Introduction of a Novel Anatomic Recession Ratio in the Treatment of Gingival Recession: A Proof-of-Principle Study

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The present study introduces a novel "anatomic recession ratio" (ARR) and evaluates the clinical outcomes of using a tunnel technique (TUN) with a connective tissue graft (CTG) for root coverage (RC). Sixteen systemically healthy patients contributing a total of 33 recession types 1 and 2 were treated with TUN + CTG. The predictive value of a panel of baseline clinical parameters (ARR) on RC was evaluated 12 months postoperatively. At 12 months, mean recession depth decreased from 2.74 ± 0.22 mm to 0.46 ± 0.13 mm (P < .0001); 19 sites (58%) showed complete RC, and the mean RC rate was 88.85% ± 2.73%. The mean ARR value was 0.74 ± 0.3, revealing a positive correlation with RC (r²: 0.73, P < .0001). The 12-month esthetic evaluation resulted in a score of 8.52 ± 1.75 using the root coverage esthetic score. TUN + CTG is effective in reducing recession depth and obtaining good esthetic outcomes. Within the limits of the present study, it may be suggested that ARR has potential as an analytical baseline parameter for RC outcomes with TUN + CTG. Int J Periodontics Restorative Dent 2022;42:e103–e112. doi: 10.11607/prd.5574

Gingival recession (GR) is defined as the apical shift of the gingival margin with respect to the cementoenamel junction (CEJ), associated with attachment loss and exposure of the root surface to the oral cavity. Various surgical techniques have been proposed in the literature that attempt to provide root coverage (RC), improve esthetics, and minimize patient discomfort. Recent technical developments have increased the interest for tunneling flap procedures in reconstructive surgery. A series of randomized clinical trials report similar RC outcomes when comparing coronally advanced flap (CAF) and coronally advanced tunneling technique (TUN). All TUN techniques aim to maintain interdental papilla integrity by avoiding any kind of incision through the interproximal soft tissues, thereby reducing the risk for scar formation and favoring a potential improvement in esthetics. Application of TUN in combination with connective tissue graft (CTG) have been proposed with various technical solutions. Complete coverage of CTG or, alternatively, partial/complete exposure of the graft to increase the keratinized tissue width (KTW) has been suggested. In isolated deep GR cases, TUN based on coronal advancement has a limited potential to cover the entire CTG despite the apical split-flap preparation, and therefore some parts of the

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Submitted November 27, 2020; accepted March 21, 2021. ©2022 by Quintessence Publishing Co Inc.
CTG may be left exposed.\textsuperscript{8} This exposure entails potential risks for graft integration and revascularization, and eventually reduces the probability for complete RC (CRC).\textsuperscript{15} To overcome this problem, a laterally closed TUN technique was recently developed for the treatment of isolated deep mandibular GRs to reduce the risk of graft necrosis by approximating the two margins of the pouch.\textsuperscript{16} At 1 year, CRC was obtained in 17 of the 24 defects (70.83\%). Obviously, the choice of the appropriate surgical technique is dependent, at least partially, on the recession depth (RD) and other anatomical parameters, but there is no available guideline for the decision-making process. A comprehensive, site-specific analysis for TUN may help to identify the possible factors associated with RC outcomes.\textsuperscript{18}

It is hypothesized that a novel clinical parameter formulated using multiple measurements may reliably predict the outcomes of RC procedures. The aim of this preliminary study was twofold: (1) to introduce a novel clinical parameter, the anatomic recession ratio (ARR), and (2) to evaluate the clinical outcomes with application of TUN + CTG in GRs with recession types (RTs) RT1 and RT2.\textsuperscript{19}

Materials and Methods

Study Population

All participants gave informed consent, and all the study procedures were performed according to the Declaration of Helsinki on experimentation involving human subjects. The study protocol was approved by the Institutional Review Board of Faculty of Medicine, Ege University in Izmir, Turkey. Inclusion criteria for patients were as follows: (1) age ≥ 18 years; (2) being systemically healthy; (3) having clinically healthy periodontium (no clinical sign of active periodontal disease) with full-mouth plaque and bleeding scores ≤ 20%; (4) presence of detectable CEJ; (5) presence of at least one buccal RT1 or RT2 GR with RD < 5 mm at anterior maxillary and mandibular sextants (incisors and canines); and (6) no history of mucogingival or periodontal surgery at the experimental sites. Patients with the self-report/detection of the following criteria were excluded: (1) smoking habit; (2) pregnancy or lactation; (3) extrusion, protrusion, presence of cervical restoration, or noncarious cervical lesion at the experimental teeth; (4) increased tooth mobility; (5) shallow vestibulum depth; and (6) sites with RT3 GR.

Clinical Parameters

Using a manual periodontal probe (PCP UNC 15, Hu-Friedy), the following clinical measurements were recorded at baseline and 12 months postsurgery for each treated tooth:

(1) Probing depth (PD) at the midbuccal site; (2) clinical attachment level (CAL) at the midbuccal site, calculated as the sum of PD and RD; (3) CAL at interproximal sites (iCAL); (4) RD at the midbuccal site; (5) recession width (RW), measured as the horizontal distance between the gingival margins of the recession at the CEJ level; (6) KTW, measured as the distance between the gingival margin and the mucogingival junction; (7) baseline gingival thickness (GT), measured 1.0 mm apical to the gingival margin using an injection needle perpendicular to soft tissue and a silicon stop over gingiva fixed with cyanoacrylate;\textsuperscript{20} and the distance between the needle tip and the inner surface of the silicon stop was measured with a digital caliper having 0.01 mm of accuracy.

Digital photographs of the experimental teeth were taken at baseline and 12 months postsurgery, taking special care to position the camera perpendicular to the long axis of the teeth as much as possible. An examiner (N.B.) was calibrated to assess the following parameters using a digital software (ImageJ Mac OS X, National Institutes of Health). Following the anatomic reference point selection (Fig 1), components of ARR were traced and calculated as follows:

- Anatomic line: curve between the GR contacts (GC), traced along the CEJ
- GR line: curve between GC, traced along the gingival margin
- mP: distance from tip of the mesial papilla to the point where GR contacts CEJ
- dP: distance from tip of the distal papilla to the point where GR contacts CEJ
- ARR was calculated as follows (Fig 2):

\[
ARR = \frac{(mP) + (\text{anatomic line}) + (dP)}{(mP) + (\text{GR line}) + (dP)}
\]

Before starting the study, intra-examiner calibration was performed.
by measuring the distance from the CEJ to the most apical extension of the gingival margin and calculating the ARR three times for a total of 20 defects not included in the present study (k coefficient > 0.85). Esthetic outcomes were assessed using the root coverage esthetic score (RES). RES uses a five-point ordinal scale (poor, fair, good, very good, excellent), which has shown satisfactory reproducibility among periodontists. A total of 10 points is the ideal esthetic score, comprising the evaluation of gingival margin position, marginal tissue contour, soft tissue texture, mucogingival junction alignment, and gingival color.

**Surgical Procedures**

All surgical procedures were performed by a single experienced periodontal surgeon (S.A.) (Figs 3 and 4) according to the modified TUN, as previously described by Sculean et al. Following local anesthesia, a buccal intracrevicular incision was performed using microsurgical blades (Micro Blades, Keydent). A tunneling elevator (TKN1 and TKN2, Hu-Friedy) was used to raise a buccal mucoperiosteal flap, extended at least one tooth mesial and distal to the experimental tooth/teeth. The pouch was then

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**Fig 1** Selection of the reference points on (a) RT1 and (b and c) RT2 gingival recessions. (a and b) All reference points are present and can be calculated. (c) This recession is missing a gingival contact reference point, and thus the anatomic recession ratio (ARR) cannot be calculated.

**Fig 2** Reference points and lines needed to calculate the ARR. $\text{ARR} = \frac{[(\text{mesial papilla}) + (\text{anatomic line}) + (\text{distal papilla})]}{[(\text{mesial papilla}) + (\text{gingival recession line}) + (\text{distal papilla})]}.$
mobilized beyond the mucogingival junction. Muscles and inserting fibers inside the flap were detached with microsurgical blades by keeping the blade parallel to the external mucosal surface to attain tension-free flap closure. An angled tunnel elevator (Stoma) facilitated the interdental tunnel preparation under the papillary tissue. Utmost care was taken to elevate the interdental papilla in a full-thickness manner up to the intact interdental bone crest. Subsequently, a CTG (1 to 1.5 mm thick) was harvested with the single-incision technique. The CTG was inserted into the pouch using positioning sutures, then stabilized in a mesiodistal direction. The graft was tightly adapted to the CEJ of the experimental tooth/teeth with sling sutures (6-0 polypropylene, SurgiPro II, Covidien). Then, the margins of the pouch were advanced coronally with

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sling sutures (6-0 polypropylene) for primary closure, without engaging the fixed CTG. In case of deep GRs (≥ 4 mm), the margins of the pouch were sutured with single sutures over the CTG in a mesiodistal direction to accomplish complete or partial coverage of the graft.16

**Postsurgical Care**

After the surgery, all the patients were prescribed ibuprofen (600 mg twice daily) for 3 days and systemic amoxicillin combined with clavulanic acid (1,000 mg, bid) for 7 days, and they abstained from mechanical measures of oral hygiene for 4 weeks.16,22 During this period, 0.12% chlorhexidine digluconate mouth rinsing was prescribed for a duration of 1 minute, twice daily. Sutures at the donor and recipient sites were removed at 7 and 14 days postsurgery, respectively. At 1 month postsurgery, patients were instructed to resume mechanical tooth cleaning with a soft-bristle toothbrush, and they received professional mechanical plaque control (performed by S.A.). Recall appointments were scheduled at 3, 6, and 12 months postsurgery.

**Statistical Analysis**

All statistical analyses were performed using SPSS Statistics software (version 25.0, IBM). Normality of parameters was assessed by Shapiro-Wilk test. Descriptive statistics included mean values, SDs, and 95% confidence intervals. For paired observations, intragroup comparisons for normally distributed parameters were performed using Student t test, and Wilcoxon signed-rank test was used for parameters that were not normally distributed. For statistical analyses, the level of significance was set at 5% (α ≤ .05). Before patient recruitment, a sample size was calculated based on mean RC percentage (mRC). Previous studies using TUN + CTG reported 87% mRC with an SD of 17%. Using this data and accepting an alpha risk of 5% and a beta risk of 20% (power: 0.8) in a two-sided test, a minimum of 14 patients was necessary. A drop-out rate of 10% was anticipated.

The following formula was used for mRC calculation: [(baseline RD) – (1-year RD) / (baseline RD)] x 100. The investigated teeth were divided into two subgroups according to the final mRC: subgroup 1 patients reached 100% RC (CRC), and subgroup 2 patients achieved partial RC (PRC). Multilevel analysis considering tooth level was performed to investigate factors related to recession anatomy influencing the mRC. Baseline variables (RD, RW, and ARR) were analyzed in the models as explicative variables.

**Results**

The study population consisted of 16 patients presenting with 33 GRs. There were no drop-outs and no missing data throughout the study period. Nine patients (56%) presented with a single recession, and 7 patients (44%) had multiple GRs. Twelve recessions (36%) were classified as RT1, and 21 (64%) were RT2. Descriptive statistics of the clinical parameters at baseline are presented in Table 1.

At 12 months, highly statistically significant decreases in RD (P < .0001) and RW (P < .0001) were observed (Table 2). There was a negligible increase in PD, without any statistically significant difference (P = .711). The mRC was 88.85% ± 2.73%, and CRC was achieved in 19 sites (58%). The esthetic evaluation performed at 12 months using RES was 8.52 ± 1.75 (Table 3).

Subgroup analyses were performed between sites showing CRC and PRC. All clinical parameters (RD, CAL, iCAL, KTW, GT, mP, dP, and ARR) measured at baseline exhibited significant differences between the two subgroups, with the exception of RW (Table 4). Sites exhibiting CRC had a mean ARR of 0.84 ± 0.06, while those with PRC had a mean ARR of 0.60 ± 0.11 (P < .001). At 12 months, RES values were 9.95 ± 0.23 in the CRC subgroup and 6.57 ± 0.65 in the PRC subgroup (P < .001).

Regression analyses at 12 months revealed a positive correlation between ARR and the mRC (Figs 5 and 6); both regression coefficients were highly significant (P < .0001).

The multilevel analyses were performed to explore anatomical factors associated with mRC. The generated model was highly significant (P < .0001) and explained 77% of the observed variability in mRC (Table 5). Only ARR was found to be associated with mRC (P = .0005). RD (P = .527) and RW (P = .191) did not...
### Table 1 Demographic Characteristics of Patients and Baseline Clinical Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Gender, n</th>
<th>CAL, mm</th>
<th>iCAL, mm</th>
<th>KTW, mm</th>
<th>GT, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Female</td>
<td>10</td>
<td>3.96 ± 0.24</td>
<td>1.97 ± 0.31</td>
<td>2.39 ± 0.25</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>6</td>
<td></td>
<td></td>
<td>1.87, 2.9</td>
</tr>
<tr>
<td>Age, y</td>
<td>Mean ± SD</td>
<td>33.75 ± 11.47</td>
<td>3.46, 4.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tooth type, n</td>
<td>Maxillary incisor</td>
<td>9</td>
<td>2.74 ± 0.22</td>
<td>2.31, 3.19</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maxillary canine</td>
<td>4</td>
<td>3.66 ± 0.21</td>
<td>3.22, 4.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mandibular incisor</td>
<td>15</td>
<td>1.18 ± 0.39</td>
<td>1.04, 1.32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mandibular canine</td>
<td>5</td>
<td>2.39 ± 0.25</td>
<td>1.87, 2.9</td>
<td></td>
</tr>
<tr>
<td>Recession type (RT), n</td>
<td>RT1</td>
<td>12</td>
<td>4.42 ± 0.33</td>
<td>3.75, 5.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RT2</td>
<td>21</td>
<td>4.17 ± 0.29</td>
<td>3.57, 4.77</td>
<td></td>
</tr>
</tbody>
</table>

RD = gingival recession depth; RW = gingival recession width; PD = probing depth; CAL = clinical attachment level; iCAL = interdental CAL; KTW = keratinized tissue width; GT = gingival thickness.

### Table 2 Clinical Measurements at Baseline and 12 Months After Treatment

<table>
<thead>
<tr>
<th>Variables</th>
<th>Baseline</th>
<th>12 mo</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>95% CI</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>RD, mm</td>
<td>2.74 ± 0.22</td>
<td>2.31, 3.19</td>
<td>0.46 ± 0.13</td>
</tr>
<tr>
<td>RW, mm</td>
<td>3.66 ± 0.21</td>
<td>3.22, 4.09</td>
<td>1.16 ± 0.29</td>
</tr>
<tr>
<td>PD, mm</td>
<td>1.18 ± 0.39</td>
<td>1.04, 1.32</td>
<td>1.21 ± 0.42</td>
</tr>
<tr>
<td>CAL, mm</td>
<td>3.96 ± 0.24</td>
<td>3.46, 4.45</td>
<td>1.66 ± 0.16</td>
</tr>
<tr>
<td>iCAL, mm</td>
<td>1.97 ± 0.31</td>
<td>1.33, 2.61</td>
<td>2.00 ± 0.32</td>
</tr>
<tr>
<td>KTW, mm</td>
<td>2.39 ± 0.25</td>
<td>1.87, 2.9</td>
<td>2.90 ± 0.25</td>
</tr>
<tr>
<td>GT, mm</td>
<td>0.89 ± 0.05</td>
<td>0.78, 1</td>
<td>1.19 ± 0.06</td>
</tr>
</tbody>
</table>

RD = gingival recession depth; RW = gingival recession width; PD = probing depth; CAL = clinical attachment level; iCAL = interdental CAL; KTW = keratinized tissue width; GT = gingival thickness.
reach the level of statistical significance individually.

Discussion

The major purpose of this study was to explore a possible correlation between RC and ARR; a novel ratio including multiple baseline anatomical characteristics of the recession site. The clinical results demonstrated a significant positive correlation between ARR and mRC: a higher mRC was associated with higher ARR values, suggesting that ARR may be used as an analytical baseline parameter for CRC in TUN + CTG treatment and may help clinicians to decide on the surgical technique.

TUN preparation, especially in deep GR cases, does not predictably allow such a coronal postsurgical gingival margin position. In a case series investigating the outcomes of TUN + CTG in the anterior mandible, 3 mm of RD was found to be the critical value affecting the clinical outcomes. In other words, as the baseline RD increased from

### Table 3 Treatment Outcomes at 12 Months

<table>
<thead>
<tr>
<th>Variables</th>
<th>All sites (n = 33)</th>
<th>RT1 sites (n = 12)</th>
<th>RT2 sites (n = 21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mRC, %</td>
<td>88.85 ± 2.73</td>
<td>96.33 ± 8.61</td>
<td>84.57 ± 17.34</td>
</tr>
<tr>
<td>Sites with CRC, n (%)</td>
<td>19 (58%)</td>
<td>10 (83%)</td>
<td>9 (43%)</td>
</tr>
<tr>
<td>RES</td>
<td>8.52 ± 1.75</td>
<td>9.5 ± 1.17</td>
<td>7.95 ± 1.8</td>
</tr>
</tbody>
</table>

mRC = mean percentage of root coverage; CRC = complete root coverage; RES = root coverage esthetic score; RT1 = recession type 1; RT2 = recession type 2. mRC and RES values are presented as mean ± SD.

### Table 4 Descriptive Subgroup Analyses of the Clinical Parameters According to Root Coverage Rate

<table>
<thead>
<tr>
<th>Variables</th>
<th>CRC sites (n = 19)</th>
<th>PRC sites (n = 14)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD, mm</td>
<td>1.93 ± 0.57</td>
<td>3.86 ± 1.03</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>RW, mm</td>
<td>3.41 ± 1.21</td>
<td>4.01 ± 1.19</td>
<td>.132</td>
</tr>
<tr>
<td>CAL, mm</td>
<td>3.08 ± 0.78</td>
<td>5.14 ± 1.18</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>iCAL, mm</td>
<td>1.11 ± 1.24</td>
<td>3.14 ± 1.83</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>KTW, mm</td>
<td>2.80 ± 1.62</td>
<td>1.81 ± 0.98</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>GT, mm</td>
<td>0.99 ± 0.34</td>
<td>0.75 ± 0.19</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>mP, mm</td>
<td>5.54 ± 1.52</td>
<td>2.89 ± 1.10</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>dP, mm</td>
<td>4.86 ± 1.39</td>
<td>3.23 ± 1.66</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>ARR</td>
<td>0.84 ± 0.06</td>
<td>0.60 ± 0.11</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>RES</td>
<td>9.95 ± 0.23</td>
<td>6.57 ± 0.65</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>mRC, %</td>
<td>100 ± 0</td>
<td>73.71 ± 13.35</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

CRC = complete root coverage; PRC = partial root coverage; RD = gingival recession depth; RW = gingival recession width; CAL = clinical attachment level; iCAL = interdental CAL; KTW = keratinized tissue width; GT = gingival thickness; mP and dP = distance from tip of the mesial and distal papilla, respectively, to the point where the recession contacts the cementoenamel junction; ARR = anatomic recession ratio; RES = root coverage esthetic score; mRC = mean percentage of root coverage. Values are presented as mean ± SD.
3 to 4 mm, the CRC rate decreased from 88% to 41.67%. From a clinical perspective, factors related to the finding of 41.67% CRC rate still remain unknown. In the present study, using ARR as an additional clinical baseline parameter provided a ratio that helped determine a cut-off value for CRC in TUN + CTG. An optimal cut-off point of 0.77 for ARR was found, meaning that an ARR of 0.77 was the critical threshold for obtaining CRC in the present study. Thus, it can be speculated that clinical scenarios with an ARR < 0.77 may benefit more from CAF-based procedures. Nevertheless, further clinical trials are necessary to confirm this finding.

Several factors specific to patient, site, and technique that affect the clinical outcomes have been evaluated in previous studies, mainly when applying CAF-based procedures. Among the site-specific factors, GT, KTW, papilla height, tooth location and position, RD, and RW seem to play a major role in obtaining good clinical outcomes. Ozcelik et al. suggested that the avascular exposed root surface area (AERSA) and interdental papilla height may predict CRC with CAF + CTG procedures. They also pointed out that the interdental papilla height was more prominent than AERSA in RT2 defects. There is a great variation in RT2 defects in terms of anatomic reference points, and thus, ARR is suggested to be calculated in the presence of both GCs along the CEJ.

ARR consists of novel reference points and distances, such as the distance between the tip of the interdental papilla and GC. To the best of our knowledge, this is the first study to evaluate the use of ARR in TUN + CTG procedures.

### Table 5 Multilevel Analysis on Tooth Level Evaluating Factors Associated with Mean Percentage of Root Coverage

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>SE</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>40.73</td>
<td>19.44</td>
<td>.045</td>
</tr>
<tr>
<td>RD</td>
<td>-1.58</td>
<td>2.48</td>
<td>.527</td>
</tr>
<tr>
<td>RW</td>
<td>-1.79</td>
<td>1.34</td>
<td>.191</td>
</tr>
<tr>
<td>ARR</td>
<td>79.78</td>
<td>20.22</td>
<td>.0005</td>
</tr>
</tbody>
</table>

RD = gingival recession depth; RW = gingival recession width; ARR = anatomic recession ratio; SE = standard error.

The model was highly significant: $P < .0001$; $r^2 = 0.768$.
of the present authors’ knowledge, this is the first study calculating the curvilinear distance of the papilla reaching the CEJ-GR contact. In the subgroup analysis, it is interesting to see the difference between the CRC and PRC groups in terms of mP and dP length. A longer curvilinear distance between the papilla tip and GC revealed a higher CRC rate. In the ARR equation, longer curvilinear papilla distances increased the ratio rate more than shorter distances. For example, a 12-mm curvilinear papilla distance is calculated with 10% more ARR value than a 6-mm curvilinear papilla distance using the same anatomic and GR lines.

Significant differences were found in the baseline values of RD, CAL, iCAL, KTW, GT, mP, dP, and ARR between the CRC and PRC subgroups, but not in RW. Sites with deeper baseline RD showed less RC. The difference in ARR between the subgroups provides strong support for the hypothesis that a higher ARR increases the probability of achieving CRC. Moreover, the present finding of higher RES values being associated with the tendency to obtain CRC is in line with previous studies reporting the highest percentage of RC in deep but narrow recessions. Further studies using different surgical techniques with and without CTG are warranted to support the present findings.

There are some limitations of the present study, such as the use of only one surgical technique and the lack of a control group. The additional digital image analysis required to calculate ARR may also be regarded as a limitation. Further controlled studies comparing the efficacy of a surgical technique with and without CTG/soft tissue substitutes using ARR would better clarify the general applicability of this novel clinical parameter. The comparison of two different surgical techniques with the same setting is likely to provide new insights for the preference of one surgical technique to the other(s).

Conclusions

Within the limitations of the present study, it can be suggested that higher ARR values are positively associated with mRC outcomes in the treatment of RT1 and RT2 GRs treated with TUN + CTG. Long-term controlled trials with a larger sample size are needed to support the findings of the present study and better clarify the potential of ARR to predict RC.

Acknowledgments

The study was funded solely by the institutions of the authors. The authors declare no conflicts of interest.

References


