 MPa) and excellent hardness (1200 Vickers) and is able to tolerate the maximum incisor load reported in the dental literature of 90 to 370 N.\textsuperscript{15,16} This prospective study describes the clinical performance of this new all-ceramic implant abutment on implants surgically placed in the bone grafted anterior maxilla during immediate load procedures in 9 patients over a 52-week observational period.

**REVIEW OF THE LITERATURE**

Replacement of the single tooth in the anterior maxilla is always a challenge to the clinician.\textsuperscript{17–19} Although preserving or recreating the osseous anatomy via bone grafting is important in gingival architecture, 2 critical variables that ultimately determine the esthetic outcome are the surrounding gingival tissues and the appearance of the tooth-colored restoration that will replace the missing tooth. In the esthetic zone, the challenge is to maintain or recreate the soft tissue contours of the interproximal papillae and the gingival profile.\textsuperscript{7,9–12,14,15} The shape of the provisional restoration allows guided soft tissue healing to maintain the architecture of the gingiva.\textsuperscript{4–13} Therefore, the provisional restoration plays an important role early in the course of treatment before the patient receives the definitive restoration to achieve a pleasing smile.

From the patient’s perspective, the most important issue is always the esthetic quality of the restoration. For decades, the use of titanium abutments for implant-supported restorations has been the standard of care. However, this technology offers many esthetic disadvantages. The use of conventional prefabricated or custom titanium abutments can decrease the translucency of porcelain in a ceramometal restoration.\textsuperscript{18,19} The result is a darker restoration compared with adjacent natural teeth.\textsuperscript{20} In addition, titanium abutments can produce a dark grey metallic hue at the gingival margin of the restoration.\textsuperscript{20,21} This may be most evident in patients with a high smile line or with thin gingival tissues.\textsuperscript{18–21} The final result is a patient who is unhappy because of a poor esthetic outcome. Another disadvantage over time with ceramometal restorations is that after several years of use in the oral cavity, the restoration becomes lighter in color.\textsuperscript{22}
Over a 4-year observational period, no abutment occlusal loads in the anterior and premolar regions. Sintered experimental zirconia were able to withstand reported that ceramic abutments made of densely 54 single implant supported all-ceramic restorations, inflammatory response with either biomaterial.21,23 the periodontium. Peri-implant tissues exhibited no biomaterials exhibit good tissue biocompatibility with the periodontium, it has also demonstrated activity with the periodontium.22–26 Two biomaterials that are responsible for this prosthetic advancement and are used to manufacture these all-ceramic implant abutments are aluminum oxide (alumina) and zirconium oxide (zirconia). Studies have demonstrated that both biomaterials exhibit good tissue biocompatibility with the periodontium.21,22 Biomaterial properties such as high biocompatibility, low electrical conductivity, low thermal conductivity, and high flexural strength and fracture resistance, which eliminate the use of a metal substructure, offer significant benefits over metal abutments.22–26 Two biomaterials that are responsible for this prosthetic advancement and are used to manufacture these all-ceramic implant abutments are aluminum oxide (alumina) and zirconium oxide (zirconia). Studies have demonstrated that both biomaterials exhibit good tissue biocompatibility with the periodontium. Peri-implant tissues exhibited no inflammatory response with either biomaterial.21,23 Although alumina has shown good biocompatibility with the periodontium, it has also demonstrated lower flexural strength and fracture toughness, which lead to higher failure rates compared with zirconia and metal abutments.27,28 Andersson et al reported a 7% fracture rate of implant abutments made from alumina to support single tooth restorations over a 1-year observational period.29 Two additional prospective studies by Andersson et al showed that implant abutments made from alumina exhibited a survival rate of 98.1% when used to support short span, fixed partial dentures over both 2- and 5-year observational periods.

In contrast, zirconia demonstrates 2 times the flexural strength and fracture toughness of alumina.23 Therefore, it has become the biomaterial of choice over alumina in esthetic dentistry. In a prospective clinical study, Henriksson and Jemt evaluated the clinical performance of customized Procera ceramic abutments on 24 implants in 20 patients. Over a 12-month observation period, they concluded that customized ceramic abutments are successful and have function comparable with that of the traditional metal abutment in supporting a ceramometal restoration. Glauser et al, in their study of 27 patients and 54 single implant supported all-ceramic restorations, reported that ceramic abutments made of densely sintered experimental zirconia were able to withstand occlusal loads in the anterior and premolar regions. Over a 4-year observational period, no abutment fracture or chipping was observed, and a 100% implant abutment survival rate was reported.

Although long-term clinical study findings are not available, one of the greatest advantages of using an all-ceramic abutment may be the ability to decrease levels of plaque accumulation around the gingival sulcus of the implant. Many variables are involved and lead to implant failure, including peri-implantitis.33–35 Inflammation around the gingival tissues of the implant due to plaque can progress to a bacterial infection, resulting in bone loss around the implant. In the study by Glauser et al, not only were the zirconia abutments able to support the all-ceramic restorations under occlusal loads without fracture or chipping, but the soft tissue response around the abutments and adjacent natural teeth was favorable. Modified plaque and gingival indices demonstrated healthy gingival and mucosal conditions that were similar to those in other implant studies, in which metal abutments were used to connect the restoration to the implant.

Rimondini and colleagues reported decreased levels of bacterial adhesion around zirconium dioxide abutments. The ability of bacteria to adhere to different material surfaces involves the specific free surface energy charge of the material. Zirconium dioxide has been shown to have a lower surface energy charge compared with titanium; this may prove to be a protective mechanism against peri-implantitis and accumulation of oral pathogens.23,36

**Terminology**

Until recently, no clear consensus had been reached as to the precise definition of immediate load and early load. As a result, considerable confusion existed as to when these terms should be applied. In 2004, the Immediate Function Consensus Conference was conducted to resolve this issue, and terminology regarding immediate load and its guidelines were developed. With the use of terminology adopted from this conference, all 9 cases included in this study were classified as nonfunctional immediate restorations. In each case, the implant prosthesis in a patient who is partially edentulous was delivered within 1 week of implant insertion with no direct occlusal load.

**Materials and Methods**

**Patient enrollment**

In this prospective clinical study, 9 implants were placed in 9 block grafted patients (8 female and 1 male) ranging in age from 18 to 57 years, with a mean
age of 42 years. Provisional composite restorations were placed on the implants 5 to 7 days after implant surgery. Clinical evaluations were performed to evaluate the bone quality and bone volume of each patient in the area of the missing tooth. Bone density was evaluated with iCAT (Imaging Sciences International, Hatfield, Pa) cone beam computerized tomography (CBCT) and an interactive CT software program (SimPlant, Materialise, Ben Gurnie, Md) prior to implant surgery and after the bone graft procedure had been performed. Results in Hounsfield units were correlated according to the bone density classification described by Lekholm and Zarb.\textsuperscript{38} Type I bone is described as dense, Type II and III as normal, and Type IV as soft.

Patients were included in the study if they fulfilled the following criteria: (1) atrophy in the labiolingual dimension, which prevents implant placement; (2) autogenous block grafting, which is indicated to reconstruct the atrophic labial cortical plate; and (3) replacement of a missing maxillary lateral or central incisor. All patients were informed of the established protocol, and informed consent was obtained. Exclusion criteria included the following: (1) parafunctional habits such as bruxism and clenching; (2) pregnancy; (3) use of tobacco; (4) therapeutic irradiation to the maxillofacial region; and (5) medical conditions that were a contraindication to implant treatment.

**Surgical protocol**

Presurgical treatment planning consisted of a diagnostic waxup of both arches with a semiajustable articulator and fabrication of an acrylic surgical template, photographs, panoramic radiographs, and CBCT with SimPlant interactive software (Materialise, Ben Gurnie, Md). All 9 patients who participated in the study completed autogenous bone grafting of the atrophic labial cortical plate. Each autogenous block graft was harvested from the ascending ramus of the mandible as described by Misch\textsuperscript{39,40} with the use of a fissure bur in a high-speed handpiece under cool water irrigation. Prior to receipt of the block graft, all graft recipient sites were contoured to receive the block graft but were not decorticated or perforated. Each block graft was adjusted passively to the dimensions of the future implant site and was stabilized to the maxilla with mini rigid fixation screws and 2-point fixation (Figure 2). After 12 weeks of healing time, observation revealed that each block graft was well consolidated with the maxilla. Rigid fixation screws then were removed and tapered, and internally hexed hydroxyapatite-coated dental implants (Screwvent, Zimmer Dental) were selected and surgically placed according to the manufacturer's recommendations under aseptic conditions and local anesthesia (Figure 4). Initial primary implant stability, evaluated as an insertion torque of 30 Ncm, was required if the implant was to be loaded immediately. Implant length and diameter varied according to bone quality and proximity to anatomic structures. Implant length was selected on the basis of proximity to vital anatomic structures such as the maxillary sinus and nasal cavity. Implant width was determined according to proximity to vital anatomic structures such as the incisive canal and its neurovascular bundle and the thickness of the reconstructed labial cortical plate.

**Prosthetic protocol**

After each implant was surgically placed in the bone grafted anterior maxilla, implant position was immediately indexed by the surgeon with the closed tray technique using the impression coping provided by the implant manufacturer and a polyvinylsiloxane impression material to facilitate fabrication of the provisional composite restoration. The Screwvent dental implant (Zimmer Dental) is supplied with a premounted titanium abutment that serves as the fixture mount, temporary abutment, and impression coping for indexing to transfer the position of the surgically placed implant to the master cast.

The Zimmer Contour ceramic abutment (Zimmer Dental) and provisional restoration were fabricated by the dental laboratory and were returned to the surgeon (Figure 5). A titanium screw was used to deliver the all-ceramic abutment to the implant (Figure 6). The screw access opening was then covered with a cotton pellet. The provisional restoration was cemented onto the abutment with temporary cement out of occlusion (Figure 7). Twelve weeks later, final impressions were obtained by the restorative dentist, and the definitive all-ceramic restoration was fabricated and delivered to the patient. The all-ceramic restoration was examined for marginal integrity, accurate occlusion with the opposing dentition, and overall esthetics. Definitive cementation was completed with the use of a glass ionomer cement. All patients were advised to avoid loading of the implant restoration for a total of 3 months after implant placement and to maintain good oral hygiene.

**Prosthetic laboratory procedure**

In the dental laboratory, a soft tissue model was fabricated with the use of a soft tissue replication material from Coletene/Whaledent (Mahwah, NJ). The soft tissue material was injected around the transfer
FIGURES 2–7. Figure 2. Sagittal view. Preoperative iCAT cone beam computed tomography (CBCT) scan of the anterior maxilla. In-office CBCT scan demonstrates atrophy in the labiolingual dimension. Less than 5.0 mm of bone width is available for implant placement. Greater than 15.0 mm of vertical bone height is available for implant placement. Figure 3. Sagittal view. Postoperative iCAT cone beam computed tomography (CBCT) scan (Imaging Sciences International, Hatfield, Pa) of the bone grafted anterior maxilla. The width of the bone grafted maxilla is now greater than 8.0 mm, which will permit implant placement. Note the use of rigid fixation screws to stabilize the block cortical graft to the maxilla. Figure 4. Implant surgically placed in well-consolidated block bone graft of the anterior maxilla after 4 months of healing. Figure 5. All-ceramic abutment prepared and ready to be delivered to the patient. Note the titanium interface ring, which provides a stable abutment-implant interface, to prevent microrotation and screw loosening. Figure 6. Zimmer Contour all-ceramic abutment seated onto the implant. Excellent scalloped soft tissue esthetics. The margin is placed 2.0 mm below the gingival crest. Figure 7. Provisional composite restoration cemented to the all-ceramic abutment. Note excellent soft tissue contours for a pleasing esthetic result. Note preservation of the gingival architecture and papillae.
coping and implant analog. The model then was poured with resin rock ×15 die stone (Whipmix Corp, Louisville, Ky). Maxillary and mandibular working cast stone models were mounted on a semiadjustable articulator. Because all 9 implants were to be immediately loaded, and optimal esthetics was the primary concern, a prefabricated all-ceramic abutment was selected (Zimmer Contour). Selection of the abutment (1.0 mm or 2.0 mm) was based on gingival crest height replicated on the working cast models. The all-ceramic abutment was prepared in accordance with manufacturer instructions. A unique feature of this prefabricated stock abutment is the offset margin, which requires very little preparation. Margins were prepared approximately 1.0 mm below the gingival crest along the contours of adjacent teeth.

Because of its high strength and esthetic properties, Sinfony hybrid composite material (3M ESPE, St Paul, Minn) was selected for fabrication of the all-composite provisional restorations. The definitive all-ceramic restorations were made with the use of computer aided design/computer assisted manufacturing (CAD/CAM) technology. This leading edge technology is used to create an accurate 3-dimensional model that is customized to each patient. More important, CAD/CAM technology enables the dental technician to mill the highly dense ceramic material; this is not possible with conventional laboratory techniques.

After each zircon ceramic crown was scanned, the crown was milled and sintered. The porcelain material then was esthetically layered and was contoured onto the crown to achieve the desired esthetic result (Figure 8).

Results

All 9 dental implants were loaded with nonfunctional, provisional composite restorations within 5 to 7 days after implant surgery. All 9 patients were followed for a period of 52 weeks that included clinical evaluations, which always included analysis of occlusion. The definitive all-ceramic restoration was delivered to the patient 12 weeks later and was observed for an additional period of 40 weeks. Follow-up office observations were scheduled at the following intervals: 1 month, 3 months, 6 months, 9 months, and 12 months. Throughout the course of the clinical study, no implant failures were observed from the time of implant surgery to the time of delivery of the final restoration. Technical problems such as abutment fracture and screw loosening were not observed. All of the ceramic restorations continue to function without fracture or chipping. All 9 patients were extremely satisfied with the final esthetic result (Figure 9A through C).

Discussion

Early reports by Branemark et al1 and Adell and colleagues2 recommended an occlusal-free submerged healing time of 6 months for implants surgically placed in the maxilla, to allow for successful osseointegration. This traditional implant protocol continues to be modified because of advances in implant technology and in the clinical experience of the implant team. Bone from the ascending ramus of the mandible is Type I bone, and grafting the anterior maxilla from the ramus effectively changes the osseous macrostructure from Type III to Type I bone. As many immediate loading studies have documented, Type I bone of the anterior mandible can be successfully and predictably loaded immediately after implant placement.41–45 The ramus grafted anterior maxilla shares these same characteristics, which most likely are due to the favorable primary stability of implants placed in dense, Type I bone. Therefore, successful early remodeling and consolidation of the graft to the native maxilla could be the most important reasons why implants can be surgically placed and immediately loaded 3 months after the grafting procedure instead of after 6 months, as recommended by the conventional Branemark protocol.

Although the immediate load protocol is being used with greater frequency, esthetic quality has now come to the forefront with advances in all-ceramic technology. Esthetic expectations of patients are greater than they have ever been, and this has placed even greater demands on the clinician and the dental laboratory. To meet this challenge, researchers have developed zirconia abutments. In contrast to a titanium abutment, use of an all-ceramic abutment does not obstruct the transmission of natural light. Opalescent and fluorescent light properties are enhanced, and with an all-ceramic restorative system, optimal esthetics resembling a natural tooth is more likely.

Abutment screw loosening under occlusal loads is due to rotational freedom at the hexagonal implant–abutment interface. This results in micromotion between these 2 metal components. Elimination of this rotational freedom will resist screw loosening.46–48 A unique feature of this ceramic abutment is the titanium interface ring (Figure 5) located below the offset margin, which provides precise fit of a titanium-
to-titanium connection with the implant and enhances stability at the implant–abutment interface. Full assembly under 30.0 Ncm of applied torque creates frictional resistance against the internal connection of the implant. This “virtual cold weld” of the interface of abutment to implant has been documented to decrease abutment microrotation, which has been associated with abutment screw loosening in many implant systems. Another feature of this all-ceramic abutment is the predefined offset margin, which is lower on the facial aspect and higher on the lingual side. The advantage of this intrasulcular design is that very little preparation for a crown is needed.

The disadvantage of selecting an all-ceramic restorative system is cost. The cost is higher compared with that of a metal abutment and ceramometal restoration for the dentist, the dental laboratory, and the patient. However, cost will not prohibit use of this all-ceramic technology as demand for esthetic dentistry by patients will continue to soar to new heights over the next several years. This will positively challenge dentistry to meet this demand by increasing the use of all-ceramic biomaterials. The physical and optical properties of ceramic biomaterials show much promise. As ceramic technology continues to progress, cost should decrease as more dentists select this technology for their patients, not only in esthetically demanding cases but in routine posterior cases as well.

**CONCLUSION**

Although the clinical observation period in this prospective study is limited to 12 months, initial results are promising when the Zimmer Contour ceramic abutment (Zimmer Dental) with an all-ceramic restoration is used during immediate loading of implants. Clearly, the all-ceramic restorative system (implant and full crown) exhibits a very high level of esthetics, as all 9 patients have been very pleased with the final result. Additional clinical studies and research
of longer duration are needed to confirm the encouraging results of this present study.

NOTE
The authors declare no financial interest in any of the products cited in this manuscript.

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