Minimally Invasive Treatment for Papillae Deficiencies in the Esthetic Zone: A Pilot Study

William Becker, DDS, MSD;* Ildor Gabitov, PhD;† Misha Stepanov, PhD;‡ John Kois, DMD, MSD;§ Ami Smidt, DMD, MSc;¶ Burton E. Becker, DDS**

ABSTRACT

Background: The presence of papillary deficiencies adjacent to dental implants or teeth presents an esthetic concern for the dental team and patients.

Purpose: The aim of this pilot project is to evaluate a new method for reducing or eliminating small papillary deficiencies. The use of a commercially available gel was evaluated as a possible method for enhancing deficient papillae.

Materials and Methods: Eleven patients, seven females and four males, with an average age of 55.8 years (ranging from 25 to 75 years) with 14 treated sites are included in this pilot study. Patients had a minimum of one papillary deficiency in the esthetic zone. Prior to treatment photographs were either taken at a 1:1 ratio or converted to a 1:1 ratio using a commercially available program. A standardization photographic device was not used. After administration of a local anesthetic, a 23-gauge needle was used to inject less than 0.2 mL of a commercially available and Food and Drug Administration-approved gel of hyaluronic acid 2–3 mm apical to the coronal tip of the involved papillae. Patients were seen every three weeks and treatment was repeated up to three times. Patients were followed from 6 to 25 months after initial gel application. A computer program measured changes in pixels between initial and final treatments. A formula was derived to determine percentage change in the negative space between initial and final examinations.

Results: Each site was individually evaluated. Three implant sites and one site adjacent to a tooth had 100% improvement between treatment examinations. Seven sites improved from 94 to 97%, three sites improved from 76 to 88%, and one site adjacent to an implant had 57% improvement.

Conclusion: Results from this pilot study are encouraging and present evidence that small papillary deficiencies between implants and teeth can be enhanced by injection of a hyaluronic gel. Improvements were maintained for a range of 6 to 25 months.

KEY WORDS: commercially available, esthetics, esthetic zone, gel, implants, injection, papillae deficiencies, teeth

INTRODUCTION

Patient demands for esthetically pleasing results after periodontal or implant therapy present significant challenges to the dental team. There are numerous papers dealing with the challenges of diagnosing, creating, and correcting deficiencies in esthetic clinical results after implant placement.[1–9] Tissues adjacent to a dental implant should be in harmony with adjacent teeth or implants and present with minimal to an absence of soft tissue deficiencies between the implant and adjacent natural teeth. A study was designed to determine whether the distance from the base of the contact area to the bone crest correlated with the presence or absence of interproximal papillae.[10] Results revealed that when the

*Private practice, Tucson, AZ; clinical professor, University of Southern California School of Dentistry, Department of Graduate Periodontics, Los Angeles, CA, USA; affiliate professor, University of Washington School of Dentistry, Department of Graduate Periodontics, Seattle, WA, USA; †professor, mathematical physicist, University of Arizona, Department of Mathematics, Tucson, AZ, USA; ‡associate professor, Department of Mathematics, University of Arizona, Tucson, AZ, USA; §Kois Center, Seattle, WA, USA; ¶Head, The Center for Graduate Studies in Prosthodontics School of Dental Medicine, The Hebrew University-Hadassah Jerusalem, Israel; **Private practice, Tucson, AZ, USA

Reprint requests: Dr. William Becker, 801 N Wilmot, B2, Tucson, AZ 85711, USA; e-mail: branebill@comcast.net

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measurement from the contact point to the crest of bone was 5 mm or less, the papilla was present almost 100% of the time. When the distance was 6 mm, the papilla was present 56% of the time, and when the distance was 7 mm or more, the papilla was present 27% of the time. Kois determined that the mean distance from the osseous crest to the tip of the papilla was 4.5 mm.[7] When the distance was remeasured following treatment the distance was 4.0 mm to the tip of the papilla 90% of the time. Cho[4] investigated the existence of interdental papillae at distances from the contact point to the alveolar crest, depending on the interproximal distance between roots. The number of papillae that filled the interproximal space decreased with increasing distance from the contact point to the alveolar crest ($p < 0.05$). In addition, the number of papillae that filled the interproximal space decreased with increasing interproximal distance between roots ($p < 0.05$) and became more prominent with increasing distance from the contact point to the alveolar crest (especially 4, 5, and 6 mm).

Others have added additional information for determining whether a papilla will be present after implant placement.[11,12] A table was devised providing parameters for predictable papillae preservation. The information relates to tooth to pontic, implant to tooth and implant to implant in vertical and horizontal distances, and the soft tissue limitations when contemplating immediate implant placement. Numerous papers have been written describing varying methods for either restoring or correcting deficiencies in papillae after implant placement. One study evaluated interproximal mucosal healing after implant healing.[13] Fifty-five patients were treated. Patients were divided into two groups. Seventeen patients received provisional restorations at second-stage surgery, while the other group of 38 patients had healing abutments inserted at the second stage. An index that assessed the size of the interproximal mucosa adjacent to the single-implant restorations was used to evaluate the volume of the papillae two years after crown insertion. The results indicated that the use of provisional crowns may restore soft tissue contour faster than healing abutments alone, but the papillae adjacent to single-implant restorations presented a similar volume in both groups after two years in function. Furthermore, the mean marginal bone loss at the implants was 0.9 mm after one year, and no differences were observed between the two groups. Nemcovsky and colleagues, at the second stage, divided a rotated palatal flap into two sections to create mesial and distal papillae.[14] The split flaps were sutured around healing abutments and provided a statistically significant increase in interproximal tissue after healing.

Using various surgical and flap designs, others described methods to create the illusion of papillae restoration for esthetic enhancement.[1,15,16] In order to achieve desirable esthetic outcomes, diagnostic keys were developed to aid clinicians during patient treatment planning.[17] These are knowledge of tooth position, periodontal form, biotype, tooth shape, and position of the osseous crest. In order to expect a good postoperative outcome an interdisciplinary approach to esthetic treatment planning and treatment execution is a primary concern.[18]

Plastic surgeons and dermatologists have a long history of using various substances to enhance esthetics in oral facial regions.[19] Recently a gel of hyaluronic acid generated by Streptococcus species of bacteria, chemically cross-linked with butanediol diglycidyl ether (BDDE), and stabilized and suspended in phosphate buffered saline at pH 7 and concentration of 20 mg/mL and fee of animal protein has been successfully used to reduce or eliminate facial creases and various other abnormalities.*[20–23] The product is approved by the Federal Food and Drug Administration (FDA).[24,25]

AIM

The aim of this pilot project is to evaluate a new method for possibly reducing or eliminating small deficient papillae adjacent to teeth or dental implants. In the esthetics zone, the use of a commercially available gel was evaluated as a possible method for enhancing deficient papillae.

MATERIALS AND METHODS

Eleven patients, seven females and four males, with an average age of 55.8 years (range 50 years) with 14 treated sites are included in this pilot project. Two patients required treatment for more than one site. These patients had deficient papillae adjacent to teeth or implants. Patients were asked if they would like to participate in a heretofore untried treatment that may reduce or eliminate the dark deficiencies adjacent to teeth or implants. Patients were explained the purpose

*Restalyne, Medicis Aesthetics Inc., 7720 North Dobson Road, Scottsdale, AZ 85256

of treatment and the history of the material to be used and were told that there would be no fee for study participation. They were advised that the test material is FDA approved and that the proposed treatment was "an off label" use of the material. Patients signed consent forms and treatment was performed under the Helsinki accords.[26] Prior to treatment, photographs were taken perpendicular to teeth of interest. These were used to take subsequent photos as close to the original photos as possible. A special, reproducible alignment device was not used.

Prior to treatment a short-acting local anesthetic was administered.† A commercially available, hyaluronic-based gel (less than 0.2 mL) was injected 2–3 mm apical to the tip of the papilla.‡ [Correction added after online publication 7 December 2009: "A commercially available, hyaluronic-based gel (less than 0.2 mL) was injected 2–3 mm coronal to the tip of the papilla," changed to, "A commercially available, hyaluronic-based gel (less than 0.2 mL) was injected 2–3 mm apical to the tip of the papilla."] After treatment individual patients' syringes were capped, identified with the patient's name, and stored in a refrigerator for future use on the same patient.[23] The needles were discarded. Patients were seen three weeks after the initial treatment and photographed, and if the dark space remained another injection was applied. This sequence was repeated up to three times. At each visit the treated sites were photographed. Patients were followed from 6 to 25 months after initial gel application. At study completion the clinical slides were reviewed and presented to an outside consultant (I.G.) for determination of measurement changes between initial and final photographs.

A computer program was written to measure changes in pixels between the initial and final treatments.

1. The photographs were first processed by GNU Image Manipulation Program or GIMP, a free raster graphics editor (gimp.org). The contrast was increased using GIMP's level tools in such a way that the dark area on the photograph corresponding to the deficient papillae became completely black, while the rest of the image turned white. A software program was written that counted the number of black pixels in a raster image. By running this program with the increased contrast version of the photograph as input, the number of pixels in the papillae deficient area was determined.
2. The physical size corresponding to a pixel is different on different photographs. To compare the absence of papillae from different photographs on the same patient, pixels were converted to a physical length. This was done in GIMP by measuring the size in pixels of the reference object in the image (using GIMP's measure tool). The reference distances used were the width of a central incisor from mesial to distal and distance between marks on the ruler's image (Figures 1 and 2). This was repeated for each patient, measuring the teeth adjacent to the treated site. An efficiency formula was developed to determine the percentage change in the dark triangles from before treatment to after treatment (Figure 3). In the efficiency formula the result does not depend on the choice of the reference object; however, the object should be large enough for the relative errors of measurement to be small.

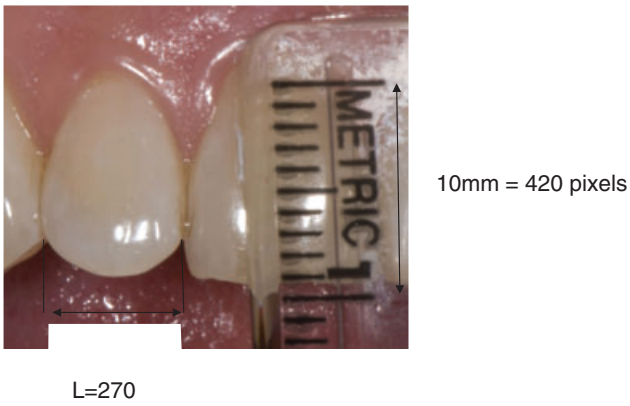

Figure 1 Method for standardizing measurements. Width of right lateral is chosen as reference size. L = (270/420) × 10⁻6.43 mm.

RESULTS

The percentage change for patients treated with dark spaces between teeth or implants is presented in Tables 1–3. Two implant sites and one site adjacent to a tooth had 100% improvement between treatment intervals. Seven sites had from 94 to 97% improvement, three sites improved from 76 to 88%, and one site adjacent to

†Septocaine, distributed by Septodont Inc., 245 Quigley Blvd., Suite C., New Castle, Delaware

‡Restylane, Medicis Aesthetics Inc., 7720 North Dobson Road, Scottsdale, AZ 85256

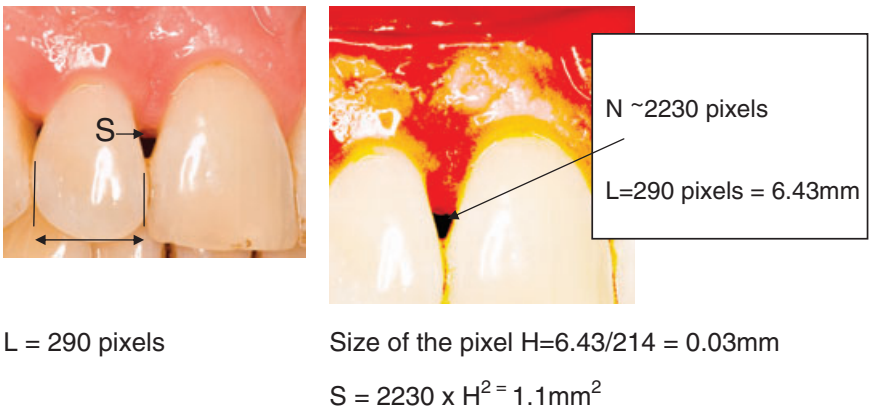

Figure 2 Method used to determine the number of pixels in the initial and final dark triangles.
Step 1: Using color levels transform color of the gap into pure black.
Step 2: Using developed software count number of image pixels that does not contain colors (black pixels). This number is proportional to the gap area S.

$$n = \%change\frac{S_{in} - S_{fin}}{S_{in}} = 1 - \left(\frac{l_{in}}{l_{fin}}\right)^2 \frac{N_{fin}}{N_{in}}$$

Figure 3 Formula for determining percentage change in deficient papillae between initial treatment and final evaluation.
$S_{initial}$ is the area of the gap before treatment.
S_{final} is the area of the gap after treatment.
$N_{initial}$ is the number of gap image pixels before treatment.
N_{final} is the number of gap image pixels after treatment.
$l_{initial}$ is the pixel size of the reference object on the image before treatment.
l_{final} is the pixel size of the reference object on the image after treatment.

an implant had improved 57%. Eight sites required two papillae injections and six required three treatments. Figures 1–5 present patient documentation for sites treated with the commercially available gel and the percentage change for individual sites.

DISCUSSION

To our knowledge this is one of the first studies evaluating a minimally invasive method for augmenting deficient interdental papillae. Investigators determined the safety and efficacy of cultured and expanded autologous

TABLE 1 Number of Gel Applications, Total Months Followed, and Percentage Change for Deficient Papillae between Teeth or Implants

Identification	Number of Applications	Tooth or Implant	Tooth Number	*Total Months Followed	Percentage Change
Boc I	2	I	7	14	57
Car I	2	I	7	25	100
Hag I	3	I	7	6	97
Har (left) I	3	I	10	13	96
Harr (right I)	3	I	7	13	100
Kor I	3	I	7	17	100
Lecy I	3	I	10	10	95
Miho T	2	T	8	17	96
Mow Left T	2	T	7	9	76
Mow Right T	2	T	10	9	96
Mow Central T	2	T	8	9	83
Rey I	2	I	10	10	97
Star I	3	I	7	13	88
PedI	2	I	7	17	94

#7 is the maxillary right lateral incisor.
*Months followed – from initial gel application to final examination.
I = implant; T = tooth.

TABLE 2 Percentage Change of Dark Triangles between Initial and After Treatment between a Maxillary Right Lateral Incisor and Right Central Incisor

10 mm = 420 pixels	L = 270 pixels	L = 6.4 mm
Before	L initial = 290 pixels	N initial = 2232 pixels
After	L final = 202 pixels	N final = 0 pixels

n = % change = 100%.

fibroblast injections for the treatment of interdental papillary insufficiency.[27] Results determined that the method was safe. When the results were compared with treatment versus placebo, differences approached significance. Clinical results from this study were inconclusive. Bioengineered hyaluronic acid derivatives are currently available and provide safe, effective soft tissue augmentation in the comprehensive approach to nonsurgical facial rejuvenation. Current hyaluronic acid fillers do not require preinjection skin testing and produce reproducible, longer-lasting, nonpermanent results compared with other fillers such as collagen.[21] Results from this pilot study evaluating the use of a commercially available injectable gel for reducing or deficient papillae between teeth and implants are promising. A total of 14 dark spaces were treated (4 teeth, 10 implants). An outside consultant applied a unique method and reproducible mathematical formula for evaluating small, dark spaces between teeth or dental implants. Each site was individually evaluated for percentage change between initial and final applications. The method measures changes in dark spaces from clinical photographs. Three sites had 100% improvement and eight had from 88 to 97% improvement. Sites were followed from 6 to 25 months after the initial gel application. Variability between visits depended on patient compliance. Once treatment was determined to be successful patients were maintained by their family dentists and asked to return if there were changes in their outcomes. The site followed for 25 months retained the improvement initially recorded. It is interesting to note that all patients considered treatment to be painless and six considered improvement to be clinically significant.

TABLE 3 Percentage Change of Dark Triangles between Initial and After Treatment between a Maxillary Left Lateral Incisor and Right Central Incisor

10 mm = 366 pixels	L = 239 pixels	L = 6.35 mm
Before	L initial = 310 pixels	N initial = 2986
After	P final = 228 pixels	N final = 184

n = % change = 97%.

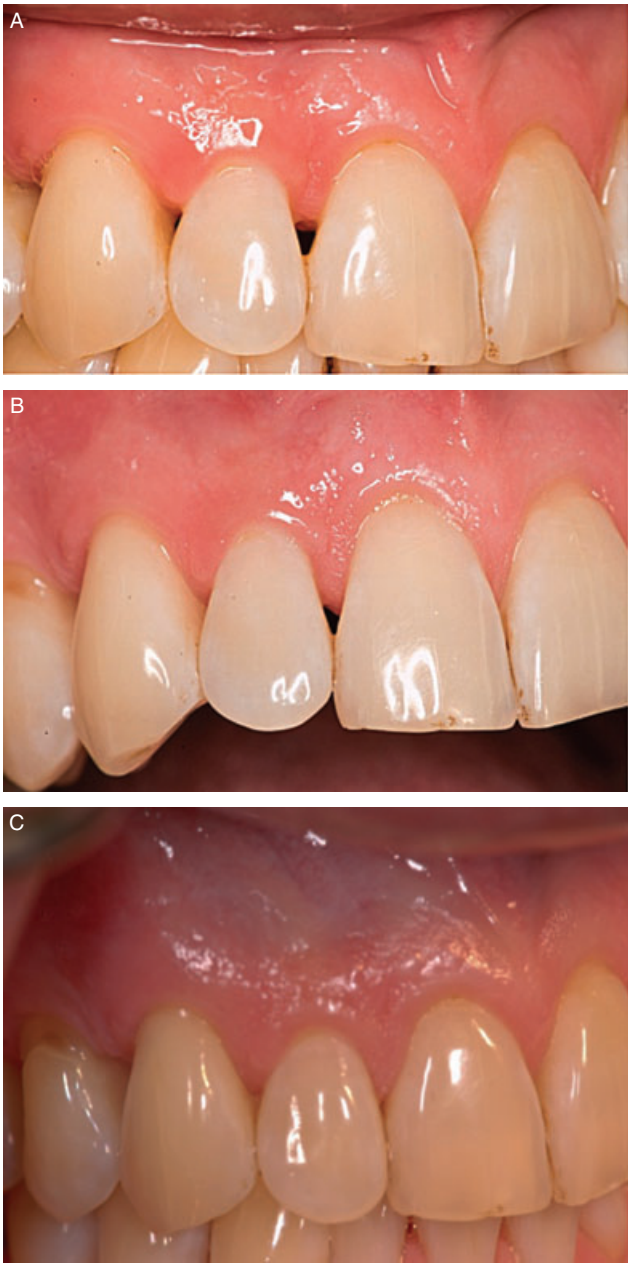

Figure 4 *A,* Photo taken before gel injection. Patient had previous periodontal surgery between the right central and lateral incisors. *B,* Photo taken three weeks after initial injection. *C,* Final photo taken 25 months after initial injection. Note perfect restoration of mesial papilla between the right lateral incisor and canine.

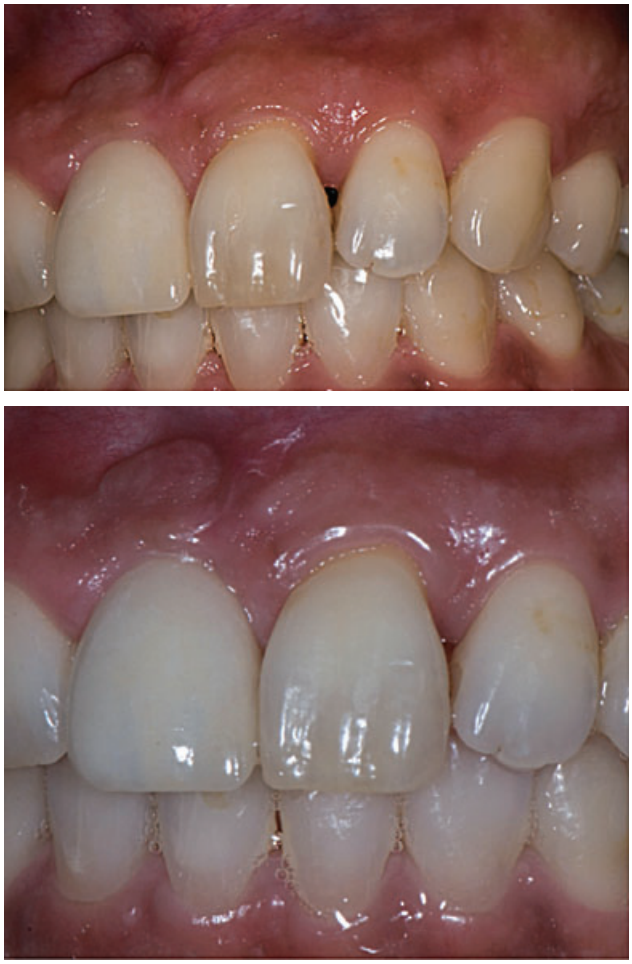

Figure 5 *A,* The left lateral incisor is an implant restoration with deficient papillae between the implant and the left central incisor. *B,* Papilla almost completely restored after two gel applications. Photo taken 10 months after initial treatment.

At final examination, none of the patients showed evidence of relapse, although this is possible over time. Ricci determined the accuracy of a new method that measures changes from photographs taken with a camera positioning device and from study casts. A commercially available computer program was used to make measurements. The technique makes it possible to measure changes in soft tissues with a high degree of accuracy.[28] Others used an image analysis system to measure changes in root coverage.[29] Esthetic demands in dentistry have been increasing and are driven by an enhanced awareness of beauty and physical appearance.[30] Because gingival esthetics has become an important factor in the overall success of most implant-supported restorations, the loss of the peri-implant papilla leads to an esthetic handicap known as "black triangle disease." Today, one of the most challenging aspects of periodontal reconstructive surgery is to obtain predictable peri-implant papillae in the esthetic zone.

Jemt was one of the first authors to evaluate inter-implant papillae. An index was developed to assess the size of the interproximal mucosa adjacent to single-implant restorations was used to evaluate the volume of the papillae two years after crown insertion.[13] The results indicated that the use of provisional crowns may restore soft tissue contour faster than healing abutments alone, but the papillae adjacent to single-implant restorations presented a similar volume in both groups after two years in function. Furthermore, the mean marginal bone loss at the implants was 0.9 mm after one year, and no differences were observed between the two groups studied. A prospective study was designed to evaluate dimensional alterations of the peri-implant tissues at single-tooth restorations from the time of implant placement to one-year post-loading.[3] All 11 patients, aged 18–36 years, subjected to single-tooth replacements with implant-supported restorations in the maxillary anterior region were included in the analysis. The implant installation was performed as a two-stage procedure with a six-month healing interval. Bone dimensions were determined by direct assessments immediately following implant placement and at abutment connection. Assessments of the soft tissues at the implant site and at the neighboring teeth were performed before and during implant placement, before abutment connection, after crown placement, and at the one-year follow-up examination. At abutment connection, a mean loss of bone height at the facial and lingual aspect of the implant amounting to 0.7 to 1.3 mm ($p < 0.05$) was recorded, whereas no significant change was noted at proximal sites. There was a mean apical displacement of the labial soft tissue margin of 0.6 mm. A papilla fill of > or =50% was observed at a frequency of 32% at crown placement and 86% at one year.

The present information focuses on the need for scientific data to evaluate different clinical procedures for optimizing esthetic results in implant dentistry. Grunder[31] evaluated soft tissue stability around 10 single implants. Patients were treated with guided tissue regeneration and connective tissue grafting. One year after prosthesis insertion soft tissue shrinkage on the buccal aspect of the implant crowns was an average of 0.6 mm. Soft tissue volume in the papilla increased an average of

0.375 mm, with no loss of tissue volume. The results of this pilot study indicate that it is possible to enhance papillae that do not entirely fill the interimplant or interdental space with an injectable hyaluronic gel. The results of this pilot study are promising.

CONCLUSION

Patients in this study were treated with a minimally invasive method for enhancing deficient papillae adjacent to dental implants and teeth. A unique model for measuring small changes in deficient papillae is presented. The use of an injectable hyaluronic gel to enhance papillary esthetics after implant treatment should be evaluated in a controlled clinical study. The results of this pilot study are promising.

DISCLOSURE

The authors do not have any financial interest in the company or materials used in this study. This study was self-funded.

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