

The Subepithelial Connective Tissue Graft: Part II. Histologic Healing and Clinical Root Coverage

Constance L. Sedon, DMD, MS; Lawrence G. Breault, DMD, MS;
Lemuel L. Covington, DMD; Barry G. Bishop, DDS



Abstract

Periodontal plastic surgical techniques have evolved to meet the demands of today's dental patient. Free gingival grafts (FGGs), pedicle flaps, subepithelial connective tissue grafts (SCTGs), acellular dermal matrix (ADM) grafts, and guided tissue regeneration (GTR) have all been used to cover denuded root surfaces. FGGs have demonstrated inconsistent results. Pedicle flaps have provided consistent results, but adequate tissue must be present initially. ADM grafts have also demonstrated success, but long-term stability may be a problem. Presently, SCTGs and GTR should be considered the treatment of choice for root coverage. They are the most predictable with average root coverage as high as 98.9% and 92.3%, respectively.

Keywords: Connective tissue graft, root coverage, gingival recession, periodontal plastic surgery

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Introduction

Gingival recession is often caused by restorations¹, trauma², inadequate oral hygiene³, orthodontic movement⁴, frenal pull⁵, and abnormal tooth position.⁶ More than 50% of the population exhibits gingival recession.⁷ The consequences of a denuded root surface can be sensitivity, increased susceptibility to caries, and an unaesthetic appearance. To meet the increasing demand for successful root coverage procedures, the periodontal community has developed a variety of periodontal plastic surgical techniques designed to cover denuded root surfaces. In a previous publication the surgical approaches to one such technique, the subepithelial connective tissue graft (SCTG), were discussed in detail.⁸ The major disadvantage of this technique is the second surgical site required to harvest the graft. This unfortunately results in significant patient morbidity. Additionally, palatal tissues are not always of adequate thickness and inadvertent severing of the palatal blood vessels can result in excessive bleeding. The pedicle flap alone, acellular dermal matrix grafts (ADM), and guided tissue regeneration (GTR) are other techniques used to circumvent these problems associated with the SCTG. This article will provide an overview of the results, in terms of histologic healing and clinical root coverage, that can be expected with the SCTG. Additionally, the SCTG will be compared with the alternative techniques mentioned above.

Although mean root coverage is the standard criteria used to determine the success or failure of a periodontal plastic surgery technique, it is only a measure of clinical success. A truly successful technique would achieve periodontal regeneration. That is the production of bone, Sharpey's fibers with periodontal ligament (PDL), and cementum with inserting collagen fibers. An histological examination is required to determine whether or not regeneration has occurred. Unfortunately, the number of human studies is limited because this necessitates the extraction of the tooth involved in the surgery.



Current Surgical Techniques

Subepithelial Connective Tissue Grafts (SCTG)

Harris examined histologic healing 6 months after two mandibular premolars (2 and 3 mm of recession) were treated with a partial thickness double pedicle



connective tissue graft (CTG). Root coverage of 100% and 83.3% was achieved. Two healing patterns emerged; a long junctional epithelium or a short junctional epithelium with a long connective tissue attachment that did not appear to insert into the cementum. No regeneration of bone or cementum was observed.⁹ In another publication Harris used a CTG with a partial thickness flap to completely cover 4 mm of recession on a maxillary central incisor. In this report he demonstrated new bone, cementum, and connective tissue attachment after 5 months of healing.¹⁰

Bruno and Bowers reported on the healing of a maxillary premolar with 8 mm of recession treated by a SCTG after 1 year. They found that the 75% root coverage was predominantly due to connective tissue adhesion. Limited regeneration occurred at the apical portion of the recession treated defect only.¹¹

Rasperini and colleagues treated a mandibular canine with 6 mm of recession using a CTG covered by a partial thickness flap and Enamel Matrix Derivative (EMD). Six months later they achieved 33% root coverage, 1.87 mm of new bone, and 2.25 mm of connective tissue anchored in 0.06 mm of new cementum.¹²

Goldstein et al. reported on the healing of a maxillary premolar with 5 mm of recession 14 months after treatment with CTG covered by a full thickness coronally positioned flap (CPF). They achieved 80% root coverage. New connective tissue attachment and periodontal ligament were apparent. Additionally, junctional epithelium extended over new cementum.¹³

Majzoub and colleagues extracted two maxillary premolars (2.5 and 3 mm recession) one year after treatment with a CTG covered by a partial thickness CPF. Final root coverage of 100% and 83.3% was reported. Healing occurred via long junctional epithelium with minimal new attachment and bone at the apical portion.¹⁴

Carnio et al. successfully treated 3 maxillary canines (two with 6 mm of recession and one with 5 mm) and 1 first premolar with 4 mm of recession using the technique described by Nelson¹⁵ and topical application of EMD. Final root coverage ranged from 50% to 100%. Two teeth were extracted at 6 months followed by the remaining two at one year. The histology indicated the attachment was primarily due to adhesion with minor periodontal regeneration in apical areas of one tooth. Interestingly, a long junctional epithelium did not develop.¹⁶

McGuire and Cochran evaluated the healing of a CTG with a CPF and EMD used to treat Miller Class IV recession on a maxillary central and canine. After 6 months, some root resorption occurred but no regeneration.¹⁷

Free Gingival Grafts (FGG)

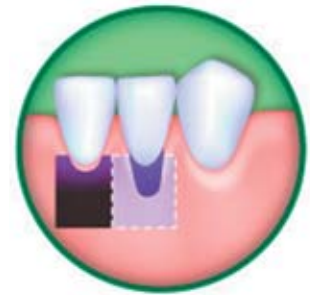
Although the FGG is not routinely utilized as the treatment of choice for root coverage procedures, some periodontal regeneration has been reported with this technique. Pasquinelli demonstrated 83% root coverage 10.5 months following a FGG on a single mandibular premolar with 6 mm of recession. True periodontal regeneration with 4.0 mm of new bone growth and 4.4 mm of new attachment had occurred. The author suggested the thick gingival graft acted as a barrier to epithelial down growth.¹⁸



Pedicle Flaps

Sugarman demonstrated a laterally positioned flap on a maxillary molar and canine and mandibular premolar produced new connective tissue attachment and bone.¹⁹ Using the same technique and root conditioning with

citric acid, Common and McFall reported new cementum and collagen fibers parallel to the root on defects created on mandibular incisors²⁰. McGuire and Cochran examined the healing of a CPF with enamel matrix derivative on a maxillary lateral and canine. This combination produced new bone, organizing PDL fibers and new cementum.¹⁷



Acellular Dermal Matrix (ADM) Grafts

Richardson and Maynard examined healing 16 weeks after placing an ADM graft on a nonrestorable maxillary canine without recession and found the matrix was separated from the root by fibrous tissue. The coronal portion of the graft was not revascularized, no new cementum was formed, but displacement of junctional epithelium was seen. The apical portion of the matrix appeared to be resorbed and replaced by connective tissue.²¹



Guided Tissue Regeneration (GTR)

Although GTR is technically demanding, when executed properly, it can result in significant periodontal regeneration.^{22, 23, 24} Cortellini et al. treated a mandibular incisor with 8 mm of recession and found periodontal regeneration. After 5 months of healing, they documented 50% root coverage, 3.66 mm of new connective tissue, 2.48 mm of new cementum, and 1.84 mm of bone growth.²³ Parma-Benfenati and Tinti treated a 7 mm recession on a mandibular incisor with GTR. After 9 months and 43% root coverage, histologic study revealed 5.6 mm of new connective tissue attachment and 6.7 mm of new bone.²⁴ Conversely, Harris reported bone loss and formation of a long junctional epithelium when GTR was used to treat

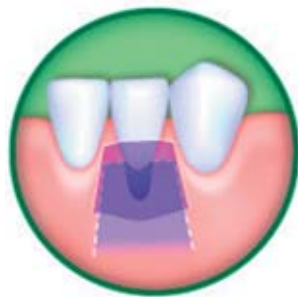


multiple maxillary anterior teeth with 2 to 4 mm of recession. Limited root coverage of 16.7% to 50% was achieved in this study.²⁵

As these studies indicate, regeneration is clearly possible with periodontal plastic surgery. Pedicle flaps and GTR seem to provide more consistent regeneration than SCTGs. Harris postulated the discrepancies in histologic healing of SCTGs might be explained by the original depth of the recession.²⁶ In most cases where regeneration was reported, the defects were greater than 4 mm. Majzoub et al. proposed that technique itself may also affect the histology. A graft that is entirely covered by a flap might put oral epithelial cells in early contact with the root surface.¹⁴ This would allow epithelial downgrowth and almost guarantee the formation of a long junctional epithelium. More histologic studies will be needed to test these hypotheses.

Creeping Attachment

In any discussion of root coverage creeping attachment is an important concept. Not only is it important in regard to the time frame of a study of root coverage, it can be clinically valuable when total root coverage requires only minimal additional attachment. Goldman was the first to describe creeping attachment as the increased gingival coverage over a denuded root surface that takes place over an extended period of time after surgery.²⁷ Borghetti and Gordella suggested any increases in attachment after 1 month of healing should be considered creeping attachment.²⁸ Studies have shown this additional attachment can range from 0.43 mm to 0.89 mm with FGGs.^{29,30} After 12 months of healing, Haeri and Parsell reported 1.23 mm of creeping attachment following a FGG and 0.96 mm following ADM graft.³¹ Harris examined creeping attachment after a SCTG with partial-thickness double pedicle flaps and tried to identify factors that could affect it. Of the 22 factors he monitored, none statistically contributed to creeping attachment. In 95.5% of sites, he found an average of 0.8 mm of additional coverage that leveled off after 26-38 weeks. In 17 of 21 sites it



provided the extra attachment needed for 100% root coverage.³² In a related effort evaluating the long-term success of SCTG Harris found that root coverage increased, on average, 0.4 mm with time.³³ According to Lee et al. at 3 years, 72.7% of sites treated by SCTG with a CPF exhibited creeping attachment, with an average increase of 0.55 mm of coverage.³⁴ Although Harris suggested that another surgery should be considered if desired results are not achieved within 6 to 9 months², Lee et al. reported creeping attachment was highest at 12 months.³⁴ This phenomenon may be unpredictable, however, it can be very valuable.

Root Coverage

Results of SCTG Techniques

Table 1 includes the results of studies designed to determine the success of a variety of subepithelial connective tissue grafting techniques. In most cases Miller Class I and II recessions were treated. The SCTG has proven to be a predictable technique with mean root coverage ranging from 69.2% to 98.9% as reported by Wennström and Zuchelli. They attributed their high success rate to the emphasis they placed on proper brushing techniques that focus on reducing trauma at the sites of recession.⁴²

The study by Goldstein et al. is of particular interest because they demonstrated a SCTG could predictably cover previously carious root surfaces. This illustrates an alternative treatment for carious roots that is perhaps more aesthetic and biocompatible than a restoration.⁴⁷

The studies by Harris and Cordioli et al. compared different connective tissue grafting techniques. Harris contrasted SCTGs with double pedicle flaps or coronally positioned flaps and achieved similar results with either technique. The double pedicle, however, produced a larger increase in keratinized tissue and greater root coverage when recessions exceeded 5 mm.⁴⁸ Cordioli and colleagues found no significant differences in the amount of root coverage achieved using a SCTG combined with either envelope flaps or CPFs. The envelope technique, however, produced greater increases in keratinized tissues.⁴⁵

Table 1 also includes the percentage of teeth exhibiting 100% root coverage. If we consider that patient satisfaction revolves around complete coverage of the recession and an aesthetic result, it follows that a successful technique would consistently result in 100% root coverage. This percentage ranges from 20% to 93% for SCTGs.^{40, 50}

Comparisons with Other Techniques

Free Gingival Grafts (FGGs)

In a study published in 1985 Miller achieved 100% root coverage of Class I recessions and 88% of Class II recessions using FGGs.⁵¹ With a similar technique, Matter reported 70% coverage of recessions less than 3 mm wide.⁵² Although these early results seemed promising, the use of the FGG for root coverage was fleeting. Jahnke et al. and Paolantonio et al. illustrated the superiority of the bilaminar SCTG technique over the FGG. Using the FGG, they achieved only 43% and 53.19% +/-21.48% root coverage, respectively. However, with a SCTG, they attained 80% and 85.23% +/-17.86% root coverage, respectively. Both authors reported complete root coverage more often with SCTG.^{37, 53}

Pedicle Flaps

Table 2 includes the results of studies that compare SCTGs with CPFs. Wennstrom and Zucchelli⁴² and later da Silva et al.⁵⁶ contrasted the CPF alone, with the SCTG covered by a CPF. They found both techniques produced similar results. Berlucchi et al. and McGuire and Nunn found that a CPF, in combination with EMD, produced similar results to the SCTG but with less morbidity.^{54, 55} The only study included here that found the SCTG statistically superior to the CPF was published by Nemcovsky et al.⁵⁷ In all of the studies the SCTG produced a greater increase in keratinized gingiva.^{42, 55, 56, 57} Clearly, if the tissues are adequate and an increase of keratinized gingiva is not a goal of surgery, pedicle flap procedures without a graft are a dependable treatment option.

Acellular Dermal Matrix

Table 3 illustrates the results of a sampling of studies comparing SCTGs and ADM.

ADM is dermis that has been treated to remove all cells, leaving behind a scaffold of collagen. When placed as a graft material, the recipient's cells repopulate the scaffold and blood vessels easily invade the channels left by the original vessels.

Novaes et al. reported root coverage of 66.5% for CPF with ADM and 64.9% for CTG with CPF on a total of 30 roots with Miller Class I or II recession. At 6 months, they noted no difference in keratinized tissue between the groups.⁵⁸

At 6 months, Aichelmann-Reidy et al. found no significant differences in coverage or keratinized tissue between the use of ADM or CTG on 44 sites with > or = 2 mm recessions. ADM produced 65.9% +/-46.7% root coverage and SCTG 74.1% +/-38.3%. Complete root coverage was more common with SCTG. However, both clinicians and patients felt ADM produced a more aesthetic result.⁵⁹

In a comparison between either a CTG or ADM covered with CPF Tal et al. found little difference in coverage of recessions > or = 4 mm. However, greater increases in keratinized tissue were noted with the CTG. They reported 89.1% coverage of 7 teeth using ADM and 88.7% for 7 teeth using CTG after 12 months.⁴³

Paolantonio and colleagues treated 30 sites with Miller Class I or II recession by either SCTG or ADM. After 1 year, they reported 88.80 +/- 11.65% root coverage and 83.33 +/- 11.40%, respectively. Although not statistically significant, complete root coverage was more common with the SCTG; 46.6% compared to 26.6% with ADM. Faster healing was also reported with the SCTG.⁶¹

Harris published a retrospective study of the short- and long-term comparisons of ADM and SCTG. After 12.3 to 13.2 weeks, the mean root coverage for ADM sites was 93.4% and for the SCTG sites 96.6%. After 48.1 to 49.2 months, the SCTG sites had achieved 97.0% coverage while the ADM sites plummeted to 65.8% coverage. However, Harris noted 32% of the ADM sites sustained coverage or improved with time.⁶²

Table 1. Reports of root coverage using SCTG.

Author, Year	Technique	# of sites treated	% Mean root coverage	Follow-up (months)	Percent of sites with 100% coverage
Raetzke, 1985 ³⁵	Partial thickness envelope flap	12	80%	2-8	42%
Nelson, 1987 ¹⁵	Full thickness flap	29	91%	6-42	62%
Harris, 1992 ³⁶	Partial thickness double pedicle flap	30	97.4%	3	80%
Jahnke et al., 1993 ³⁷	Partial thickness envelope flap	9	80%	6	56%
Allen, 1994 ³⁸	Envelope flap	23	84%	6-48	61%
Borghetti and Louise, 1994 ³⁹	Nelson's Subpedicle CTG ²⁵ (double papilla pedicles, full thickness flap)	15	70.9%	12	40% (75-100% covered)
Bouchard et al., 1994 ⁴⁰	Langer and Langer ⁴¹ technique, with citric acid root conditioning, without the epithelial collar on CTG	15	70%	6	20%
Bouchard et al., 1994 ⁴⁰	Langer and Langer ⁴¹ technique, without root conditioning, with epithelial collar on CTG	15	65%	6	33%
Wennström and Zucchelli, 1996 ⁴²	CTG+CPF	58	98.9%	24	88%
Müller et al., 1998 ⁴⁴	Envelope flap	28	74%+/-30%	12	39.3%
Cordioli et al., 2001 ⁴⁵	CTG+CPF	31	94.7%+/-11.4%	12-18	81%
Cordioli et al., 2001 ⁴⁵	Partial thickness envelope flap	31	89.6%+/-15%	12-18	64%
Hirsch et al., 2001 ⁴⁶	Langer and Langer technique ⁴¹	44	95%+/-1.84%	Mean of 32.6	84.1
Goldstein et al., 2002 ⁴⁷	Modification of Langer and Langer ⁴¹	33 intact teeth 27 previously carious roots	97.46%+/-0.79 92.41+/-2.38.%	72	73%
Harris, 2002 ⁴⁸	CTG + CPF	144	96.1%	3	84%
Harris, 2002 ⁴⁸	CTG + Double pedicle flap	122	97.6%	3	86.9%
Lee et al., 2002 ³⁴	CTG + CPF	21	91.28%	36	52.38%
Harris, 2002 ³³	CTG + envelope flap	146	98.4%	27.5	92.5%
Harris, 2003 ⁴⁹	CTG + envelope	50	91.1%	3	58%
Tözüm and Dini, 2003 ⁵⁰	Modified tunnel technique (partial and full thickness envelope flap)	14	95%	8	93%

Table 2. Root coverage: Pedical Flaps and SCTG.

Author, Year	Techniques compared	Root coverage	Follow up (months)	Percentage of sites with 100% root coverage
Wennström and Zucchelli, 1996 ⁴²	CPF alone	97.1%	24	80%
	CPF + CTG	98.9%	24	88%
Berlucchi et al., 2002 ⁵⁴	CPF + EMD	93.97%+/-11.78%	6	76.9%
	CPF+CTG+EMD	93.59%+/-16.01%	6	84.6%
McGuire and Nunn, 2003 ⁵⁵	CPF +EMD	93.8%	12	79%
	CPF + CTG	95.1%	12	89.5%
daSilva et al., 2004 ⁵⁶	CPF alone	69%	6	9%
	CPF + CTG	75%	6	18%
Nemcovsky et al., 2004 ⁵⁷	CPF + EMD	71.7%+/-16.14%	12	NR
	CTG + CPF	87.0%+/-12.22%	12	NR

NR – Not reported

Table 3. Root coverage: ADM and SCTG.

Authors	Percent Root coverage ADM	Percent Root Coverage SCTG	Follow up (months)	Percentage of sites with 100% root coverage ADM	Percentage of sites with 100% root coverage SCTG
Novaes et al., 2001 ⁵⁸	64.9%	66.5%	6	33%	40%
Aichelmann-Reidy et al., 2001 ⁵⁹	65.9%+/-46.7%	74.1%+/-38.3%	6	32%	50%
Tal et al., 2002 ⁶⁰	89.1%	88.7%	12	43%	43%
Paolantonio et al., 2002 ⁶¹	83.33%+/-11.40%	88.80%+/-11.65%	12	26.6%	46.6%
Harris et al., 2004 ⁶²	93.4%	96.6%	3	80.7%	82.1%
	65.8%	97.0%	12	39.6%	89.7%

Guided Tissue Regeneration

Table 4 illustrates the results of a sampling of studies comparing SCTGs and GTR.

The majority indicate that neither procedure is statistically superior. The studies by Trombelli et al., Zuchelli et al., Müller et al., and Cetiner et al. reported better results using a SCTG.^{64, 66, 71 74} Zuchelli et al. found SCTG preformed better only when compared to non-resorbable membranes. They found

no significant differences when using a bioabsorbable membrane. Müller et al. found the odds of achieving > 80% root coverage were 3.3 times greater with a SCTG when treating shallow recession in the 1.5 to 3.5 mm range. Harris noted GTR was more successful when the tissue in the area of the defect was not thin.⁶⁵ Other differences noted between the two techniques were the greater increase in keratinized gingiva achieved with SCTGs^{63, 67, 68 73} and the superiority of GTR for coverage of severe mucogingival defects.^{63, 74} However Zuchelli et al. tested the

Table 4. Root coverage: GTR and SCTG.

Author, Year	Average root coverage with SCTG	Average root coverage with GTR	Percentage of sites with 100% root coverage SCTG	Percentage of sites with 100% root coverage GTR	Follow-up (months)
Ricci, 1996 ⁶³	77.08%	80.88%	NR	NR	12
Trombelli, 1998 ⁶⁴	81%	48%	50%	8.3%	6
Harris, 1998 ⁶⁵	95.0%	92.3%	73.7%	72.2%	6
Zuchelli et al., 1998 ⁶⁶	93.5%+/-8.6%	85.7%+/-13.8% and 80.5%+/-14.9%*	66%	39% and 28%	12
Borghetti, 1999 ⁶⁷	76%	70.2%	29%	29%	6
Rosetti, 2000 ⁶⁸	95.6%	84.2%	NR	NR	18
Tatakis et al., 2000 ⁶⁹	96%	81%	83%	58%	6
Romagna-Genon, 2001 ⁷⁰	84.84%	74.59%	NR	NR	6
Müller et al., 2001 ⁷¹	81-82%	50%	NR	NR	12
Wang et al., 2001 ⁷²	84%	73%	43.8%	43.8%	6
Paolantonio, 2002 ⁷³	90%	81.01%	60%	40%	12
Cetiner et al., 2003 ⁷⁴	86.3%	74.3% and 69.6%**	NR	NR	12

NR – not reported

*Bioabsorbable and non-resorbable membrane, respectively.

**Two types of bioabsorbable barriers were used in the study.

superiority of the GTR in severe defects (>4 mm) and found SCTGs performed just as well.⁶⁶

Roccuzzo et al., in a thorough review of 30 trials of periodontal plastic surgery techniques for root coverage, found that although neither technique was clearly superior, the SCTG was statistically slightly more effective at reducing gingival recession.⁷⁵ Similarly, in their review of randomized clinical trials, Oates et al. concluded SCTGs appeared to be more successful than GTR in increasing keratinized tissue width and root coverage.⁷⁶

Minimal gingival thickness is a known risk factor for recession.⁷⁷ Cetiner et al. reported a SCTG provides thicker keratinized tissues than GTR.⁷⁴ This difference could potentially affect the long-term success of these techniques. Several authors have examined the stability of root

coverage using the GTR technique. Pini Prato and colleagues reported an average root coverage of 72.73% at 18 months and 73.07% after 4 years in 25 sites.⁷⁸ They noted GTR was more effective than a CTG with a CPF in recessions > or = 5 mm. Scabbia and Trombelli demonstrated mean root coverage of 80% in 20 sites after 4 years.⁷⁹ Conversely, Harris reported that mean root coverage of 92.3% in 17 sites at 6 months dropped to 58.8% after a mean of 25.3 months.⁸⁰ Further studies are necessary to evaluate the long-term success of GTR for root coverage.

For more results regarding root coverage using a variety of surgical techniques, the reader is directed to a paper published by Pagliaro et al. This article presents, in table format, the results of 90 studies spanning a 30 year period.⁸¹

Summary

The evolution of periodontal plastic surgical techniques has allowed the clinician to meet the demands of today's dental patient. FGGs, pedicle flaps, SCTGs, ADM grafts, and GTR have all been used to cover denuded root surfaces. FGGs provided inconsistent results and are no longer widely used for root coverage. If adequate tissues exist, pedicle flaps are a reliable treatment modality. ADM has been

used successfully, but the long-term stability of these sites is now in question. SCTGs and GTR should be considered the treatment of choice for root coverage. They are the most predictable; with average root coverage as high as 98.9% and 92.3%, respectively. The majority of studies concluded they provide comparable results, however, SCTG has statistically been shown to be slightly superior to GTR. Additionally, the long-term success of GTR has yet to be proven.

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About the Authors

Constance L. Sedon, DMD, MS



Captain Sedon graduated from the Advanced General Dentistry Program (AGDP-1) at Fort Benning in 2003. She presently is assigned to the 561st Medical Company in Grafenwöhr, Federal Republic of Germany.

Lawrence G. Breault, DMD, MS



Dr. Breault currently serves as a Colonel in the United States Army and is a Diplomate of the American Board of Periodontology. He is the Periodontic mentor and Chief of Periodontics, U.S. Army Dental Activity, Fort Benning, GA.

Lemuel L. Covington, DMD



Colonel Covington is the Director of the Advanced General Dentistry Program at Fort Benning, Georgia.

Barry G. Bishop, DDS



Colonel Bishop is the Director of the AGDP-1 at Fort Benning, GA. He is a Master in the Academy of General Dentistry and a Diplomate of the American Board of General Dentistry.

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