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Sometimes Goodwill Cannot Restore Goodwill

Hurricanes Harvey, Irma and Maria assaulted Texas, Louisiana, Florida, Puerto Rico and the U. S. Virgin Islands with destructive winds and storm surge flooding. These disasters took lives, caused personal injury and displaced individuals from entire regions. Authorities advised more than six million residents to evacuate in response to Hurricane Irma alone.¹

While human tragedy and suffering dwarfed economic losses, financial costs still devastated both individuals and businesses, including dental practices. National, state and local agencies, the ADA Foundation Emergency Disaster Grant Program, state and local dental associations, and insurers, among others, responded to affected dentists quickly and effectively with benevolence and compassion. The tremendous outpouring of support on all fronts provided heartening and heroic examples of our willingness to help each other in times of need. However, no amount of charitable goodwill or insurance reimbursements can make dentists whole for their lost practice goodwill.²

Natural disasters, such as these recent hurricanes, involve four levels of damage and associated relief. First, personal injuries and displacement from homes and offices require basic emergency medical care and supplies, food, water and shelter. Funds from the ADA and state disaster relief grant programs assist members with these challenges. Second, casualty insurance benefits compensate policyholders for property damage to dental office buildings and equipment. Third, disability and practice interruption or overhead insurances can, in part, reimburse injured claimants for lost income or defray overhead costs when conditions force practices to close.

Finally, when a practice ceases operations for an extended period of time or evacuations, temporarily or permanently, displace part or all of a practice’s patient base, it decreases the likelihood that its patients will return to the reopened or relocated practice. This loss of patients’ allegiance to a specific practice significantly reduces the practice cash flow, which, in turn, decreases the practice market value. Regretfully, no government agency, organized dentistry foundation or insurer compensates the dentist for such lost value.

Practice valuations routinely quantify the value of the intangible asset of practice goodwill in preparation for a practice sale, merger or partner buy-in or buyout. In order to calculate a specific value, appraisers will typically analyze the factors that will most influence the likelihood that the patient base will continue to patronize a new owner. These i-
clude location, cash flow, net profit and patient demographics. Goodwill can, on aver-
age, constitute 75 percent to 80 percent of the total practice fair market value. Hence, a practice with a fair market value of $400,000 can include a goodwill value of over $300,000.

Natural disasters can unpredictably and irreparably damage practice goodwill. Although goodwill values significantly outweigh the value of the tangible assets, such as equipment and leasehold improvements, no form of relief currently exists to compensate owners for such loss. Consequently, practice and personal financial planning must reflect the uninsurable and irreplaceable nature of such an intangible asset. Depending on an owner dentist’s career status, such permanent financial loss could drastically reduce a mature dentist’s ability to retire. Hence, dentists should not rely on the sale of their practice goodwill to fund their retirement. It could also impair a new practice owner’s capacity to repay practice acquisition debt. With this in mind, new dentists should limit borrowing and maintain an emergency fund to facilitate debt service in times of reduced cash flow.

All dentist owners must recognize their practice goodwill, while their most valuable practice asset may also stand as the most fragile and vulnerable.

REFERENCES
Chronic Localized Osteomyelitis in an Immunocompetent Patient


ABSTRACT

Chronic suppurative osteomyelitis still constitutes a significant oral health burden in developing countries. However, it is a relatively rare complication of odontogenic infections in the United States. This case report serves to heighten awareness of suppurative osteomyelitis as an important, albeit uncommon, sequela of long-standing infection of the jaw in a healthy U.S. adult with no known predisposing factors. We describe a case of chronic suppurative osteomyelitis that presented in a healthy, young, adult female with no predisposing factors besides smoking 11 years post-endodontic therapy.

Established risk factors of suppurative OM are typically characterized by a decrease in blood perfusion of bone. These conditions (Table 1) include head and neck irradiation therapy, malignancies, osteopetrosis, osteoporosis and Paget’s disease of bone.1,2,3,14,15 Systemic conditions that compromise immunity, such as anemia,
TABLE 1  
Conditions that Increase Risk of 
Developing Osteomyelitis

<table>
<thead>
<tr>
<th>OSTEOMYELITIS PREDISPOSING FACTORS</th>
<th>Local Factors</th>
<th>Systemic Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic lymphedema</td>
<td>Malnutrition</td>
<td></td>
</tr>
<tr>
<td>Venous stagnation</td>
<td>Kidney/liver failure</td>
<td></td>
</tr>
<tr>
<td>Impaired blood circulation</td>
<td>Diabetes mellitus</td>
<td></td>
</tr>
<tr>
<td>Neuropathy</td>
<td>Malignant diseases</td>
<td></td>
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<tr>
<td>Radiation fibrosis</td>
<td>Paget’s disease</td>
<td></td>
</tr>
<tr>
<td>Small vessel disease</td>
<td>Osteoporosis/osteoporosis</td>
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</table>

In terms of presentation, acute and secondary chronic forms of osteomyelitis may also serve as contributing factors. Additionally, patients on bisphosphonate therapy, which has become increasingly popular for the treatment of multiple myeloma, metastatic cancer and advanced osteoporosis, are also, unfortunately, at increased risk of necrosis of the jaw bones and inflammation of the surrounding tissues following surgery. This condition is known as bisphosphonate-related osteonecrosis of the jaw (BRONJ) and is extensively reported in the literature. The term “medication-related osteonecrosis of the jaw (MRONJ)” has since replaced BRONJ because there are other antiresorptive drugs besides bisphosphonates that can also induce osteonecrosis of the jaws.

In terms of presentation, acute and secondary chronic forms of osteomyelitis can be delineated, depending on how long the infection has been present. An infection present for less than four weeks is defined as acute, whereas one that has persisted longer than four weeks is defined as chronic. Various other classifications also exist in the literature. The clinical signs of chronic osteomyelitis include fever, malaise, pain, recurring infection in the same location, sequestrum (dead bone), new bone formation (sclerosis) and a draining fistula.

Osteomyelitis of the skull may present in the maxilla, mandible, frontal, nasal, temporal and/or skull base bones. The mandible is the most commonly affected bone of the maxillofacial region. Clinical diagnoses of OM can be made quickly, but a combination of radiographic and microscopic analyses is usually used for detection of early lesions, extent of involvement and confirmation of diagnosis.

Acute and secondary chronic forms of OM demonstrate a male predilection, with a 2:1 ratio. The average age of onset is 42.9 years old and 44.1 years old for the acute and secondary chronic forms, respectively. Primary chronic OM of the jaw occurs more commonly in females and does not appear to have an age predilection. Although the literature supports this female predilection, there is no clear explanation for this phenomenon. Primary chronic OM is most commonly seen in adults, although it has been noted in every age group. However, the age of onset has not been shown to affect treatment outcomes.

It is not clearly understood why osteomyelitis would occur in patients who are immunocompetent. This report presents a unique case of OM in an immunocompetent patient with no major predisposing risk factors.

Case report
A 32-year-old female presented to the urgent care clinic of a dental school with a chief complaint of pain, tenderness and root exposure on a lower left tooth. Medical history was significant for anxiety disorders and chronic left-sided facial pain and headaches, which she attributed to the tooth. There was no history of bisphosphonate therapy or head and neck irradiation. The patient’s social history is positive for smoking, drinking alcohol and previous recreational drug use. Past dental history revealed root canal treatment on tooth #19 11 years ago that had become symptomatic within the past year, with the patient self-reporting various episodes of swelling and pain. The patient had previously completed a course of 850 mg clindamycin three times daily for three months, prescribed by her primary care physician. Head and neck (extraoral) examination revealed no further abnormalities.

Intraoral examination showed an area of bony dehiscence associated with tooth #19 (lower left first molar) and exposure of the mesial root on tooth #19. The exposed bone appeared necrotic, while the associated tooth was mobile, and the surrounding area was very tender to touch (Figure 1).

Figure 1. Tooth #19 with sequestrated bone.
A periapical radiograph (Figure 2) revealed that the tooth had been endodontically treated; there was also evidence of severe loss and furcation involvement of tooth #19. A panoramic radiograph showed bony pathology associated with tooth #19, as well as a large periapical radiolucency related to the distal root of the contralateral tooth #30, which had also been treated endodontically.

Tooth #19 was extracted, the socket curetted and granulation tissue removed. The extraction site was irrigated with saline. Contents of the socket, including the surrounding bony sequestra, were sent for histopathological analysis. The patient was placed on Tylenol 3 every six hours, as needed, for pain; chlorhexidine mouthwash twice daily for one week; and amoxicillin 500 mg every eight hours for five days.

**Histopathology**
Microscopic examination of the specimen confirmed a diagnosis of secondary chronic or suppurative (localized) osteomyelitis. This is characterized by the presence of multiple irregular fragments of non-viable mature bone trabeculae exhibiting loss of osteocytes from their lacunae and accompanying bone resorption. In addition, the intertrabecular spaces demonstrated heavy colonization by bacterial microorganisms, interspersed with patchy infiltrates of inflammatory cells, mostly neutrophils, lymphocytes and plasma cells (Figures 4,5).

**Discussion**
The case of osteomyelitis described here was most likely due to an untreated chronic infection associated with tooth #19, which persisted long enough to cause osteonecrosis in that area. The tooth was endodontically treated 11 years prior; however, it is possible not all canals were sufficiently cleaned, or contamination of the periapical region may have occurred during the root canal procedure. There may also have been an associated fracture not evident radiologically. Arsenic trioxide, a compound used in dentistry for pulp devitalization and in its extirpation, has been linked to osteomyelitis or osteonecrosis following leakage into the periradicular tissues, but that seems unlikely in this case, since it is not commonly used in the United States.

The patient is a known smoker, with a one pack per day history for 21 years. Scientific evidence indicates smoking alters the healing response of tissues and may contribute to development...
of chronic osteomyelitis. The panoramic radiograph (Figure 3) shows a similar lesion on the lower right quadrant, associated with tooth #30, which though asymptomatic at this time, may precipitate the development of OM in the future.

Results from the patient’s bloodwork two weeks after diagnosis showed evidence of slight anemia. Hemoglobin (Hgb) was 11.3 (normal range 12-16); hematocrit (HCT) 33.3 (normal range 36-46). Though anemia is a predisposing factor to development of osteomyelitis, it is unlikely the patient’s slightly reduced hemoglobin and hematocrit levels played a role in this case.

Tissue culture and sensitivity, with histopathologic analysis of the affected bone, is the gold standard for determining the exact nature of the pathogens involved so that the appropriate treatment regimen can be instituted. Blood samples aid in determining whether hematogenous spread is involved, with laboratory tests typically showing elevated leukocytes, erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP). It should be noted that an elevated ESR can be attributed to factors other than osteomyelitis, such as fever, ongoing antibiotics and dehydration. Lastly, CRP can be used as a monitoring tool to evaluate clinical resolution of an infection in these patients. In this case, only the complete blood count profile was captured and monitoring of serum CRP levels was deemed unnecessary.

At one-week follow-up, there was no swelling or tenderness to palpation of the extraction site, but granulation tissue was present in the extraction socket, and there was some bony exposure distobuccally.

At the three-week follow-up, the patient said a piece of bone had come out of the area, although she had no associated discomfort, pain or swelling. At the eight-week postoperative visit, facial asymmetry was no longer evident, but the patient reported slight discomfort on chewing in the area. Intraoral examination revealed a healed extraction site with an appreciable concavity from the underlying bony defect (Figure 6). This could have contributed to the slight discomfort on chewing. Removal of the local source of infection, i.e., tooth #19, and curettage of sequestered bone, in addition to antibiotic coverage, produced complete healing of the local condition. The patient is now pregnant. A CBCT scan and bone grafting are planned post-delivery, prior to replacement of the extracted tooth #19.

Pregnancy-related osteomyelitis in the jaw and other bones is rare, but it has been reported in the literature. It is, however, the non-suppurative variety, unlike in this case. A preoperative radiograph, prior to root canal therapy, as well as follow-up postoperative radiographs at intervals, would have been necessary tools in assessing the progression of the lesion on tooth #19. Since the
patient’s endodontic treatment was performed elsewhere, it was not possible to readily obtain those records.

Conclusion
The authors postulate that a chronic, unresolved periapical lesion, in addition to a long-term smoking history, may have contributed to a patient’s osteomyelitis. Routine follow-up appointments after root canal therapy could have detected early infection, warranting retreatment or apicoectomy with retrograde filling, which may have prevented development of OM.

Queries about this article can be sent to Dr. Ogbureke at ezinne.i.ogbureke@uth.tmc.edu.

REFERENCES

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The Furcation Defect Dilemma

Multidisciplinary Approach to Diagnosis and Treatment


ABSTRACT

Periodontists are often called upon to provide treatment for furcation bone loss. However, periodontal disease is only one cause of bone loss within the furcation of teeth. Endodontic pathosis, tooth fractures, periodontal disease, as well as non-odontogenic causes, must be considered before beginning treatment. Periodontal treatment of a furcation defect should never be done without a proper endodontic diagnosis. Radiographic and clinical findings can help the clinician arrive at a correct diagnosis. While some furcation defects are relatively simple to treat and have a good long-term prognosis, others can render a tooth hopeless. A new etiology-based classification system of furcation defects is needed to lead the clinician to a proper diagnosis. Understanding the etiology of the defect is critical to avoiding unnecessary, irreversible and ineffective procedures.

In clinical practice, diagnosing the origin of furcation defects on mandibular molars is challenging. It is essential when determining the etiologic factors of a furcation defect that endodontic, as well as periodontal factors, be explored.

In 1978, Gutmann discussed the intercommunication between the pulp and the periodontium through accessory canals. A widely held view is that teeth with interradicular bone loss is primarily related to periodontal problems; however, if the anatomy of the furcation region, endodontic influences and the overall periodontal status of the patient are considered, the decision-making process for the definitive diagnosis of a tooth with furcation involvement may indeed include periodontic only, both endodontic and periodontic, or merely endodontic concerns.

This report explores issues relating specifically to the endodontic origin of furcation lesions and the importance of establishing an endodontic diagnosis, which should be included when evaluating molar furcation defects.

Challenges of Furcal Area Anatomy

The furcation area provides a unique environment, favorable to bacterial plaque and retention, which may hinder professional and personal plaque control and affect the pathogenesis of periodontal destruction. In addition, there are furcal accessory canals that allow for communication between the pulp and periodontal tissue. Accessory canals are found in 28.4% of molars, with 29.4% in mandibular molars and 27.4% in maxillary molars. Of the total, 25.5% showed furcation accessory canals in the fur-
cation area only, and 10.2% showed canals on the lateral root surface. This communication between the pulp and periodontal tissue is through dentinal tubules. Another article found 24% of mandibular first molars and 20% of mandibular second molars had patent furcal accessory canals.

**Challenges of Vertical Root Fractures**

Published reports of the dilemma of managing root fractures go back as far as 1903. Bifurcation radiolucency of endodontically treated mandibular molars could present as a vertical root fracture (VRF) along the vertical axis of the root. Bifurcation radiolucency, in conjunction with other areas of radiolucency, was found to be statistically significant for a VRF. Additional diagnostic tests, including cone beam computed tomography (CBCT), have not proven to be any more valuable than conventional radiographs for VRF diagnosis.

In 2008, the American Association of Endodontists stated that a narrow isolated probing defect associated with an endodontically treated tooth can be considered pathognomonic for a VRF. Vertical root fractures, especially early on, are difficult to diagnosis. The typical J-shaped radiographic lesion often appears in later stages. The periapical lesion in multi-rooted molars has a higher tendency of expanding into the furcation rather than on the external root surface. Hence, if the “J-shaped” lesion in multi-rooted teeth radiographically extends from the apex towards the furcation, it is more likely to have an endodontic cause.

On the other hand, if the lesion extends radiographically from the apex towards an adjacent tooth, it is highly suggestive of a root fracture. Some signs and symptoms that can help direct the clinician to a proper diagnosis of root fracture, as opposed to a periodontal defect, include:

- Pain and sensitivity while chewing.
- Swelling.
- Association with an endodontically treated tooth, with or without a post; however, VRF can also occur on non-endodontically treated teeth.
- A sinus tract located in an area more coronally than an apical abscess.
- A deep, narrow isolated periodontal pocket inconsistent with the general periodontal condition.

**Challenges of Diagnosis and Therapy**

It is well established that clinicians follow recommended guidelines for the diagnosis and periodontal therapy of furcation defects, in-
cluding predictable periodontal regeneration, root amputation, hemisection, osseous surgery and biscuspidization; however, the majority of articles published do not mention the exclusive role of endodontics in furcation defects. The decision-making process for the diagnosis and therapy of furcation involvement definitely requires a thorough periodontal and radiographic evaluation. The missing link is the endodontic component. Indeed, there may be a periodontal aspect, but the tooth may also be endodontically involved with or without a periodontal component. Thus, all endodontic diagnostic tests should be performed, along with a periodontal assessment, when a tooth presents with a furcation defect.

It should be noted that although a molar may respond to temperature testing, there are multiple roots, and one or more roots may be nonvital. In addition, teeth with full-coverage restorations pose a unique challenge when attempting to determine the pulp status. Therefore, when the clinician is unable to accurately perform pulp sensibility testing, a referral to an endodontist is recommended. Sensibility testing is a more appropriate term than pulp tests. Sensibility is defined as the ability to respond to a stimulus.

We propose four categories of furcation defects that expound on the initial classification of endo/perio lesions. They are:

**Category 1:** Periodontal origin.

**Category 2:** Endodontic origin (including accessory canals).

**Category 3:** Root fracture.

**Category 4:** Mixed.

**Categories of Furcation Defects**

**Category 1**
Furcation defect of periodontal origin: extensive osseous destruction with deep probable depths and no sulcular communication. Sensibility testing shows a normal pulp response. Presence of calculus, local factors and deep, wide probing (Figure 1). Furcation defect treated only periodontally.

**Category 2**
Furcation defect of endodontic origin: localized furcation defect with no probable depth; tooth exhibits pulp necrosis (Figures 2a,b,c). Furcation defect treated by endodontics alone. The necrotic pulp may cause a sinus tract originating from the apex or lateral canals through the periodontium, along the mesial or distal root surface, up to the cervical part of the tooth. A radiolucency appears along the entire length of the root.

**Category 3**
Furcation defect due to fracture: clinically, an abscess may be present that resembles a periodontal lesion. Exploratory surgery or microscopic endodontic visualization may be needed to confirm a root fracture (Figures 3a,b,c).

**Category 4**
Mixed lesions: extensive osseous destruction with deep probable depths and sulcular communication (Figure 4). Requires both periodontal and endodontic treatment.

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**Figure 2.** (2A) Initially believed to be periodontal problem, tooth # 30 was referred to periodontist for treatment. (2B) Pulp sensibility testing confirmed non-vital pulp, and endodontic treatment was performed (note accessory canal). (2C) At six months, defect was resolved.
Summary
In summary, a decision-making flow chart should be followed when a molar presents with a furcation involvement, whether it has previous root canal treatment or not (Figure 5). The entire dentition should be evaluated for periodontal disease. Periodontal and pulpal problems are responsible for more than half of tooth mortality. Identification of the involved etiologic factors is important for adequate treatment and healing of both pulpal and periodontal tissues.

Periodontal treatment of a furcation defect should never be done without a proper endodontic diagnosis. The differential diagnosis for bifurcation radiolucency mandibular molars includes root fracture, presence of furcation accessory canals, endodontic/periodontic involvement or only periodontic involvement. The periapical lesion in multi-rooted molars has a higher tendency of expanding into the furcation rather than on the external root surface.

We strongly recommend that molars with furcation defects have pulp sensibility tests performed, in addition to a periodontal...
examination. Understanding the etiology of the defect is critical to avoid unnecessary, irreversible and ineffective procedures.

Queries about this article can be sent to Dr. Weinberg at maw2@nyu.edu.

REFERENCES
The aim of this study was to compare the immediate postoperative pain and tissue response after surgery with and without application of low-level laser (810 nm diode-laser) on 16 generalized periodontitis subjects. Statistically significant differences were seen for pain medication (PM) (p= 0.0023), pain scale (PS) (p= 0.0063) and tissue edema (TE) (p= 0.0313), favoring the use of LLLT with periodontal flap surgery. Tissue color (TC) did not show statistically significant result. Calculated effect size was large (Cohen’s $d=1.018$). LLLT is an effective, safe and predictable adjunct, accelerating wound healing and leading to favorable clinical outcomes, improved patient compliance and acceptability of periodontal surgery.

Inflammation of the supporting tissues of the teeth, progressive attachment loss and bone loss often result as the result of chronic periodontitis. Periodontal diseases are ubiquitous, affecting the majority of adults worldwide. But only a few affected individuals receive sufficient treatment.

Mechanical debridement that includes removal of calculus and other plaque-retentive factors helps in the cessation and stabilization of the disease. Adjunctive anti-microbial therapy and surgery also facilitate the cause.

Periodontal surgery that began initially with gingivectomy is the mainstay of periodontal treatment. Periodontal surgery is mainly aimed at increasing accessibility to root deposits removal by scaling and root planing, pocket reduction/elimination, and access to osseous defects, either for resection or regeneration.

The access flap, the original Widman flap 1918, Neumann flap 1920, apically repositioned flap 1962 and modified Widman flap 1974, enabled access to the root surface, root concavities and furcations for adequate debridement and uneventful healing.

A physiologically conducive environment that promotes tissue repair and regeneration is an important requisite for healing. This environment should be furnished with adequate blood supply, growth factors and nutrients.

The role of low-level laser therapy (LLLT) in dentistry was a novelty 30 years ago. It was considered promising, as well as controversial. Mester et al., in 1971, reported improvement in wound healing with the application of a low-energy 1J/cm2 ruby laser. This concept was considered “soft laser” and “bio-stimulation”/”bio-modulation.” Initially, there were conflicting reports in the literature. This could be attributed to the various types of lasers with several different parameters. Inert gases like argon 488 and 514 nm, helium neon HeNe: 634 nm, ruby 694 nm, krypton 521, 530, 568 and 647 nm were used. Subsequently, semiconductor laser diode devices, such as gal-
lrium arsenic GaAs: 904 nm, gallium aluminum arsenic GaAlAs: 810, 820 and 830 nm 904 nm, were explored.9

Low-level laser (LLL) mechanism is defined on the basis of several different parameters, such as power, intensity, dosage, pulse duration, rate, wavelength, irradiation/exposure time, and mode of irradiation to tissue.9 Positive LLLT therapeutic effects have been reported in the treatment of lesions of herpes simplex recurrence, glossitis, cheilitis exfoliative,11,13 chronic desquamative gingivitis, acute herpes, post-herpetic neuralgias,8 oral ulcerations, mucositis induced by cancer chemo/radio therapy,16,17 pain reduction in patients undergoing active orthodontic treatment,18 endodontic surgery,19 periodontal treatment like gingivectomy,20,21 adjunct after nonsurgical22-24 and surgical therapy,19,25,26 pain in temporomandibular joint disorders,27 tooth hypersensitivity and pain.28

LLLT may improve the regenerative effects of enamel matrix derivative (EMD) by promoting healing and reducing postoperative complications such as gingival recession.25 LLLT has been shown to improve the predictability of coronally advanced flap (CAF) in the treatment of multiple recession defects.9

Cellular behavior can be altered by irradiating the tissue at specific wavelengths, which acts on the cellular mitochondrial respiratory chain29 or on membrane calcium channels30 and leads to an increase in not only cell proliferation, but also metabolism of the cell.31,32 However there is scanty scientific literature that has evaluated the effect of LLLT on pain and clinical parameters of wound healing immediately after periodontal surgery. The objective of this randomized, controlled, split-mouth clinical trial was to assess the effects of LLLT on pain perception and clinical outcomes after conventional periodontal flap surgery.

Materials and Methods
The current study design was a split-mouth, double-blinded, placebo-controlled, randomized, controlled clinical trial (Figure 1).

Sample Size
A power calculation before initiation of this study revealed that a sample size of 15 was necessary to detect a difference of 2 in the pain scale out of 10,33 assuming a maximal mean standard deviation of 2.5 using a paired test with 80% power, and to reveal a level of significance within 95% confidence limits.34

Study Population
A total of 16 patients, with a mean age of 42.22 ± 7.53 years (Table 1), who satisfied the inclusion and exclusion criteria were included in the study from October 2013 to March 2014. Subject selection criteria were as follows: (i) patients who had two contralateral quadrants, each with a probing depth of ≥7mm, clinical attachment loss ≥7mm;34,35 (ii) age between 22 and 50 years; (iii) no systemic disease known to affect the periodontal tissues, according to Cornell Medical Index;24 (iv) not pregnant; (v) no history of smoking; (vi) no history of any periodontal treatment in the past six months; (vii) not on any type of medication; (viii) a full-mouth plaque score of 10% or less (Loe 1967). None of the patients had previously received laser treatment. Hence, they had no specific anticipation of the effect of this treatment.

The study was conducted in accordance with principles of the Declaration of Helsinki (version 2008). And the study protocol was reviewed and approved by the institutional Ethical Committee and Review Board (REF: KCDS/168a/2013-2014) of Krishnadevaraya College of Dental Sciences and Hospital, Bangalore, India. All patients were informed about the biologic effects of

### TABLE 1
Demographics of Study Participants

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>16</td>
</tr>
<tr>
<td>Age (years)</td>
<td>42.22 ± 7.53</td>
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<tr>
<td>Sex—males</td>
<td>9 (56.25%)</td>
</tr>
<tr>
<td>Sex—females</td>
<td>7 (43.75%)</td>
</tr>
</tbody>
</table>

![Figure 1. CONSORT statement flow chart.](image-url)
LLLT and periodontal flap surgery; and informed written consent was obtained from all participating patients.

Clinical Measurements
The same blinded examiner recorded all the clinical parameters to ensure an unbiased evaluation. The examiner was calibrated by the evaluation of study parameters on two separate occasions on 10 patients who were not enrolled in the study. Calibration was accepted if the measurements were similar at 90% level on both examinations.9,25

Primary outcomes measured were: (i) pain scale33 - reduction of self-reported postoperative pain, as measured by the modified Visual Analog Scale (VAS) graduated from 1 to 10, in which 1 is no pain and 10 is unbearable, severe pain;35 35 (ii) daily intake of pain medication (PM) – 200 mg tab ibuprofen up to three tablets every eight hours allowed.34,36

Secondary outcomes measured were tissue healing responses, evaluated at surgical sites (test and control) at baseline and at one week after surgery at the time of suture removal. Tissue edema (TE) was scored as: 1= absent; 2= slight; 3= moderate; 4= severe. Tissue color37 was recorded as: 0=no redness; 1= moderate redness; 2= pronounced redness.38

Clinical Procedures and Randomization
All patients received cause-related therapy, which consisted of through scaling and root planing, performed using hand instruments (area specific curettes, Hu-Fridy, Chicago, IL) and ultrasonic devices (EMS Electro Medical Systems Sa, Ch-1260 Nyon, Switzerland). Patient education, motivation and oral hygiene instructions were given at least three weeks prior to periodontal flap surgery.1,9

After three weeks, patients were reassessed. Patients who demonstrated bilaterally symmetrical periodontal pockets deeper than 5 mm were included in the study and were treated surgically. After the periodontal flap operation, one of the symmetrical surgical areas was randomly assigned to receive LLLT by the operator with a toss of a coin.9,26

The same operator performed surgical procedures on both the test and control sites in all of the patients to prevent inter-operator variations. The surgeries between sites were performed at no less than one-month intervals25 to evaluate and compare the postoperative pain between the two surgical sites.

Surgical Procedure and LLLT Application
After achieving local anesthesia with 2% lidocaine hydrochloride (Lignox 2%, Indoco Remedies Ltd., Goa, India), using a No. #12 stainless steel surgical blade (#12 Bard Parker Surgical Blade), intrasulcular incisions were placed and full mucoperiosteal buccal and lingual access flaps were elevated in each patient. Two to 3 mm of bone was exposed, and gentle root debridement and elimination of granulation tissue (Figures 2a,b), using hand instruments, ultrasonic and rotary instruments, were done. Root surfaces were scaled and planed with curettes.

Figure 2. Test group overview. (a) Preoperative view of pocket probing depth. (b) Intraoperative view of periodontal defect after flap reflection and debridement. (c) LLLT irradiation was done in surgical field using 810 nm diode laser. (d) Flap stabilization achieved by suturing. (e) LLLT irradiation repeated immediately after flap closure on outer surface of periodontal flap for five minutes. (f) Postoperative view after one week depicting healed periodontal tissue with no edema and no change in tissue color.
Laser irradiation protocol used in this trial has been described by Sanz-Moliner et al.\textsuperscript{34} The low-level laser used was a semiconductor aluminum, gallium and arsenide diode laser with a wavelength of 810 nm,\textsuperscript{34} output power of 100mW, and the power density was 4J/cm\textsuperscript{2} for five minutes of irradiation.\textsuperscript{9}

Before suturing, prior to flap approximation, the surgical field, i.e., the inner surface of the mobilized flap, and exposed bone and root surfaces\textsuperscript{34} of the test sites, were irradiated by applying the laser probe tip perpendicular to the target area\textsuperscript{9,24} in a continuous wave mode for five minutes (Figure 2c),\textsuperscript{9,26} leading to a total dosage of 4 J/cm\textsuperscript{2} per surface.\textsuperscript{34}

Then the flaps were repositioned and stabilized with 4-0 interrupted sutures (nonabsorbable surgical sutures, Mersilk, Ethicon, Johnson & Johnson, Himachal Pradesh, India) (Figure 2d). Periodontal flap surgery with active semiconductor diode laser radiation on the test site and the control site had only periodontal flap surgery with sham laser irradiation (laser was simulated, without pushing the start button and without activating the laser device in order to assure patient blindness).

LLLT irradiation was repeated immediately after flap closure on the outer surface of the periodontal flap for the test sites for five minutes (Figure 2e). The margins of the wound area were demarcated by the sutures, and laser probe was applied by slight contact with the tissues from the margins towards the center of the wound in circular motions.\textsuperscript{9} Laser therapy was performed on five consecutive days.\textsuperscript{25} It was noted in in-vitro studies that LLL irradiation induced significant differences in the proliferation of periodontal ligament fibroblasts for 48 hours, as compared to 72 hours, probably because of the diminishing effects of laser irradiation. This revealed that proliferation of fibroblasts is positively affected by repeated laser application.\textsuperscript{19,48} No periodontal dressings were placed.

Postoperative Laser Irradiation and Instructions
All test sites received postoperative LLLT daily for five days from outer buccal surfaces of the flaps for five minutes.\textsuperscript{25} LLLT stimulation without starting the laser machine (sham radiation) was also performed for five days for the control sites.

Bacterial decontamination using 0.12% chlorhexidine mouthrinse three times a day and doxycycline 100 mg bid for one week was prescribed.\textsuperscript{25,39} Patients were advised not to chew vigorously, to avoid flossing in the treated surgical area\textsuperscript{9} and to use a soft toothbrush for two weeks following surgery,\textsuperscript{34} after which they were advised to resume full oral hygiene and were placed on a regular three-month recall system.
Postoperative Assessment
Postoperatively, analgesic tablet ibuprofen 200 mg (up to three tablets a day) every eight hours as pain medication was permitted. The postoperative pain was measured and recorded on a chart given to the patient daily at night for one week using modified VAS with markings from 1 to 10, ranging from “no pain” to “unbearable, severe pain.” The chart was returned to the examiner one week later.

One week postsurgery, sutures were removed and tissue response was evaluated at the surgical sites (Figure 2f).

Statistical Method
A software package (IBM SPSS Statistics 21.0; SPSS, Chicago, IL) was used for statistical analysis. A Shapiro-Wilk test was used to assess the normality of the data. Since the data was not normally distributed, a non-parametric test was selected for data analysis. The difference between primary (PS and PM) and secondary (TC and TE) outcomes between the independent study groups (test and control) at the end of one week was analyzed using Mann-Whitney U test. Intra-group comparisons over time (baseline to one week) for the investigated secondary outcomes (TC and TE) between dependent groups were performed using Wilcoxon signed-rank test. The difference associated with p value <0.05 was considered statistically significant. Results were presented as mean ± SD.

Results
All patients included in the evaluation completed the study. No patient reported any adverse effects, such as burning, pain or sensitivity, after laser irradiation during the follow-up period. Healing was uneventful in all cases. The immediate postoperative VAS scores showed that significantly lower pain was reported by patients in the first two postoperative days on the flap + LLLT test sites, in comparison to sites treated only with periodontal flap + sham irradiation.

The pain medication (PM) consumption (200 mg ibuprofen) was 1.63 ± 0.74 for the test group. The control group showed 4.50 ± 1.31, which was statistically significant (p< 0.05) greater consumption of pain medication (Figure 3). PS value for the control site was 5.00 ± 1.77; for test sites it was 2.38 ± 0.92. A statistically significant difference (p< 0.05) between the study sites was seen, favoring the test sites, which received LLLT (Figure 4).

Tissue response was evaluated at baseline and at one week after suture removal. Statistically significant differences p = 0.0313 (p< 0.05) in the edema response existed between the treatment groups. Sites that were treated with LLLT had significantly less edema (1.38 ± 0.52) in comparison to the control group, which received sham laser irradiation (2.38 ± 0.92) (Figure 5). The average tissue color was 1.88 ± 0.64 at the control sites and 1.25 ± 0.46 at the test sites. The color of the tissue was not statistically

* Indicates statistical significance.
significant (p = 0.0742) between the test and control sites. Intragroup comparison at baseline and one week, in both the test group (0.75 ± 0.46, p = 0.2777) (p < 0.05) and the control group (1.38 ± 0.52, p = 0.0117) (p < 0.05) were statistically significant (Figure 6).

The effect of order of surgery on postoperative pain was evaluated. It was noted that the surgical treatment, in either the test or the control, performed first was significantly more painful than when done second. The difference was seen in PS scores (p = 0.0063) and in the amount of PM consumed (0.0023).

Further, Cohen’s effect size value was calculated to be d = 1.018, suggesting a high clinical and practical significance of the results obtained.

Discussion
Literature is replete with studies which show that LLLT has demonstrated potentially beneficial effects after surgery. These include:
- Better coagulation and activation of microcirculation, leading to accelerated angiogenesis and new capillary formation and eventual thickening of capillary bed and, as a result, more vascularization and nutrients to healing sites.
- Anti-inflammatory effect.
- Analgesic effect due to blockage of nociceptors and peripheral nerve endings.
- Increased proliferation of fibroblasts in the initial stage of healing, which would increase the tensile strength of the wound and prevent its collapse.
- Stimulation of growth and regeneration of bone cells.
- Accelerated bone consolidation.

At the molecular and cellular stage, due to the LLL, photoreception at the mitochondrial level may intensify the respiratory metabolism and electro-physical properties of the membrane, thus leading to changes in the physiology of the cell. Motility of fibroblasts and keratinocytes is facilitated, leading to an increase in the collagen synthesis and release of growth factors. Moreover, laser irradiation increases Adenosine triphosphate synthesis within the mitochondria, thus accelerating the speed of cell mitosis and neo-angiogenesis, which, in turn, leads to accelerated and favorable wound healing.

The response of PDL fibroblasts to LLL at 809 nm is stimulatory in nature, thereby leading to proliferation of PDL fibroblasts and production of basic fibroblast growth factor. LLLT also promotes the proliferation of mesenchymal stem cells or progenitor cells of PDL.

In the study presented here, periodontal flap, root surface were all irradiated with LLL. According to studies, wounds treated with LLLT demonstrated increased granulation synthesis, improved angiogenesis and micro-circulation. Increase in fibroblast proliferation, maturation, attachment and matrix synthesis has also been reported. All these factors contribute to the higher tensile strengths of gingival flap margins, rapid neo-vascularization and protection and stability of the granulation tissue under the wound margins, which may subsequently prevent the collapse of wound healing, thus even minimizing soft tissue recession. This may also explain the enhanced healing effect of LLLT, associated primarily with the early, most sensitive stages of the healing process, in which the wound has started remodeling.

The study conducted by Sanz-Moliner et al. in 2013 utilized one watt laser to de-epithelialize and completely remove the pocket lining during modified Widman flap surgery, followed by LLL stimulation by 809 nm diode laser for only a single application. The rationale behind it was that surgical lasers can remove diseased pocket lining epithelium and assist in coagulation and detoxify root surfaces. In our study, laser de-epithelialization was not performed and removal of the pocket lining and debridement of root surface were achieved during the conventional flap surgery. Kriesler et al., in 2003, clearly stated that repeated laser applications are necessary to achieve a positive effect on the proliferation of fibroblasts. Using this rationale, in the present study, emphasis was given to LLL irradiation during surgery and repeated application for five consecutive days in the periodontal flap area.

At the present time, there is extreme variation in the laser application parameters, such as wavelength, dose, time-duration of application, energy density and mode of application. Therefore there is an urgent need for LLL parameters to be standardized for different procedures.

In the study presented here, during the postoperative healing period, patients reported decreased pain in LLLT irradiated sites; the result was statistically significant and in concordance with the results reported by Sanz-Moliner et al. in 2013 and Ozcelik et al. in 2008. This analgesic effect has historically been a major clinical application of the technique. Pain reduction following
root canal treatment and postsurgical dental extraction have also been reported after LLLT application. LLLT has been used to selectively inhibit a range of nociceptive signals arising from peripheral nerves, including neuronal discharges elicited by pinch, cold, heat stimulation and chemical irritation. It is also believed to stimulate vascular smooth muscle relaxation, thus contributing to the analgesic effect of laser therapy.

The anti-inflammatory and anti-edema effects exerted by laser may occur through acceleration of microcirculation, resulting in changes in capillary hydrostatic pressure, thereby reducing vascular hyperemia and edema resorption and disposal of the accumulation of intermediary metabolites. Oliver et al., in 1969, and Qadri et al., in 2005, demonstrated in their studies that application of LLLT reduced gingival inflammation, which may explain the statistically significant reduction of swelling found in this study. However, clinically, a difference was noted in the tissue color between the test and control groups after one week of healing. But it was not statistically significant.

Even though our study showed marked significant improvement with LLLT, it has certain limitations. First, the considered sample size may affect the reproducibility of the outcomes. Second, daily application of low-level laser on five consecutive days may be an issue for compliance, as this procedure requires multiple appointments.

In the present study, the effects of LLLT were presented by clinical recordings only, but their co-relation with the histological and/or immune-histological healing aspects were not performed. Hence, in order to better understand the utility of LLLT for wound healing and regeneration, future well-controlled trials can be carried out to co-relate clinical alterations with changes at the cellular and molecular level.

Conclusion
Within the limitations of the present study, the results have shown that LLLT may significantly reduce postoperative pain and edema, thereby decreasing the intake of pain medication. The enhanced wound healing seen in the immediate postsurgical period can further benefit the desired clinical outcome and further improve patient compliance and acceptability to periodontal surgery. This can open up new avenues of research in pain reduction and management postsurgery. However, further studies with a larger sample size and a standard laser protocol are needed to evaluate healing and pain relief and to develop appropriate clinical recommendations.

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Two-year Clinical Evaluation of One-Step Composite System vs. Two-Step Composite System in Posterior Teeth


ABSTRACT

One hundred-twenty composite restorations were placed either for new carious lesions or for restorations requiring replacement. All restorations were randomized by surface and restoration class. Eighty Class II restorations were placed on molars. The remaining 40 were placed on premolars, all of which were bonded. In summary, there were no differences in objective measurements of the 111 restorations recalled at six months and at 12 months. Measurements of the iBOND and GLUMA restorations included margin staining, margin breakdown, surface wear and postoperative hypersensitivity. The quicker one-step offers the advantage of timesavings, with no loss of excellent results, compared to the two-step etching technique.

This in-vivo study evaluated the clinical performance of a one-step, self-etch primer/adhesive system (iBOND Self Etch, Heraeus Kulzer, South Bend, IN) versus a two-step, total-etch primer/adhesive system, (GLUMA Comfort Bond, Heraeus Kulzer) in Class II restorations using a medium-viscosity microhybrid composite resin (Venus, Heraeus Kulzer). A single Class II composite restoration was placed on a randomized patient and evaluated after 24 hours, one week, one month, six months and one year. All restorations were randomized by the adhesive system used and all were dentin bonded. Eighty restorations were placed on molar teeth and 40 were placed on premolars.

All teeth were prepared and restored by one of three New York University College of Dentistry faculty dentists, who were calibrated for preparation and placement technique. A 24-hour postoperative assessment for sensitivity was conducted by telephone interview to determine if any patient experienced symptoms on the restored teeth. Two calibrated examiners evaluated the restorations at recalls of one week, one month, six months and one year, using the modified Ryge criteria.
The examiners were blinded as to the bonding agent used for each restoration. In summary, there were no significant differences in the restorations recalled at 12 months. Measurements of the iBOND and GLUMA restorations included margin staining, margin breakdown, surface wear and postoperative hypersensitivity. iBOND is a universal, light-cured bonding adhesive compatible with all dental materials. GLUMA (GLUMA Comfort Bond) is a light-cured, single component bonding agent used in combination with adhesive restorations. GLUMA and iBOND both contain methacrylate, ethanol, photoinitiators and glutaraldehyde. Only GLUMA contains 4-Meta (4-methacryloyloxyethyl trimellitate anhydride), a strong adhesive.

Both adhesive systems, in conjunction with the microhybrid composite, were rated as excellent in all categories (modified Ryge criteria) for Class I and II restorations.

Introduction
Resin-based composites are currently the material of choice for single- and multi-surface operative dental restorations on posterior teeth, based upon conservation of the tooth structure, made possible through adhesive dentistry and restorative success. A recent 12-year clinical assessment of large multi-surface composite restorations found excellent results compared to similar dental amalgam restorations. And a 10-year clinical trial also provided evidence for the excellent survival rate of posterior composite restorations. Dental composites are typically made from radiopaque silicate glass particles, combined with diacrylate monomers that are polymerized during application, notably with polymerization shrinkage manifesting as a major clinical concern.

A bonding system, most frequently dentin bonding, is essential to the increased retention of resin-based composites, which helps prevent microleakage and minimizes the effects of polymerization shrinkage. With proper utilization, dentin bonding can minimize and even prevent marginal leakage that can result in secondary decay and tooth postoperative hypersensitivity. The conventional three-step dentin bonding systems include etching, priming and resin application. In bonding procedures, primer and resin adhesive infiltrate and adapt to a demineralized intertubular dentin and exposed collagen fibers.

In the two-step, self-etch dentin bonding systems, the technique consists of a phosphoric acid etching step, followed by a combined primer/adhesive application (one example is GLUMA...
Comfort Bond). GLUMA is a glutaraldehyde desensitizer/disinfectant, e.g., G5 (Clinician’s Choice); GLUMA (Heraeus Kulzer); GluSense (Centrix) or MicroPrime G (Danville).  

Two-step systems (like three-step) are reported to be efficacious on wet or dry dentin and are indicated for bonding both direct and indirect restorations. One-step, self-etch bonding systems are becoming increasingly popular and are widely used, primarily because of their ease of application and significant clinical success. These one-step systems are also referred to as 7th generation bonding agents or as all-in-one bonding agents. One example is iBOND self-etch. The all-in-one step bonding systems aim to simplify the clinical procedure by eliminating both the phosphoric acid etching and rinsing steps. The most common side effect of teeth to bonded restoration is etching acid hypersensitivity. The one-step self-etch bonding system is thought to minimize sensitivity by not removing the smear layer during etching but, instead, dissolving this layer and extending the bonding agent into the underlying dentin.

A concern for dentists with all-dentin bonding systems and particularly the newest generation is decreased bond strength over time, as reviewed by Breschi et al. A review of clinical data on Class V restorations indicates better retention for three-step, total-etch bonding systems compared to one-step systems. Another concern with self-etch systems is whether the bonds to freshly prepared enamel are adequate as compared to when the self-etch adhesive is applied to etched enamel. An overview of dentin bonding presented by Perdigao discusses variables and methods to prevent bond degradation.

This double-blind clinical study was designed to compare a one-step adhesive system and a two-step, total-etch adhesive system in posterior restorations. Signs that show clinical loss of bond strength and polymerization shrinkage are marginal staining and postoperative hypersensitivity that turns into chronic pain and elective root canal treatment.

**Materials and Methods**

One hundred and twenty posterior restorations that included new carious lesions or defective restorations with detected secondary decay were placed in our study. Restorations were restored randomly using either the one-step adhesive (iBOND) or the two-step, total-etch adhesives GLUMA Comfort Bond.

**Selection Criteria**

There were 60 subjects enrolled in this study, which were sufficient to complete the N = 120 posterior teeth that required restoration. Sixty-one restorations were GLUMA and 59 were iBOND. Eighty of the Class II restorations were done on molars, and 40 Class II on premolars. Only vital teeth, as determined by a vitalometer, were selected. The total number provided rational power for the primary outcome of bonding agent differences while allowing for a dropout rate of no more than 10% over the course of the study. Subjects were recruited from the general population at NYU College of Dentistry in compliance with an IRB-approved protocol.
Inclusion criteria included the following: healthy adults between 18–70 years of age with vital molar or premolar teeth, as determined by a vitalometer (Sybron-Endo, Glendora, CA) with one or more carious lesions and defective restorations with secondary decay. The size of the occlusal lesion had to be at least one-third of the facial-lingual extension. Class II lesions, with either mesial (MO) or distal (DO) surface involvement, had to be in contact with the adjacent tooth. The restored tooth had to be in occlusion. Subjects with one or more, but not more than four, lesions were enrolled. The criteria for exclusion from the subject popu-
lation were preoperative hypersensitivity, absence of primary or recurrent decay, extensive decay that was close to a pulp exposure, and non-vital teeth, as determined by the vitalometer.

**Restoration Procedure**

High-speed and low-speed handpieces were employed for both cavity preparation and caries removal. Completed cavity preparations were photographed using an intraoral camera. For Class II restorations, a sectional matrix band system was used to assure a tight contact and to reduce the likelihood of excess material beyond the margin. A resin-modified glass ionomer (RMG) liner (Fuji Liner LC, GC America, North Costa Mesa, CA) was placed on deep regions of the cavity preparation and cured for 10 seconds. Two bonding systems, either iBOND Self Etch or GLUMA Comfort Bond, were randomly assigned to the preparation and used as per the manufacturer’s instructions. The bonding agent was cured for 20 seconds following manufacturer’s directions. Following bonding, a Venus (Heraeus Kulzer) resin-based composite was placed and polymerized by light cure in 2 mm increments. Both the bonding agent and resin-based-composite were light-cured using a calibrated unit with a minimum output of 400 mW/cm following manufacturer’s instructions. The final restorations were finished and polished using a fine diamond bur and diamond polishing paste.

Postoperative hypersensitivity was evaluated after 24 hours via patient survey. Subjects were contacted by telephone and a postoperative hypersensitivity questionnaire was administered by telephone. Follow-up clinical evaluations were performed at one-week, six-months and one-year intervals. Two calibrated dentists performed a blinded clinical evaluation of the restorations using the modified Ryge criteria (Table 1).

The subjects and the evaluators were blinded as to the bonding agent used. Evaluation criteria were: color stability, marginal discoloration, secondary caries, occlusal wear, marginal adaptation,
proximal contact, functional occlusion, axial contour, restoration retention, restoration fracture and other failure. The same evaluation criteria were used at each reevaluation of the restorations.

**Bonding Procedure**
The two-step bonding procedure entailed use of GLUMA Comfort Bond (GCB Heraeus Kulzer), which is an ethanol-based, two-step adhesive bonding system. The entire cavity surface was etched for 20 seconds, starting on the enamel, with GLUMA Etch Gel, the supplied etchant solutions for GLUMA. It is a 35% phosphoric acid, the universal standard material to etch teeth. The teeth were rinsed with copious amounts of water then air-dried for one to two seconds, leaving the cavity moist and not desiccated. Three coats of the combined primer and adhesive were applied generously on the entire surface. After 15 seconds, the coated surface was air-dried carefully to spread the adhesive uniformly and remove the solvent. If the dried surface did not appear glossy, another coat was applied. The adhesive was light-cured for 20 seconds and the tooth restored with Venus (Heraeus Kulzer), a nano-hybrid, resin-based composite.

The one-step bonding procedure entailed use of iBOND (Heraeus Kulzer), an acetone-based, light-curing, self-etching, all-in-one adhesive. Following rinsing and lightly drying of the cavity preparation, a generous amount of iBOND was applied on the entire surface of the cavity preparation, followed by two additional coats of iBOND. After 30 seconds, the applicator was agitated over the surface. A gentle air stream was used to volatize any solvent, until no movement of the adhesive film was apparent. The adhesive was light-cured for 20 seconds. If the surface was not shiny, additional coats of adhesive were applied, air-dried and cured.

**Results**
A total of 120 teeth were restored. At follow-up, nine patients had moved away after six months. Total teeth evaluated at the one-week, six-month and one-year recall was used as baseline. GLUMA was the bonding agent for 61 teeth and iBOND was used for 59 teeth. Ethnicity and gender were nearly equally diversified. Random distribution for gender, age and bonding agents was set. In the iBOND experimental group of 59 patients, the mode was 24 years old, where there were 12 patients who were 24 years old (Figure 4). In the GLUMA experimental group of 61 randomized patients, there were 9 patients who were 27 years old (Figure 5).

No patient exhibited any preop sensitivity. Evaluation for GCB and iBOND bonding agents at one week, six months and one year has shown no significant sensitivity (Table 2). After 24 hours, both GLUMA and iBOND showed some sensitivity (Table 2). After one day.
week, iBOND showed less sensitivity than GLUMA. In general, the two bonding agents showed no significant differences in any evaluation category (Table 3). No secondary caries, occlusal wear and open margins were detected for either bonding agent.

One minor marginal defect was detected; a small chip was observed in one restoration at the six-month evaluation (Table 2). On one restoration, a space was observed on radiographic examination at the gingival area. However, on clinical inspection, there was no open margin detected on the restoration. The thickness of the bonding agent, plus the angulation of the original X-ray cone, permitted imaging this thick layer of unfilled resin.

A balance for gender and age across the two classes of lesions was made; and pictures for baseline and after one year were made, with some margin discoloration.

Discussion
In effect, total etching (enamel and dentin) is more practical than selective etching of the enamel, in particular for Class II preparations. According to Haller et al., self-etch is indicated for Class V and total-etch for Class II.

The study conducted by Schmaltz et al. demonstrated that the antibacterial effect of GLUMA Comfort Bond inhibits secondary caries formation and pulp inflammation by eliminating residual bacteria in and on dentin. The total-etch concentrations approach 30% to 60% phosphoric acid to remove a smear layer and demineralize the intertubular dentin, followed by rinsing off the dissolved smear layer with water spray, achieving an opening of the dentinal tubules. Additionally, disbanding the apatite crystals covering the collagen fibers creates micro-channels between the demineralized collagen fibers that advance the penetration of the primer and the bonding resin. Thus, etching with phosphoric acid removes the smear layer and enhances dentin permeability.

It has been reported that since self-etch adhesives are composed of phosphoric acid esters that have a higher pH than phosphoric acid-etching gels, they do not etch enamel as well as in the acid-etch technique with lower pH. The all-in-one system leaves out the rinsing and drying preparation of the cavity prior to restoration placement, which, therefore, prevents the risk of exposing the etched collagen network, which can result in the collapse of collagen. Mild self-etching adhesive systems, compared to strong self-etching adhesive systems, have a pH=2, and the hybrid layer is thinner than that with a strong self-etching system; the bond is just as successful. A one-year clinical trial demonstrated that both the one-step and two-step self-etching systems fared equally well.
Perdigao concluded that self-etch adhesives are less technique-sensitive than total-etch adhesives. Additionally, the results of marginal discoloration and sensitivity did not change for both self-etch and total-etch adhesives. Another study is necessary to follow up on retention rates. This study demonstrated an overall retention rate of 93.3% using GLUMA, an ethanol-based adhesive group, and a retention rate of 89.4% using iBOND, an acetone-based adhesive group. An in-vitro study concluded that one-step adhesives generated lower µTBS (microtensile bond strength) to enamel than two-step self-etch adhesives. On the other hand, a one-step self-etch adhesive generated lower µTBS to dentin than the two-step self-etch adhesives. In general, one-step adhesives were shown to be the least durable.

Both the three-step etch-and-rinse and the two-step self-etch adhesives continue to show the highest performance, as reported in the majority of studies. One-step self-etch adhesives are the most user-friendly adhesives, but have been associated with lower bonding effectiveness than two-step and three-step adhesives. It was concluded that the resin bond that was bonded to enamel helped to protect the resin-dentin bond against degradation. A recent study determined that the enamel resin bond is comparable to the one-step, total-edge adhesives.

Long-term clinical studies on Class V composite restorations demonstrate that retention rates in non-caries cervical lesions were not statistically different after 36 months. A significant increase in margin discoloration was observed with self-etch adhesives, e.g., etch-and-rinse and self-etch. In Class V restorations, the adhesive interface produced by the etch-and-rinse adhesive is stronger than that produced by a self-etch system. From these results, one-step self-etch dentin bonding agents are expected to experience reductions in bond strength at a faster rate than two-step dentin-bonding agents.

Based upon differences in adhesive approach, we anticipated a significant difference between the single-step self-etch bonding agent and the three-step-bonding agent, based upon laboratory studies. The reduction in bond strength was also confirmed where peripheral enamel bonding prevented a significant drop in dentin bond strength with aging. In our study, there was no dentin bond degradation, because enamel margins were present in all restorations. Some of the one-step adhesive systems have shown that enamel bonds may degrade. Based upon concerns with enamel bonding, we might expect to see evidence of enamel bond reduction, such as marginal staining increasing over time in our study population. Some marginal staining was observed for iBOND, but it was not statistically significant.

The difference in composition technique between GLUMA Comfort ethanol-based adhesive and iBOND acetone-based adhesive is the etching step; GLUMA was only prime and bond, whereas iBOND was etch, prime and bond.

Initial Results

At one year, 77 restorations were available for recall; 35 were restored with GLUMA and 42 with iBOND. Ethnicity and gender were distributed at baseline. Restorations were randomized for gender and age between bonding agents. Postoperative sensitivity at 24 hours and at one week demonstrated a small number of restorations with mild-to-moderate sensitivity and equally distributed. Sensitivity reduced with time but less so in the iBOND group.

Color stability was equally distributed, and all materials were rated excellent in Class II restorations. At 12 months, there were no differences in objective measures between iBOND and GLUMA, with both performing very well.
Recent studies have demonstrated comparable results from both the one-, two- or three-step binding techniques. The results can be explained by the fact that iBOND and GLUMA are nearly the same components, except that GLUMA contains the powerful adhesive 4-META as a desensitizing agent. The results were identical.

Clinical research was done at New York University College of Dentistry, in the Bluestone Research Center, with PI Dr. Ben Godder and mentored by the senior researchers Dr. Van Thompson and Dr. Mark Wolff, associate dean. Inquiries about this article can be sent to Dr. Meeker at hgm1@nyu.edu.

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