Treatment of furcation lesions is one of the most challenging tasks in periodontal therapy today. The anatomical features of the furcation area, which include numerous small ridges, peaks and pits forming convexities and concavities,1–3 offer limited access for routine periodontal debridement. The presence of accessory canals in the furcation region (the actual furcation area plus 4 mm apically on the internal aspect of the root surfaces) in up to 25% of permanent molars,4 as well as the presence of enamel projections in 29% of mandibular and 17% of maxillary molars,5 further complicates the management of furcation invasions.

Attempts to treat inaccessible furcation lesions have led to therapies ranging from surgical flap debridement to root resection and hemisection and, more recently, regenerative therapy. Surgical access significantly enhances removal of calculus from molars with furcation invasion; however, in most cases residual calculus has been detected even after open-flap surgery,6 and there is clinically significant loss of attachment within the furcation area during at least the first 2 years of maintenance care.7 Root resection combined with conservative root canal preparation and use of the remaining root(s) as bridge abutments was successful in up to 70% of cases over a 10-year period, with most failures occurring within 5 years of the resection procedure and involving

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**Abstract**

This study compared the effectiveness of 2 barrier membranes, expanded polytetrafluoroethylene (e-PTFE) and collagen, in treating Class II furcation defects of mandibular molars in humans. Seventeen nonsmoking subjects with no history of systemic disease each presenting with Class II furcation defects in 2 mandibular molars were selected and underwent initial therapy. At the time of the surgery and at 8-month follow-up, soft-tissue measurements consisting of the gingival index, vertical and horizontal probing depth, recession and clinical attachment level were obtained at the midfurcation level. At the time of membrane placement and at 12-month re-entry, horizontal midfurcation probing depth and hard-tissue measurement of vertical fill (from the crown to the depth of the pocket) were also obtained. According to the surgical protocol, both membranes were completely covered with a coronally positioned flap, and in all cases healing was uneventful. Data were analyzed first by comparing baseline measurements (at surgery) with measurements at 8-month follow-up and 12-month re-entry for both e-PTFE and collagen membranes according to repeated-measures analysis of variance. The changes from surgery to follow-up and re-entry were then compared between the 2 treatment modalities with paired Wilcoxon rank-sum tests. No statistically significant differences were found between e-PTFE and collagen membranes with respect to gingival index, reduction in probing depth, gain in clinical attachment or filling of the horizontal defect. However, the improvement in vertical fill at 12-month re-entry was more substantial for the teeth treated with collagen membrane than those treated with e-PTFE (p < 0.05). Within the limits of this study, it appears that collagen is a beneficial material for regenerative therapy of Class II furcation defects in humans, yielding results that are similar to or better than (vertical fill) those for e-PTFE membrane.

**MeSH Key Words:** collagen/metabolism; furcation defects/surgery; guided tissue regeneration/methods
migration and supporting new connective tissue attach-
dogs, maintaining their integrity, preventing epithelial
membranes have been successful in GTR studies in
used in the management of periodontal osseous defects, and
at 8 months and re-entry at 12 months.

of periodontal Class II mandibular molar furcation defects
with processed type I collagen from bovine tendon in GTR
progenitor cells from the periodontal ligament to repopulate
epithelium and connective tissue from the alveolar bone
attachment. The rationale for GTR is to exclude gingival
epithelium and connective tissue from the alveolar bone
and root surfaces, thus creating areas into which progenitor
cells from the periodontal ligament or alveolar bone (or
both) can migrate.11–13 The GTR technique has many indi-
cations in periodontal therapy, among the most important
being treatment of Class II furcation lesions in molars. It is
well established that the efficacy of GTR procedures using
expanded polytetrafluoroethylene (e-PTFE) membrane in
treating Class II mandibular furcations is much better than
that of debridement alone,14–16 and human studies using
e-PTFE membrane for the treatment of furcation defects
have reported significant and predictable gains in new
attachment.16,17 However, during the postsurgical peri-
odontal healing period, use of the e-PTFE barrier can lead
to clinical complications such as acute or chronic inflam-
mation and early membrane exposure,18,19 and a second
surgical procedure (to remove the membrane) 4 to 6 weeks
after the initial procedure is always required. The use of a
resorbable membrane eliminates the need for the second-
stage surgery. The resorbable materials most commonly
used in both animal studies and human clinical trials have
been collagen, polyglycolic acid, polylactic acid and their
copolymers.20–26 For example, these materials have been
used in the management of periodontal osseous defects, and
collagen membranes have been successful in GTR studies in
dogs, maintaining their integrity, preventing epithelial
migration and supporting new connective tissue attach-
ment in experimental defects.21,22 Collagen is a natural
protein that lends itself to GTR procedures because the
body’s own enzymes eventually break it down into its
constituent amino acids. Type I collagen of bovine tendon
origin has been effective in GTR procedures in animals and
humans.20–24

The study reported here compared e-PTFE membranes
with processed type I collagen from bovine tendon in GTR
of periodontal Class II mandibular molar furcation defects
over a 12-month healing interval, with clinical assessments
at 8 months and re-entry at 12 months.

Materials and Methods

Seventeen nonsmoking subjects (8 women and 9 men),
ranging in age from 35 to 75 years (mean ± standard devi-
ation 56.5 ± 13.3 years) who were receiving periodontal
care at the faculty of dentistry, University of Manitoba,
Winnipeg, Manitoba, and who had no history of systemic
disease participated in the study. The investigation was
approved by the Committee on Ethics Involving Human
Subjects of the University of Manitoba. Before acceptance
into the study, each patient received a brief description of
the investigation and provided signed informed consent.
Each subject had undergone initial periodontal therapy
without occlusal adjustment (as such adjustment was not
indicated in any of the cases) and had been re-evaluated at
6 to 8 weeks. The primary inclusion criterion for each
subject was presence of 2 teeth with Class II mandibular
first and second molar furcation defects. In 13 patients the
affected teeth were contralateral, and in 4 patients the
affected teeth were located on the same side of the mouth.
Both teeth in each subject were treated by GTR, one with
an e-PTFE membrane (standard Gore-Tex periodontal
material; W.L. Gore & Associates Inc., Flagstaff, Arizona)
and the other with a bioabsorbable collagen membrane
(CollaTec Corporation, Plainsboro, New Jersey), with the
type of membrane assigned randomly before surgery. There
was no control group (i.e., no teeth underwent debride-
ment only).

All measurements were completed by 2 experienced
examiners (VKP and SCG). A simple classification system
for assessing the severity of furcation was used.27
Measurements before surgery consisted of the gingival
index of Loe28 and vertical probing depths relative to the
gingival margin, horizontal probing depth, recession and
clinical attachment level were obtained at the midfurcation
level. After administration of adequate local anesthesia,
full-thickness envelope flaps were raised buccally and
lingually at least one tooth mesial and one tooth distal to
the test tooth, and soft-tissue debridement and root planing
were performed with hand instruments. No osteoplasty or
ostectomy was performed. Hard-tissue measurements at the
time of surgery consisted of horizontal probing depth and
vertical depth from the occlusal surface of the crown to the
base of the defect without an acrylic stent (determined with
a manual periodontal probe, PCP UNC15 Hu-Friedy,
Hu-Friedy Mfg. Co. Inc., Chicago, Illinois) and midfurca-
tion horizontal probing depth from the tooth surface into
the furcation from the buccal to the lingual direction
(determined with a Nabers furcation colour-coded probe,
Hu-Friedy Mfg. Co. Inc.).

The membrane for each tooth was trimmed to cover the
furcal opening and overlap 3 to 4 mm over adjacent tooth
and bone. The collagen membrane was held in place with
chronic gut (4-0) sling sutures and the e-PTFE membrane
was sutured with Gore-Tex material. Finally, the flaps were positioned coronally over the membrane (either type) and closed with interrupted silk (4-0) sutures.

Periodontal dressing was placed and the subject was given a prescription for doxycycline (200 mg on the first day and 100 mg daily for the subsequent 13 days), oral analgesics as needed and 0.12% chlorhexidine rinse (twice daily for 4 weeks). Patients were seen for professional removal of supragingival plaque at 1, 2 and 4 weeks, and the e-PTFE membrane was removed 4 to 6 weeks after the initial surgery. All patients were seen every 3 months for periodontal maintenance.

Soft-tissue measurements were repeated at 8 months and a re-entry procedure was carried out at 12 months. At the time of re-entry, a vertical incision was used to raise a small flap at the surface of each treated tooth, and hard-tissue measurements were obtained. The decrease in probing depth, gain in clinical attachment level and increase in horizontal midfurcation attachment level (horizontal and vertical fill) were analyzed in 2 ways. First, comparisons were made individually for the 2 types of membrane between baseline (at surgery) and 8-month follow-up (soft-tissue measurements) and 12-month re-entry (soft- and hard-tissue measurements) according to repeated-measures analysis of variance. Second, the changes from surgery to follow-up and re-entry were compared between the 2 treatment modalities by means of paired Wilcoxon rank-sum tests.

Vertical and horizontal midfurcation measurements are presented in Tables 1 and 2, respectively. Pocket depths were measured from the gingival margin to the depth of the pocket, recession was measured from the cemento-enamel junction (CEJ) to the gingival margin, and clinical attachment levels were measured from CEJ to the depth of the pocket. Vertical fill (from the crown to the base of the defect) was measured in each subject at 12-month re-entry.

### Table 1 Vertical midfurcation measurements

<table>
<thead>
<tr>
<th>Variable</th>
<th>e-PTFE</th>
<th>Collagen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pocket depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At surgery</td>
<td>4.53 ± 1.77</td>
<td>4.73 ± 1.16</td>
</tr>
<tr>
<td>At 8-month follow-up</td>
<td>3.60 ± 1.30</td>
<td>3.33 ± 0.90</td>
</tr>
<tr>
<td>At 12-month re-entry</td>
<td>3.47 ± 1.41</td>
<td>3.20 ± 0.94</td>
</tr>
<tr>
<td>Change from surgery to 8-month follow-up</td>
<td>0.93 ± 0.88</td>
<td>1.40 ± 0.98</td>
</tr>
<tr>
<td>Change from surgery to 12-month re-entry</td>
<td>1.12 ± 1.36</td>
<td>1.47 ± 1.01</td>
</tr>
<tr>
<td>Recession</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At surgery</td>
<td>1.87 ± 1.46</td>
<td>1.80 ± 1.42</td>
</tr>
<tr>
<td>At 8-month follow-up</td>
<td>2.33 ± 1.59</td>
<td>2.33 ± 1.84</td>
</tr>
<tr>
<td>At 12-month re-entry</td>
<td>2.73 ± 1.87</td>
<td>2.20 ± 1.74</td>
</tr>
<tr>
<td>Change from surgery to 8-month follow-up</td>
<td>-0.40 ± 1.18</td>
<td>-0.73 ± 1.03</td>
</tr>
<tr>
<td>Change from surgery to 12-month re-entry</td>
<td>-0.47 ± 1.18</td>
<td>-0.65 ± 1.32</td>
</tr>
<tr>
<td>Clinical attachment level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At surgery</td>
<td>6.47 ± 2.33</td>
<td>6.33 ± 1.75</td>
</tr>
<tr>
<td>At 8-month follow-up</td>
<td>5.93 ± 1.79</td>
<td>5.67 ± 1.95</td>
</tr>
<tr>
<td>At 12-month re-entry</td>
<td>6.20 ± 2.14</td>
<td>5.40 ± 1.68</td>
</tr>
<tr>
<td>Change from surgery to 8-month follow-up</td>
<td>0.53 ± 1.64</td>
<td>0.67 ± 1.05</td>
</tr>
<tr>
<td>Change from surgery to 12-month re-entry</td>
<td>0.47 ± 1.81</td>
<td>1.00 ± 1.22</td>
</tr>
<tr>
<td>Vertical fill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At surgery</td>
<td>11.12 ± 2.19</td>
<td>11.62 ± 2.06</td>
</tr>
<tr>
<td>At 12-month re-entry</td>
<td>12.12 ± 2.42</td>
<td>10.81 ± 2.46</td>
</tr>
<tr>
<td>Change from surgery to 12-month re-entry</td>
<td>-1.00 ± 2.03</td>
<td>0.81 ± 1.80</td>
</tr>
</tbody>
</table>

*SD = standard deviation, e-PTFE = expanded polytetrafluoroethylene*

*Two subjects missed the 8-month follow-up.

### Table 2 Horizontal midfurcation measurements

<table>
<thead>
<tr>
<th>Time</th>
<th>Mean furcal score ± SD (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>e-PTFE</td>
</tr>
<tr>
<td>At surgery</td>
<td>2.00 ± 0.00</td>
</tr>
<tr>
<td>At 8-month follow-up</td>
<td>1.60 ± 0.51</td>
</tr>
<tr>
<td>At 12-month re-entry</td>
<td>1.60 ± 0.63</td>
</tr>
<tr>
<td>Change from surgery to 8-month follow-up</td>
<td>0.36 ± 0.50</td>
</tr>
<tr>
<td>Change from surgery to 12-month re-entry</td>
<td>0.41 ± 0.62</td>
</tr>
</tbody>
</table>

*SD = standard deviation, e-PTFE = expanded polytetrafluoroethylene*

*Two subjects missed the 8-month follow-up.
between the 2 treatments.

Table 3  Mean gingival index scores (± SD), at the time of surgery, at 8-month follow-up and at 12-month re-entry

<table>
<thead>
<tr>
<th>Treatment</th>
<th>At surgery</th>
<th>8-month follow-up</th>
<th>12-month re-entry</th>
</tr>
</thead>
<tbody>
<tr>
<td>e-PTFE</td>
<td>0.20 ± 0.41</td>
<td>0.33 ± 0.72</td>
<td>0.20 ± 0.56</td>
</tr>
<tr>
<td>Collagen</td>
<td>0.33 ± 0.72</td>
<td>0.00 ± 0.00</td>
<td>0.13 ± 0.35</td>
</tr>
</tbody>
</table>

SD = standard deviation, e-PTFE = expanded polytetrafluoroethylene
* Two subjects missed the 8-month follow-up.

Results

Of the 17 subjects who completed the study, 2 missed the 8-month follow-up but were not excluded from the final analysis. The results were not analyzed according to buccal and lingual lesions because the experiment paired 2 available mandibular teeth in each patient, one tooth being treated with the e-PTFE membrane and the other with the collagen membrane. In 11 subjects, both defects were buccal, in 1 subject both were lingual, and 5 subjects had one buccal and one lingual defect.

The gingival health of the 2 groups of teeth, as measured by the gingival index, is shown in Table 3. A decline in the gingival index was observed for the teeth treated with collagen membrane, whereas the gingival index was consistent over the study period for the e-PTFE teeth. However, the difference between the 2 groups of teeth was not statistically significant.

Both treatments resulted in a significant decrease in probing depths from surgery to 8-month follow-up (p < 0.01) and from surgery to 12-month re-entry (p < 0.005), but the changes were not statistically different between the 2 groups of teeth. Recession increased equally for the 2 treatment groups from the time of the surgery and reached statistical significance (p < 0.05) at 12-month re-entry. Clinical attachment level, the composite of pocket depth and recession, remained fairly consistent within each treatment group over time and did not differ between the 2 treatment groups.

The mean measurement from the crown to the base of the defect (vertical fill), determined at baseline and re-entry, increased from 11.12 mm to 12.12 mm (p < 0.005) for the teeth treated with e-PTFE membrane, but decreased from 11.62 mm to 10.81 mm (p < 0.05) for the teeth treated with collagen; this difference between the 2 treatments was statistically significant (p < 0.05). Both treatment groups showed a decrease in horizontal measurements from surgery to 8 months (p < 0.005) and from surgery to re-entry (p < 0.0005), but there was no statistically significant difference between the 2 treatments.

Discussion

This study compared the effectiveness of a collagen membrane with that of the gold standard, e-PTFE membrane, in treating Class II mandibular molar furcation defects in humans. Our study did not include a control group receiving debridement only, because previous studies have shown the e-PTFE membrane is more effective than debridement alone.14–16 We used type 1 collagen derived from bovine tendon. Type 1 collagen is the major structural protein in the periodontal ligament as well as most extracellular organic matrices and connective tissues throughout the body. The properties of collagen that favour its use as a biomaterial are numerous.29–31 It is biodegradable and when implanted in the body is absorbed at a rate that can be controlled by the degree of cross-linking to which it is subjected.30 As a membrane, it is semipermeable and is a good support for cell growth.32 For all practical purposes, collagen is immunologically inert and safe.26,33

Researchers have compared the effectiveness of collagen membrane with a control procedure consisting of flap-approach curettage in treating Class II furcation defects. Statistically significant improvements in horizontal and vertical fill, relative to control, occurred over a 12-month period, whereas treatment with debridement alone afforded little or no improvement.23,24,29 The results of the study reported here indicate the clinical effectiveness of bioabsorbable collagen membrane in achieving reduction in pocket depth, gain in attachment and horizontal filling of the defect over a 12-month period similar to what can be attained with e-PTFE membrane. Interestingly, significantly better vertical fill at 12-month re-entry was observed for the collagen membrane than for the e-PTFE membrane.

With regard to vertical fill, we obtained different results from those obtained by Yukna and Yukna.34 This difference could have resulted, in part, from the exposure of the e-PTFE membrane during the healing process, which might have accounted for the less encouraging results with this type of membrane in terms of vertical probing depths in our study. Conversely, the collagen membrane proved easy to use, it was biocompatible, and it resulted in no adverse healing in any of the patients.26,33 Similar results were obtained by Blumenthal,23 who reported that sites treated with a different collagen membrane gained vertical open-probing new attachment at 12-month re-entry. Our results also agree with those of Wang and others,29 who demonstrated significant improvement at 12-month re-entry in terms of reduction of pocket depth, gain in attachment and...
filling of horizontal defect. Similar findings were reported by Chung and others\textsuperscript{35} in their 1-year study.

A limitation of this study was the small sample size, and this shortcoming might have some effect on the power and significance of the statistical analysis. Future investigations should involve a larger sample and longer follow-up time to determine the long-term effect of treatment with collagen membrane. In retrospect, it would have been helpful to use an acrylic stent and a more accurate measurement system amenable to photographic recording.

Within the limits of this study, the following conclusions can be drawn. No significant differences were observed between bioabsorbable collagen membrane and e-PTFE membrane in terms of reduction of pocket depth, gain in attachment gain or filling of horizontal defects over a 12-month period. Only partial closure of the furcations was observed, and the furcations appeared clinically healthy. From a statistical point of view, the results with collagen membranes appeared similar to or better than (vertical fill) those obtained with commercially available e-PTFE membrane. Mandibular molar furcations are easier to treat because there is much better access to these teeth than to the maxillary molars; therefore, these results probably do not apply to mesial and distal furcations. Because bioabsorbable collagen is a natural protein of the human body that is degraded by host enzymes, there is no need for second-stage retrieval surgery. The collagen membranes were easier to manipulate than the e-PTFE membranes and resulted in no adverse healing. Overall, treatment with barrier membranes improves Class II mandibular molar furcation defects in humans. After such treatment, teeth with questionable prognosis are more easily maintained. 

\textbf{References}


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