A Short-Term and Long-Term Comparison of Root Coverage With an Acellular Dermal Matrix and a Subepithelial Graft

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Background: Obtaining predictable and esthetic root coverage has become important. Unfortunately, there is only a limited amount of information available on the long-term results of root coverage procedures. The goal of this study was to evaluate the short-term and long-term root coverage results obtained with an acellular dermal matrix and a subepithelial graft.

Methods: An *a priori* power analysis was done to determine that 25 was an adequate sample size for each group in this study. Twenty-five patients treated with either an acellular dermal matrix or a subepithelial graft for root coverage were included in this study. The short-term (mean 12.3 to 13.2 weeks) and long-term (mean 48.1 to 49.2 months) results were compared. Additionally, various factors were evaluated to determine whether they could affect the results. This study was a retrospective study of patients in a fee-for-service private periodontal practice. The patients were not randomly assigned to treatment groups.

Results: The mean root coverages for the short-term acellular dermal matrix (93.4%), short-term subepithelial graft (96.6%), and long-term subepithelial graft (97.0%) were statistically similar. All three were statistically greater than the long-term acellular dermal matrix mean root coverage (65.8%). Similar results were noted in the change in recession. There were smaller probing reductions and less of an increase in keratinized tissue with the acellular dermal matrix than the subepithelial graft. None of the factors evaluated resulted in the acellular dermal graft having a statistically significant better result than the subepithelial graft. However, in long-term cases where multiple defects were treated with an acellular dermal matrix, the mean root coverage (70.8%) was greater than the mean root coverage in long-term cases where a single defect was treated with an acellular dermal matrix (50.0%).

Conclusions: The mean results with the subepithelial graft held up with time better than the mean results with an acellular dermal matrix. However, the results were not universal. In 32.0% of the cases treated with an acellular dermal matrix, the results improved or remained stable with time. *J Periodontol 2004;75:734-743.*

KEY WORDS

Connective tissue/surgery; follow-up studies; gingival recession/surgery; grafts, connective tissue; grafts, gingival; grafts, soft tissue; surgical flaps; tooth root/surgery.

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Predictable and esthetic root coverage has been documented in multiple clinical studies.[1,2] Additionally, several techniques have been developed to obtain these results. The autogenous masticatory graft (free gingival graft) was proposed by Miller[3] as the first predictable technique to obtain root coverage. However, the esthetics were not ideal. The use of a connective tissue graft and an overlaying pedicle graft or pouch (subepithelial graft) were developed by Langer and Langer[4] and Raetzke.[5] These techniques had excellent predictability and improved esthetics over the free gingival graft. Over the years various modifications to the original techniques have been developed.[1,2] This group of root coverage procedures has become the standard by which other root coverage techniques are judged.

In an effort to avoid removing a connective tissue graft from the palate, other root coverage techniques have been suggested. The pedicle graft was shown to be extremely predictable by Allen and Miller.[6] However, it was made very clear in their article that the technique was recommended in shallow recession defects. In an effort to treat a wider array of defects, guided tissue regeneration techniques were developed.[1,2] However, the ability of guided tissue regeneration to produce a stable long-term result has been questioned.[7]

Recently, the use of an acellular dermal matrix† has been proposed as a technique to obtain root coverage.[8-16] The goal of this procedure was to maintain the high

† AlloDerm BioHorizons, Birmingham, AL.

rates of success and outstanding esthetics documented with the subepithelial graft without needing to obtain a connective tissue graft from the palate. This would simplify the surgery, eliminate the need for a second surgical site and permit treating an unlimited number of defects at one time. These potential advantages could improve patient acceptance, decrease complications and increase clinical efficiency. These potential advantages have contributed to the rapid acceptance and incorporation into clinical practice of this root coverage technique.

Multiple clinical studies have documented predictable and esthetic results with an acellular dermal graft.[8-16] Reported mean root coverages, 86%,[9] 94.3%,[10] 95.8%,[11] 95%,[12] 93%,[12] 83.2%,[13] 83.33%,[14] 91.7%,[15] 87.0%,[15] 89.1%,[16] compare well with other root coverage techniques.[1,2] However, there is only limited information available when one questions the long-term results of this technique. The study with the longest follow-up using the acellular dermal matrix for root coverage reported on a group of 20 patients with a mean follow-up of 18.6 months.[15] This group of patients had a mean root coverage of 91.7% at 12 weeks postoperative and 87.0% at 18.6 months. This difference was not statistically significant. However, the numerical change in a negative direction demands further study, especially when the results of that study are compared to a similar long-term study of subepithelial grafts for root coverage.[17] One hundred patients treated with subepithelial grafts had a mean root coverage of 97.1% at 13.0 weeks and 98.4% at 27.5 months postoperative.[17] Contrary to the acellular dermal matrix study,[15] the change from short-term to long-term was a positive change, and it was statistically significant.[17]

There is a need for additional long-term study of the acellular dermal matrix for root coverage. This will aid the clinician in selecting a technique to utilize. The goal of this study was to evaluate the long-term root coverage results obtained with an acellular dermal matrix. These results would be compared to the short-term results with an acellular dermal matrix, as well as the short-term and long-term results with a subepithelial graft.

MATERIALS AND METHODS

In order to be sure that an adequate sample size was utilized, an *a priori* power analysis was accomplished with a computer program for size determination.‡ The calculation would be based on two root coverage studies.[15,17] One study was a long-term (27.5 months) evaluation of subepithelial grafts, with a sample size of 100[17] and the other study was a long-term (18.6 months) evaluation of acellular dermal grafts, with a sample size of 20.[15] Data from those root coverage studies,[15,17] an alpha of 0.01, and power of 0.8 were to be used. The calculations were done so that the statistical analysis would be able to detect a 5% difference in the mean root coverage. Once an adequate sample size was determined, this number of patients would be divided between the treatment groups included in the study. The resulting number was rounded up to the next integer to keep group sizes the same. This number, the number of patients required in each group, was called n.

A starting date was selected. It was the first date that an acellular dermal matrix was used for root coverage by the author. Starting from that date, n consecutive patients presenting to my office for any reason treated with an acellular dermal matrix for root coverage and n consecutive patients presenting to my office for any reason treated with a subepithelial graft for root coverage, meeting the following criteria, were included in this study. The criteria were: in good health with no contraindication to surgical periodontal therapy; able to understand and willing to sign an informed consent form (or if the patient is a minor, then a guardian that could do this); never had surgical therapy in the area to be treated with the root coverage procedure; have at least one Miller Class I or Class II defect[18] with a marginal tissue recession (recession) of at least 2 mm treated with one of the two techniques to be evaluated in this study; and have an approximately 3-month follow-up (minimum 9 weeks) and at least a 3-year follow-up. The patients included in this study were not randomly assigned to the treatment groups. The selection criteria to determine which surgical procedure was used was based on a clinical decision by the clinician, and agreed to by the patient. All patients were treated in a fee-for-service private practice environment. Descriptive information about the groups would be reported. This would include information on the number of defects, location of the defects, age of the patient, gender of the patient, and smoking history.

Preoperative photographs were taken (Figs. 1A, 2A, and 3A) and preoperative clinical measurements (PR) were recorded. All measurements were made with a Williams style periodontal probe, by the author. These included: recession (measured in the deepest location), probing depth (measured in the same location as the recession), and attachment level (measured from the cemento-enamel junction or a fixed reference point in the same location as the recession). The measurements were rounded to the nearest 0.5 mm.

All procedures would be performed as previously reported.[15,19] After obtaining anesthesia, the exposed root surface was root planed and treated with tetracycline. Incisions were made to create a recipient bed for the graft and the overlaying pedicle graft. The goal of the pedicle design was to cover the maximum amount of graft with the least tension. All cases treated with an acellular dermal graft would utilize a coronally positioned pedicle. The cases treated with a subepithelial

‡ PC-Size, Dallal GE, Boston, MA.

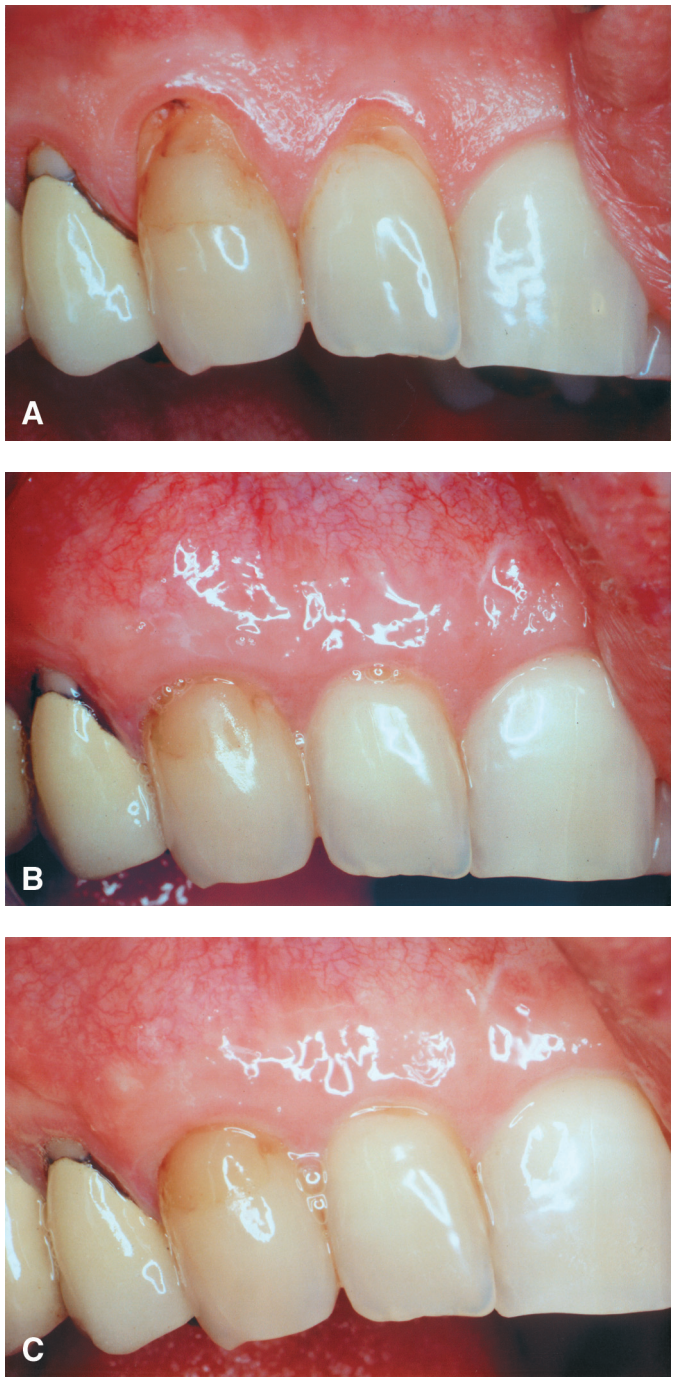

Figure 1.
A) *Preoperative defect treated with acellular dermal matrix, teeth #6 and 7.* ***B)*** *Short-term postoperative 12 weeks, teeth #6 and 7.* ***C)*** *Long-term postoperative 49 months, teeth #6 and 7. Note the stable result between 12 weeks and 49 months.*

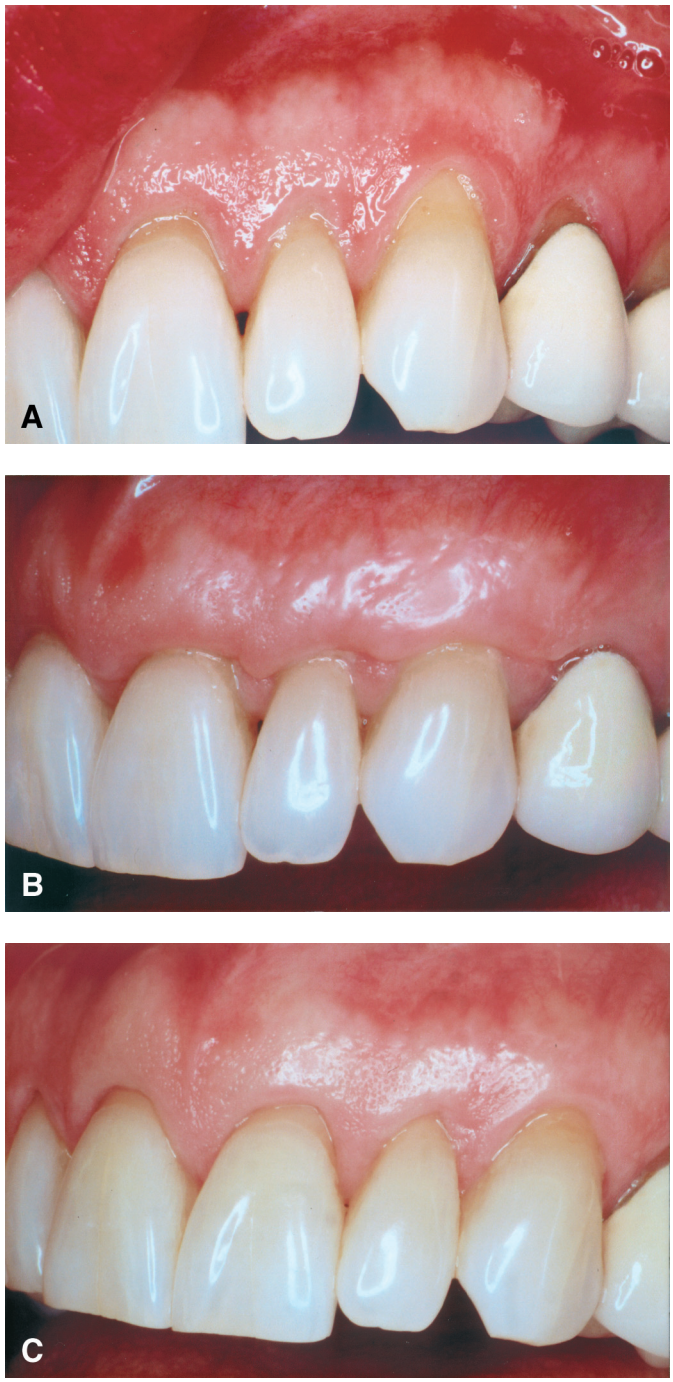

Figure 2.
A) *Preoperative defect treated with acellular dermal matrix, teeth #9,10, and 11.* ***B)*** *Short-term postoperative 12 weeks, teeth #9,10, and 11.* ***C)*** *Long-term postoperative 57 months, teeth #9,10, and 11. Note the increased recession between 12 weeks and 57 months.*

graft would be treated with a double pedicle graft or a coronally positioned pedicle. The pedicle was reflected by sharp dissection as close to periosteum as possible.

The acellular dermal matrix material was prepared as suggested by the manufacturer. This material was the graft in the cases where an acellular dermal matrix was used. In cases treated with a subepithelial graft, a connective tissue graft was removed from the palate with a scalpel with parallel blades§ as previously described.[20] The epithelial border was removed and discarded. In

§ Harris Double Blade Graft Knife, H & H Company, Ontario, CA.

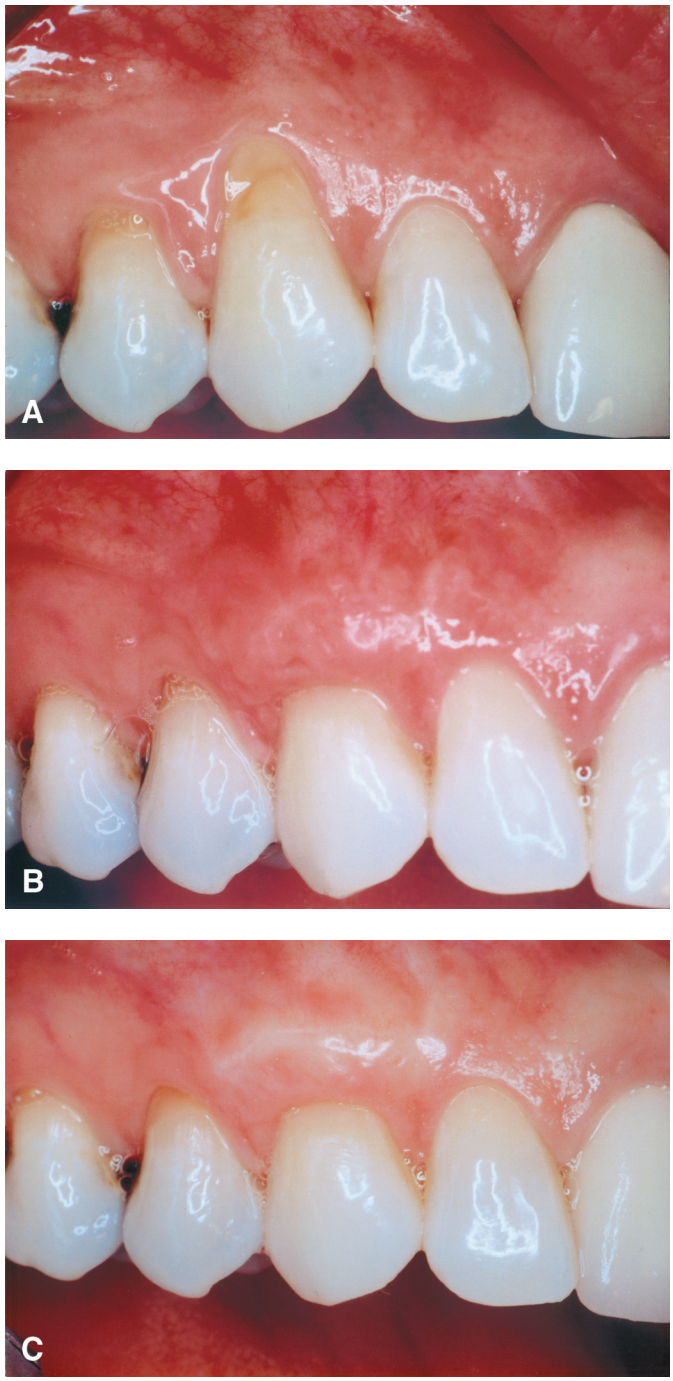

Figure 3.
A) *Preoperative defect treated with subepithelial graft, tooth #6.* ***B)*** *Short-term postoperative 13 weeks, tooth #6.* ***C)*** *Long-term postoperative 52 months, tooth #6. Note the stable result between 13 weeks and 52 months.*

the cases treated with a subepithelial graft, this piece of connective tissue was the graft. The grafts were sutured into the recipient bed with 5-0 or 6-0 gut or chromic gut. The pedicle was sutured over the graft with 5-0 gut or chromic gut sutures. Isobutyl cyanoacrylate‖ and a periodontal dressing¶ were applied. Verbal and written postoperative instructions were given. Unless contraindicated, all patients were placed on ibuprofen, chlorhexidine rinse, and given a narcotic preparation prescription to be taken if needed. All surgeries were performed by the author.

Patients were seen for postoperative care at 1 to 2 weeks, 4 to 6 weeks, 9 to 16 weeks, and as determined to be needed. Patients were returned to normal oral hygiene as soon as the tissues had healed enough to permit it. At 9 to 16 weeks postoperative (Figs. 1B, 2B, and 3B), clinical measurements were recorded (FU1). These were the same measurements that were recorded preoperatively. All measurements were made by the author. Patients were either returned to their referring dentist or placed into maintenance therapy, alternating between the patient's general dentist and the author. A second follow-up evaluation was done at least 3 years postoperative (FU2) (Figs. 1C, 2C, and 3C). The reason for the reevaluation of the treated area was either part of routine maintenance therapy or that the patient was referred back to the author for treatment of another area. The same clinical measurements were recorded as at PR and FU1. Once again, all measurements were made by the author.

Statistical evaluation was accomplished in five parts. For all statistical evaluations the patient was maintained as the unit of measurement. In patients where more than one defect was treated, a mean of the clinical measurements was used. Each patient produced one set of data. An alpha of 0.01 was selected for all calculations. The first part of the statistical analysis was to compare the defects preoperatively to be sure that they were similar. To do this, the PR clinical measurements for the two procedures were compared with a *t* test.[21] The second part was to see if the surgical procedures had an effect on the clinical parameters. To do this, PR was compared to FU1 and PR was compared to FU2 for the two procedures with a paired *t* test.[21] The third part was to see if there was a change in the clinical parameters between FU1 and FU2. To do this, FU1 and FU2 were compared for the two procedures with a paired *t* test.[21] The fourth part was to see if one procedure or the other resulted in different changes in the clinical parameters or mean root coverage at FU1 or FU2. To do this, the changes in the clinical parameters and mean root coverage from PR to FU1 and PR to FU2, for both procedures, were compared with a one-way analysis of variance (ANOVA).[21] If a statistically significant F was found, then a Fisher's least significant difference test would be utilized to determine which groups were different by a statistically significant amount.[22] The fifth part was to see if any factors could be related to a statistically significant difference in the

‖ IsoDent, Ellman International, Hewlett, NY.
¶ Barricaid, Dentsply, L.D. Caulk Division, Milford, DE.

amount of mean root coverage. The factors were: preoperative recession depth (≤3.0 mm or >3.0 mm), attached gingiva in the area of the defect (was the probing depth less than the amount of keratinized tissue), patient in a recall program or referred back to the author for treatment of another area, defect in the maxillary arch or mandibular arch, defect in the anterior (#6-11 and #22-27) or posterior (#1-5, #12-21, and #28-32) (if the patient had defects in both the anterior and posterior, then the patient was placed in the group based on which defects had the greatest recession depth), defect was a single defect or treated as multiple defects, the age of patient (greater than or less than the total mean of all patients), and gender of patient. An ANOVA was used.[21] If a statistically significant F was found, then a Fisher's least significant difference test would be utilized to determine which groups were different a statistically significant amount.[22] Since there would be an increased number of groups in this evaluation, the *a priori* power analysis would not be adequate in this part of the evaluation. In part 5 of the statistical evaluation, if a difference between two groups was not statistically different, one could not conclude that they were statistically equivalent. A computer spreadsheet[#] was used for the calculations. A *P* value was reported for all calculations where a *t* test was used. An F value, as well as a *P* value, was reported for ANOVA tests. All *P* values were reported to five decimal places. Any *P* <0.01000 was considered to be statistically significant. A *P* value <0.000005 was rounded off to 0.00000.

RESULTS

The calculations to determine an adequate sample size for each group showed that n = 25. The first 25 patients treated after the starting date, meeting the criteria of the study, treated with an acellular dermal matrix were called Group ADM. This group was made up of 15 female patients and 10 male patients. The mean age was 46.9 years (range 32.3 to 68.7 years, standard deviation [SD] = 9.7 years). There were two smokers in this group. Twelve patients had been on an alternating recall schedule between their general dentist and the author, while 13 had been referred back to the author for treatment of another area. Group ADM was made up of 57 defects. There were six patients where the recession defects were treated as single defects and 19 patients where the defects were treated as multiple defects. Group ADM included: three maxillary molars, 11 maxillary premolars, six maxillary cuspids, five maxillary incisors, seven mandibular molars, 15 mandibular premolars, five mandibular cuspids, and five mandibular incisors. The first 25 patients treated after the starting date, meeting the criteria of the study, treated with a subepithelial graft were called Group SUB. This group was made up of 16 female patients and nine male patients. The mean age was 48.0 years (range 34.7 to 64.8 years, SD = 10.0 years). There were two smokers in this group. Ten patients had been on an alternating recall schedule between their general dentist and the author, while 15 had been referred back to the author for treatment of another area. Group SUB was made up of 39 defects. There were 11 patients where the recession defects were treated as single defects and 14 patients where the defects were treated as multiple defects. Group SUB included: five maxillary premolars, six maxillary cuspids, 10 mandibular premolars, 11 mandibular cuspids, and seven mandibular incisors.

There was no statistically significant difference between the groups in PR recession (mean: Group ADM 3.2 mm, Group SUB 3.8 mm, $P = 0.02130$), PR probing depth (mean: Group ADM 2.0 mm, Group SUB 2.0 mm, $P = 0.70221$), and PR attachment level (mean: Group ADM 5.2 mm, Group SUB 5.8 mm, $P = 0.01300$). However, the difference in PR keratinized tissue was statistically significant (mean: Group ADM 2.1 mm, Group SUB 1.1 mm, $P = 0.00480$).

Between PR and FU1, Group ADM had a statistically significant change in recession (3.2 to 0.2 mm, $P = 0.00000$), keratinized tissue (2.1 to 3.0 mm, $P = 0.00000$), and attachment level (5.2 to 2.3 mm, $P = 0.00000$). The change in probing depth was not statistically significant (2.0 to 2.0 mm, $P = 0.16856$). Between PR and FU1, Group SUB had a statistically significant change in recession (3.8 to 0.1 mm, $P = 0.00000$), keratinized tissue (1.1 to 3.6 mm, $P = 0.00000$), probing depth (2.0 to 1.0 mm, $P = 0.00000$), and attachment level (5.8 to 1.2 mm, $P = 0.00000$).

Between PR and FU2, Group ADM had a statistically significant change in recession (3.2 to 1.1 mm, $P = 0.00000$), keratinized tissue (2.1 to 2.8 mm, $P = 0.00164$), and attachment level (5.2 to 3.0 mm, $P = 0.00000$). The change in probing depth was not statistically significant (2.0 to 1.9 mm, $P = 0.73223$). Between PR and FU2, Group SUB had a statistically significant change in recession (3.8 to 0.1 mm, $P = 0.00000$), keratinized tissue (1.1 to 4.2 mm, $P = 0.00000$), probing depth (2.0 to 1.4 mm, $P = 0.00000$), and attachment level (5.8 to 1.5 mm, $P = 0.00000$).

The changes from FU1 to FU2 for Group ADM were statistically significant in recession (0.2 to 1.1 mm, $P = 0.00031$) and attachment level (2.3 to 3.0 mm, $P = 0.00228$). The changes from FU1 to FU2 for Group ADM in keratinized tissue (3.0 to 2.8 mm, $P = 0.33334$) and probing depth (2.0 to 1.9 mm, $P = 0.12674$) were not statistically significant. The changes from FU1 to FU2 for Group SUB were statistically significant in keratinized tissue (3.6 to 4.2 mm, $P = 0.00221$), probing depth (1.0 to 1.4 mm, $P = 0.00000$), and attachment level (1.2 to 1.5 mm, $P = 0.00842$). The change from FU1 to FU2

Excel, Microsoft, Redmond, WA.

for Group SUB in recession (0.1 to 0.1 mm, $P = 0.90118$) was not statistically significant.

The results showed that the mean root coverage of the long-term Group ADM (65.8%) was less than the short-term Group ADM (93.4%), short-term Group SUB (96.6%), and long-term Group SUB (97.0%). The changes in the clinical measurements are summarized in Table 1.

In Group ADM, there was complete root coverage at FU1 in 46 of 57 defects (80.7%) and 17 of 25 patients (68.0%). By FU2 there were 22 of 57 defects (39.6%) and six of 25 patients (24.0%) who had complete root coverage. Seventeen patients (68.0%) had a reduction in percent root coverage between FU1 and FU2. This included 12 of 25 patients (48.0%) changing from complete to incomplete root coverage. In five patients (20.0%), the percent root coverage remained the same, while in three patients (12.0%), the percent root coverage increased. One out of 25 patients (4.0%) changed from incomplete root coverage to complete root coverage.

In Group SUB, there was complete root coverage at FU1 in 32 of 39 defects (82.1%) and 20 of 25 patients (80.0%). By FU2 there were 35 of 39 defects (89.7%) and 21 of 25 patients (84.0%) who had complete root coverage. Three patients (12.0%) had a reduction in percent root coverage between FU1 and FU2. This included two of 25 patients (8.0%) changing from complete to incomplete root coverage. In 18 patients (72.0%), the percent root coverage remained the same, while in four patients (16.0%), the percent root coverage increased. Three out of 25 patients (12.0%) changed from incomplete root coverage to complete root coverage.

The factors under investigation are reported in Table 2. In all but one comparison, Group ADM long-term results were statistically different in mean root coverage than the Group ADM short-term results, the Group SUB short-term results, and the Group SUB long-term results. The one case where this was not true was that of the long-term results with an acellular dermal matrix used to treat multiple defects at one time was not statistically different from the short-term results where an acellular dermal matrix was used to treat single defects.

Table 1.

Changes From Preoperative to Short-Term and Long-Term Postoperative

	Mean	Range	SD	F	*P*	Stat Sig?
Mean root coverage (%)						
ST group ADM	93.4	55.6-100.0	11.8	17.39	0.00000	a
LT group ADM	65.8	0.0-100.0	32.4			a,b,c
ST group SUB	96.6	80.0-100.0	7.1			b
LT group SUB	97.0	75.0-100.0	7.5			c
Change in recession from preoperative (mm) (Positive values are a reduction in recession depth)						
ST group ADM	3.0	1.5-5.0	0.7	13.89	0.00000	d
LT group ADM	2.2	0.0-3.8	1.1			d,e,f
ST group SUB	3.7	2.0-5.5	1.0			e
LT group SUB	3.7	2.0-5.5	1.0			f
Change in keratinized tissue from preoperative (mm) (Positive values are an increase in keratinized tissue)						
ST group ADM	1.0	−1.5-2.3	0.8	25.91	0.00000	g,h
LT group ADM	0.7	−1.0-2.8	1.0			i,j
ST group SUB	2.6	−0.3-5.5	1.4			g,i
LT group SUB	3.2	−1.0-6.0	1.3			h,j
Change in probing depth from preoperative (mm) (Positive values are a reduction in probing depth)						
ST group ADM	−0.1	−0.8-0.5	0.3	39.82	0.00000	k,l
LT group ADM	0.0	−0.5-0.5	0.3			m,n
ST group SUB	1.0	0.0-1.5	0.5			k,m,o
LT group SUB	0.6	−0.5-1.5	0.4			l,n,o
Change in attachment levels from preoperative (mm) (Positive values are a gain in attachment levels)						
ST group ADM	2.9	1.5-4.5	0.7	27.58	0.00000	p,q
LT group ADM	2.2	−0.5-3.8	1.2			r,s
ST group SUB	4.6	2.3-7.0	1.2			p,r
LT group SUB	4.2	1.5-6.5	1.2			q,s

ST group ADM = short-term (12.3 weeks) results from PR to FU1 of group treated with an acellular dermal matrix.
LT group ADM = long-term (48.2 months) results from PR to FU2 of group treated with an acellular dermal matrix.
ST group SUB = short-term (13.2 weeks) results from PR to FU1 of group treated with a subepithelial graft.
LT group SUB = long-term (49.1 months) results from PR to FU2 of group treated with a subepithelial graft.
SD = standard deviation.
F = F statistic from ANOVA test.
P = *P* value of the F statistic.
Stat sig? = Which groups are statistically significantly different based on Fisher's least significant difference test?
aa, bb, cc, dd, etc. mark pairs of groups that are significantly different based on Fisher's least significant difference test.

DISCUSSION

The most interesting finding of this study is the breakdown with time of the root coverage results obtained with an acellular dermal matrix. Between 12.3 weeks and 48.2 months, the mean root coverage slipped from 93.4% to 65.8% and the mean recession increased from 0.2 to 1.1 mm. These changes were statistically, as well as clinically, significant. This could not be considered a stable result when it is compared to the defects treated with a subepithelial graft. With the subepithelial graft, between 13.2 weeks and 49.1 months the mean root coverage changed from 96.6% to 97.0% and the mean recession changed less than could be detected at one decimal

place from 0.1 to 0.1 mm. These changes were not statistically or clinically significant. The net result was that the mean root coverage for the short-term acellular dermal matrix, short-term subepithelial graft, and long-term subepithelial graft were statistically similar. Additionally, all were statistically different from the long-term acellular dermal matrix mean root coverage results.

The short-term acellular dermal matrix mean root coverage results (93.4%), short-term subepithelial graft mean root coverage results (96.6%), and long-term subepithelial graft mean root coverage results (97.0%) were statistically similar and compare well with other studies examining root coverage results.[1,2] In the review by Wennstrom,[1] he reported a mean root coverage for 12 studies using a subepithelial graft of 89.3%. Bouchard et al.[2] reported mean root coverages for a subepithelial graft based on the type of pedicle graft used. If the pedicle was rotational, the mean root coverage was 83%. If the pedicle was coronally positioned, the mean root coverage was 82%. If the pedicle was an envelope, the mean root coverage was 83%.

The results of the present study also compare well with the studies that have a follow-up of 1 year or less that evaluate root coverage results with an acellular dermal matrix: 86%,[9] 94.3%,[10] 95.8%,[11] 95%,[12] 93%,[12] 83.2%,[13] 83.33%,[14] 91.7%,[15] 89.1%.[16] Only the long-term results with an acellular dermal matrix (65.8%) do not compare well with these studies.

The short-term results with an acellular dermal matrix in this present study (93.4%) compare well with the study by Harris which examined root coverage results of using an acellular der-

Table 2.

Factors and Their Effect on Mean Root Coverage

	N	Mean	Range	SD	F	*P*	Stat Sig?
Preoperative recession depth							
≤3.0 mm vs. >3.0 mm							
ST group ADM <	13	94.2	75.0-100.0	9.3	8.21	0.00000	a,g
LT group ADM <	13	58.3	0.0-100.0	38.1			a,b,c,d,e,f
ST group ADM >	12	92.5	55.6-100.0	14.4			b,h
LT group ADM >	12	74.0	14.3-100.0	23.9			g,h,i,j,k,l
ST group SUB <	9	96.7	80.0-100.0	7.1			c,i
LT group SUB <	9	97.8	80.0-100.0	6.7			d,j
ST group SUB >	16	96.6	80.0-100.0	7.4			e,k
LT group SUB >	16	96.6	75.0-100.0	8.1			f,l
Attached gingiva							
Absence of attached gingiva (–) vs. presence of attached gingiva (+)							
ST group ADM –	16	91.0	55.6-100.0	13.8	7.37	0.00000	a,g
LT group ADM –	16	65.6	0.0-100.0	30.2			a,b,c,d,e,f
ST group ADM +	9	97.6	83.3-100.0	5.6			b,h
LT group ADM +	9	66.2	0.0-100.0	37.9			g,h,i,j,k,l
ST group SUB –	21	96.0	80.0-100.0	7.6			c,i
LT group SUB –	21	96.5	75.0-100.0	8.1			d,j
ST group SUB +	4	100.0	100.0-100.0	0.0			e,k
LT group SUB +	4	100.0	100.0-100.0	0.0			f,l
Recall status							
Not on recall (–) vs. on alternating recall (+)							
ST group ADM –	13	92.4	55.6-100.0	13.8	7.32	0.00000	a,g
LT group ADM –	13	65.3	0.0-100.0	35.9			a,b,c,d,e,f
ST group ADM +	12	94.4	71.4-100.0	9.7			b,h
LT group ADM +	12	66.5	8.3-100.0	29.7			g,h,i,j,k,l
ST group SUB –	15	98.7	80.0-100.0	5.2			c,i
LT group SUB –	15	98.5	77.8-100.0	5.7			d,j
ST group SUB +	10	93.6	80.0-100.0	8.8			e,k
LT group SUB +	10	94.8	75.0-100.0	9.4			f,l
Location of defect (arch)							
Defect in maxillary arch (MX) vs. mandibular arch (MD)							
ST group ADM MX	12	96.8	83.3-100.0	6.5	7.68	0.00000	a,g
LT group ADM MX	12	70.1	14.3-100.0	27.8			a,b,c,d,e,f
ST group ADM MD	13	90.2	55.6-100.0	14.7			b,h
LT group ADM MD	13	62.0	0.0-100.0	36.8			g,h,i,j,k,l
ST group SUB MX	8	100.0	100.0-100.0	0.0			c,i
LT group SUB MX	8	97.2	77.8-100.0	7.9			d,j
ST group SUB MD	17	95.0	80.0-100.0	8.2			e,k
LT group SUB MD	17	97.0	75.0-100.0	7.6			f,l
Location of defect: anterior (#6-11, 22-27) or posterior (#1-5,12-21,28-32)							
Defect in anterior (A) vs. defect in posterior (P)							
ST group ADM A	10	92.1	55.6-100.0	14.2	7.73	0.00000	a,g
LT group ADM A	10	58.8	0.0-100.0	38.1			a,b,c,d,e,f
ST group ADM P	15	94.2	71.4-100.0	10.3			b,h
LT group ADM P	15	70.5	0.0-100.0	28.4			g,h,i,j,k,l
ST group SUB A	15	97.3	80.0-100.0	7.0			c,i
LT group SUB A	15	96.4	75.0-100.0	8.3			d,j
ST group SUB P	10	95.6	80.0-100.0	7.5			e,k
LT group SUB P	10	98.0	85.0-100.0	6.3			f,l

Table 2. (continued)

Factors and Their Effect on Mean Root Coverage

	N	Mean	Range	SD	F	*P*	Stat Sig?
Number of defects treated							
One defect treated (S) vs. > one defect treated (M)							
ST group ADM S	6	82.9	55.6-100.0	16.7	9.25	0.00000	a,
LT group ADM S	6	50.0	0.0-100.0	40.3			a,b,c,d,e,f
ST group ADM M	19	96.7	71.4-100.0	7.7			b,h
LT group ADM M	19	70.8	0.0-100.0	29.0			c,h,i,j,k,l
ST group SUB S	11	98.2	80.0-100.0	6.0			d,i
LT group SUB S	11	95.7	75.0-100.0	9.6			e,j
ST group SUB M	14	95.4	80.0-100.0	7.9			f,k
LT group SUB M	14	98.1	85.0-100.0	5.5			g,l
Age							
≤ mean 47.5 years vs. > 47.5 years							
ST group ADM <	15	93.7	55.6-100.0	13.4	7.17	0.00000	a,g
LT group ADM <	15	66.0	0.0-100.0	34.5			a,b,c,d,e,f
ST group ADM >	10	92.9	75.0-100.0	9.6			b,h
LT group ADM >	10	65.7	0.0-100.0	30.7			g,h,i,j,k,l
ST group SUB <	14	97.1	80.0-100.0	7.3			c,i
LT group SUB <	14	96.2	75.0-100.0	8.6			d,j
ST group SUB >	11	96.0	80.0-100.0	7.3			e,k
LT group SUB >	11	98.2	80.0-100.0	6.0			f,l
Gender							
Female (F) vs. male (M)							
ST group ADM F	15	92.0	55.6-100.0	11.1	7.94	0.00000	a,g
LT group ADM F	15	70.6	0.0-100.0	31.5			a,b,c,d,e,f
ST group ADM M	10	95.4	83.3-100.0	7.5			b,h
LT group ADM M	10	58.7	0.0-100.0	34.0			g,h,i,j,k,l
ST group SUB F	16	98.8	80.0-100.0	5.0			c,i
LT group SUB F	16	98.2	77.8-100.0	5.7			d,j
ST group SUB M	9	92.9	80.0-100.0	9.0			e,k
LT group SUB M	9	95.0	75.0-100.0	10.0			f,l

N = Number of subjects.
ST group ADM = short-term (12.3 weeks) results from PR to FU1 of group treated with an acellular dermal matrix.
LT group ADM = long-term (48.2 months) results from PR to FU2 of group treated with an acellular dermal matrix.
ST group SUB = short-term (13.2 weeks) results from PR to FU1 of group treated with a subepithelial graft.
LT group SUB = long-term (49.1 months) results from PR to FU2 of group treated with a subepithelial graft.
SD = standard deviation.
F = F statistic from ANOVA test.
P = *P* value of the F statistic.
Stat sig? = Which groups are statistically significantly different based on Fisher's least significant difference test? aa, bb, cc, dd, etc. mark pairs of groups that are significantly different based on Fisher's least significant difference test.

mal matrix for root coverage at 12 weeks (91.7%) and 18.6 months (87.0%) postoperative.[15] However, once again the long-term results with an acellular dermal matrix in this present study (65.8%) do not compare well. In the previous study, the short-term results (91.7%) were not statistically different from the long-term results (87.0%). There are many possible explanations. The mean follow-up period in the previous study was 18.6 months. This is significantly less than the present study where the mean long-term follow-up for the defects treated with an acellular dermal matrix was 48.2 months. This time difference in follow-up evaluation may have contributed to the different results. Another difference is that in the previous study, an *a priori* power analysis was not done. Therefore, based on the results of the previous study one can only conclude that the long-term and short-term results are not statistically different. This is not the same as saying that the results are statistically equivalent. It is possible that a larger sample size in the previous study may have produced a different result. The make-up of the groups may have contributed to the difference. In this present study, there were 10 molars out of the 57 defects treated with an acellular dermal matrix (17.5%), while in the previous study there were only six molars out of the 47 defects treated (12.8%). The possible difference in how molars treated with an acellular dermal matrix hold up with time will need to be examined. These explanations, or possibly other explanations, may have contributed to the different results.

Both procedures were able to produce statistically significant reductions in recession, increase in keratinized tissue and improved attachment levels, as well as a good mean root coverage between PR and FU1. Therefore, one must conclude that both of the procedures can produce root coverage and favorable clinical changes. However, the results are not the same at FU1, even though there was a statistically similar amount of root coverage (Group ADM 93.4%, Group SUB 96.6%) (Table 1). The subepithelial graft produced a statistically significant reduction in probing depth (1.0 mm), whereas the acellular dermal matrix had a mean gain in probing depth (0.1 mm). Additionally, the subepithelial graft produced a greater increase in keratinized tissue (Group SUB 2.6 mm, Group ADM 1.0 mm) and improvement in attachment levels (Group SUB 4.6 mm, Group ADM 2.9 mm) (Table 1). It is not known if any of these short-term clinical differences contributed to the long-term differences but additional study in the area is needed. The histology of the results may provide useful information. However, this was beyond the scope of this study.

The changes from PR to FU2 show statistically significant reductions in recession for both procedures (Group SUB 3.7 mm, Group ADM 2.2 mm). Therefore, both procedures are root coverage procedures capable of decreasing the amount of recession long-term. Once again, the results with the procedures are not the same. The subepithelial graft produced a greater increase in keratinized tissue (Group SUB 3.2 mm, Group ADM 0.7 mm), reduction in probing depth (Group SUB 0.6 mm, Group ADM 0.0 mm), and improvement in attachment levels (Group SUB 4.2 mm, Group ADM 2.2 mm). Additionally, the recession improvement was better for the subepithelial graft (Group SUB 3.7 mm, Group ADM 2.2 mm). It is not possible to know why the subepithelial graft had better mean root coverage from PR to FU2. However, the long-term (PR to FU2) mean root coverage for the subepithelial graft (97.0%) was statistically and clinically better than the long-term (PR to FU2) mean root coverage for the acellular dermal graft (65.8%).

The changes between FU1 and FU2 are important. Group ADM had a statistically significant increase in recession (0.2 to 1.1 mm) and attachment loss (2.3 to 3.0 mm), with no statistically significant change in probing depth (2.0 to 1.9 mm) or keratinized tissue (3.0 to 2.8 mm). Group SUB had a statistically significant increase in keratinized tissue (3.6 to 4.2 mm). The importance of this increase is unknown. Additionally, Group SUB had a statistically significant increase in probing depth (1.0 to 1.4 mm) and attachment loss (1.2 to 1.5 mm). However, the recession did not change a statistically significant amount (0.1 to 0.1 mm). Therefore, the attachment loss is solely the effect of the increased probing depth. The importance of the increased probing depth is unknown. However, it is important to note that it is still a statistically significant amount less than preoperative. It will be important to see whether the probing depth continues to increase with time or if it stops at some point.

The evaluation of the factors confirms that long-term results using the acellular dermal matrix are not as good as the short-term acellular dermal matrix results, short-term subepithelial graft results, or long-term subepithelial graft results. This pattern of which groups were statistically different was universal, except when the data was divided based on the number of defects treated at one time (single defect or multiple defects). The long-term results of Group ADM, where multiple defects were treated (70.8%), was not statistically different from the short-term results of Group ADM, where a single defect was treated (82.9%). Additionally, the long-term Group ADM results where single defects were treated had a mean root coverage of 50.0% which was statistically less than the long-term results of Group ADM where multiple defects were treated (70.8%). The reason why the results are better long-term when multiple defects are treated is beyond the scope of this study. However, it is important to note that the results of the long-term multiple defects treated with an acellular dermal matrix (70.8%) is still statistically less than the defects treated with subepithelial grafts (both long-term and short-term) (95.7% to 98.2%) (Table 2).

Most of the problems with this study are the result of it being completed in private practice. There were no blinded evaluations, no evaluations of the reproducibility of the measurements, no calibrations of the examiner, no pressure sensitive probes, no stents for reference points, or no untreated controls. Probably the largest potential problem was the design of this study. Patients were not randomly assigned to treatment groups, treated, and then followed with time. That design would have been better and more generalizable than the retrospective design of this present study. However, the design used in this study does reflect what a typical clinician might expect to see in their private practice. The reason is that a clinician does not randomly select treatment options for a patient. Rather, treatment is based on a clinical opinion as to what is indicated. This probably explains why the group treated with an acellular dermal graft had more keratinized tissue preoperatively. The clinician had a bias towards using a subepithelial graft in situations with less keratinized tissue. The validity or lack of validity of this bias will need to be evaluated. Another potential problem was the make-up of the groups. Group ADM had 18 more defects than Group SUB. Additionally, Group ADM had eight molars in it, while Group SUB had no molars. Based on the results of short-term subepithelial grafts on molars,[23] one would expect the group with the greatest number of molars to have the lowest mean root coverage. However, this did not occur. The short-term results of Group ADM and Group SUB were statistically similar. The fact that the short-term results were similar suggests that the make-up of the groups was not a major factor. However, it may be advisable to consider a design looking at patients with paired defects, where the treatment received is randomly assigned, to better control potential problems. While every attempt was made to avoid potential biases, it is important to note that the author performed all of the surgeries and did all of the evaluations. Unfortunately, it was not possible to control these factors. It is certainly possible that different results may have been obtained with a study designed differently.

Based on the results of this study, one must conclude that an acellular dermal matrix and a subepithelial graft can produce similar amounts of root coverage short-term. However, the results with an acellular dermal matrix tended to break down long-term, while the long-term results with a subepithelial graft tended to remain stable. In this study, the findings were not universal. There were five patients treated with an acellular dermal matrix that had complete root coverage at FU1 and still had complete root coverage at FU2. Additionally, three

patients had an increase in the amount of root coverage between FU1 and FU2. Therefore, there are situations where the results with an acellular dermal matrix are stable and improve with time. This occurred in eight of 25 patients (32.0% of the cases). Unfortunately, at this time, it is not possible to predict which situations will remain stable or improve with time. It seems as though treating multiple defects with an acellular dermal matrix has an advantage over treating singular defects with an acellular dermal matrix. However, the results are still not as good as the results with a subepithelial graft. Therefore, until it becomes possible to predict situations where the results of an acellular dermal matrix will remain stable or improve, one must conclude that a subepithelial graft is a better procedure to produce more predictable and stable long-term root coverage results.

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