I am proud to present RSDM’s first student research journal. Research is the bedrock of the oral healthcare profession. It’s how treatments evolve and care is perfected. At the Rutgers School of Dental Medicine, we have produced groundbreaking research in the field of oral biology that has the potential to successfully treat cancer and drug-resistant disease, in addition to dental diseases like periodontitis. We have made great strides in the study of oral facial pain. We are also leaders in the kind of academic/industrial research that results in consumer products that improve oral health. This journal is a testament to the importance of this work at RSDM — and how we impart its value as educators. The journal was produced entirely by students, who comprised the editorial board, oversaw the review process and every other task involved in production and publication. Congratulations on a job well done! I hope to see journal staffers continue their passion for research in the days ahead, and I look forward to future issues.

Sincerely,

Dean Cecile A. Feldman
Dental school is a balancing act between the didactic education and the clinical experiences. During the first two years of dental school the didactics were the primary focus as we sat in lectures and absorbed anatomy, physiology, and biochemistry. Of course, we began learning the dental sciences as well during our first two years, but the real transition happened rapidly upon entering the clinic in the third year of dental school.

Research is the link between these two, at times, seemingly discrete components of dental school. For me, my research experience in dental school connected the sciences to the clinical in a real and tangible way. After my first year of dental school, I signed up for a research project in the radiology department. Previously, the basic sciences that I had been studying, specifically that of genetics and inheritance patterns, seemed distant from the class I composite preparations I was learning in the pre-clinic and the acrylic teeth I had been setting into dentures. The research study I signed up for aimed to link tooth eruptions abnormalities as identified in panoramic radiographs to genetic mutations. Our summer days were split between surveying radiographs identifying the presence of tooth growth abnormalities and researching genetic mutations prevalent in families with these findings. It was a true melding of basic science and clinical dentistry.

Editorial
Rebecca Eis
Naruthorn Tanaiutchawoot
While meeting with a subject from our study and discussing the prevalence of delayed tooth eruption present in several generations of their family, and the potential for a genetic cause or predisposition that we were hoping to confirm with the saliva sample they provided, the necessity of dental research clicked for me. I sincerely hope that for all of my classmates this has happened for them as well at some point over the past four years of dental school. It may have been when the New York Times recently opened the controversial conversation about the necessity of flossing, or perhaps while appreciating the strength of a dental bonding agent and the hours of material research that went into developing it. Or perhaps it was while partaking in a research study as the student researcher slicing teeth or observing cells through a microscope, or perhaps as a research subject brushing their teeth with a mysterious toothpaste for weeks on end. Whenever that “click” may have occurred, it solidified the link between our basic science knowledge and clinical dentistry.

Without dental research, our field would not be advancing as rapidly as it has. Everything we do clinically is backed with hours of research and we must strive to practice dentistry that respects the literature. During our time in school, the current literature has been taught to us but as we prepare to graduate we must all take it upon ourselves to stay abreast of dental literature and practice evidence based dentistry. Without exposure to research in dental school, this would be an unrealistic expectation and I am therefore thankful for the experiences I have been blessed with over the past four years and hope my classmates feel similarly inspired.

-Rebecca Eis

RSDM Class of 2017

“What is a student journal”? “Why are we doing this when there are plenty of journals out there”? “No one will read this”. Those were my thoughts before I started as coeditor of this journal. I admit, I began this project with little enthusiasm, but suddenly, things changed. Along the way, I had a chance to work with an efficient team and energetic people. Along the way, I had a chance to meet many great students who love doing research just because they want to discover something new and beneficial for their patients. This journal carries hope and expectation, not only for people who were involved in the team, but also to our many patients who are waiting for some magic to happen in their lives. Along the way, I learned that this journal is not going to be only one of the reading materials. But, it is a reward for some people’s hard work. It is a trophy for some small researchers that their hearts might be bigger than their works. It is proof for non-believers, like me initially, that it is not the result that matters, but the experience along the way that is valuable. My message to those students in doubt about research and about creating this journal is that nothing is impossible once you stop questioning it and start doing it. For me, this is not a journal, but it is a journey that contains many interesting stories to be enjoyed.

This journey of mine has ended. Right now, I am writing an editorial with a complete journal in front of me and one question just came to mind. Who will have this wonderful opportunity to experience this journey next year?

- Naruthorn Tanaiutchawoot, DDS

Resident, Department of
Diagnostic Sciences, Center for TMDs and Orofacial Pain
We are extremely excited to present the first edition of the Rutgers Journal of Dentistry. This journal was the work of a wonderful team of faculty, staff and students who deserve more credit than the space on this page will allow for.

First and foremost we would like to acknowledge and thank Jaimie Testai, from the Office of Research, immensely for all of her hard work on this journal. Without Jaimie’s organization, drive, and vision this journal would still be an idea. We appreciate her guidance and support in bringing this wonderful idea into fruition.

We would also like to thank the undergraduate and post-graduate students who served on the editorial board and various subcommittees that helped to establish the guidelines for this publication, some of whom are pictured above.

The articles published here were reviewed by volunteer faculty members, and post-graduate and undergraduate students. We very much appreciate and value their time, opinions and contributions. We are also very thankful for the students who shared their research with us in their articles and the faculty members who mentored them, as well.

Finally, we would like to thank Drs. Singer and Benoliel who gave hours of their time to teach us about producing a dental journal from scratch and bridging the gap from the science, via the manuscript to publication. Their knowledge, perfectionism and expertise, in serving as our mentors was invaluable to us. Thank you!

Rebecca Eis & Naruthorn Tanaiutchawoot
It is with great pride in our students at Rutgers School of Dental Medicine that we introduce the Rutgers Journal of Dentistry. The goal of the Journal is to familiarize our pre- and postdoctoral dental students with the publication process of research to which they might not otherwise be exposed.

Student participation in research at RSDM has been growing over the past years. Increasingly predoctoral students participate in the Summer Research Program and in the Research Selective-Elective, assist in our laboratories, and work side by side with our clinical faculty on significant and cutting edge projects. Additionally, a growing number of our MDS and MSD students design and execute their own research projects as part of their thesis requirements. These changes reflect our efforts based on the belief that experience in research at the predoctoral and postgraduate levels enrich the educational experience.
Research trains the mind in critical thinking and in the understanding of and appreciation for scientific methodology.

Clearly the processes of writing, peer review, participation in editing and producing a scientific journal bring the research experience full circle.

Our goals have been to serve in an advisory capacity. The students selected an editorial board comprised of both pre-and postdoctoral students, solicited peer reviewers, put out calls for submission of manuscripts, and, ultimately, produced this first issue.

We look forward to your feedback on this undertaking and hope that you will be inspired to participate in future issues, either as a contributor of a manuscript or in our editorial and production teams.

We wish all our graduating students good luck in their future careers!
Experiences with the RSDM Student Summer Research Program

Chelsea Rajagopalan, RSDM Class of 2017

The Rutgers School of Dental Medicine Student Summer Research Program has opened my eyes to the wide range of possibilities within dental research and academia. I participated in the program for the past three years during the summer months between D1-D2, D2-D3, and D3-D4 years.

Special care dentistry had been (and remains!) of great interest to me. So I reached out to the faculty of the Special Care Treatment Center (SCTC) during my D1 year to see if I could spend time in their clinic over the summer assisting, observing, and perhaps participating in research. The timing was quite serendipitous, as they were preparing to launch new research studies. I was incredibly fortunate that their faculty and staff team welcomed me with open arms.
The first year was foundational for our 2-member student/faculty team, as we prepared IRB applications and began a pilot study. We performed a retrospective chart review to explore the variances of caries prevalence between different subsets of the special needs population. The second year we welcomed 3 more students to the project and broadened the scope to grow beyond our initial pilot study (essentially quadrupling our “n”), and also explore a new element of interest – changes in surgical times based upon anesthetic agents used in general anesthesia cases for full mouth rehabilitation in the special needs population. The third year we spent more closely analyzing the data, drafting manuscripts on our findings, and discussing future directions for building upon the research that had been done.

Over the course of these 3 years, we presented posters on our studies at RSDM Balbo Research Day, the Garden State Dental Conference (New Jersey Dental Association), and the annual sessions of the American Academy of Developmental Medicine and Dentistry (AADMD) and the American Association for Dental Research (AADR). I worked primarily with one faculty advisor (Dr. Tomas Ballesteros), but we regularly relied upon the help and input of the other 3 attendings in SCTC, as well as faculty in the Department of Pediatrics. The support of the staff of the SCTC was also critical. These instructors have been instrumental in my development as a student at RSDM and have helped prepare me for what lies beyond graduation day.

The Summer Research Program has grown tremendously over the past few years, with more students interested in and seeking these opportunities each year. Essentially every department across campus has studies currently underway or ready to hit the ground running with the help of some student energy, including radiology, orthodontics, oral biology, and more. If there is an area of particular interest for dental students, the Office of Research and the faculty at RSDM are determined to help students in their quest to explore elements of dentistry outside the classroom, and to ensure their dental school experience prepares them for a successful future in dentistry.
Scientific Articles
Lesions of non-endodontic origin are often overlooked in the differential diagnosis of apical periodontitis, illustrating the importance of proper endodontic diagnostic testing before treatment planning and management [1]. While periapical cysts or periapical granulomas are the most common periapical lesions noted following endodontic surgery, a classic study evaluating more than two thousand periapical lesions excised during endodontic surgery found that 10% of lesions did not classify into either of these categories [2]. Cemento-osseous dysplasia is one of the most, if not the most common, fibro-osseous lesion of the jaw [3]. Cemento-osseous dysplasia has three forms: focal, periapical and florid, and all have a higher female prevalence. Cemento-osseous dysplasia is usually asymptomatic, and is often discovered as a coincidental finding. It is characterized by replacement of normal bone tissue by newly formed mineralized tissue [3]. Focal cemento-dysplasia is usually seen as a solitary lesion, ranging from radiolucent to radiopaque, and is typically located in the posterior mandible. Periapical cemento-osseous dysplasia usually involves multiple teeth in the mandibular anterior area. Florid type cemento-osseous dysplasia presents with multifocal involvement. In order to differentiate the etiology of the lesion, endodontic pulpal testing must be performed, with a negative response indicating a lesion of endodontic origin. Numerous case reports have reported the similar potential appearance of cemento-osseous dysplasia.

Figure 1: Periapical radiograph demonstrates a large well delimited radiolucency involving the apices of teeth #28 and #29

Philippe Duquette DMD
Resident, Department of Endodontics.
osseous dysplasia and a lesion of endodontic origin [4].

Case report

A 24 year-old Hispanic female presented with no contributory medical history for root canal therapy on tooth #29. The patient’s chief complaint was occasional cold sensitivity in the posterior right sextant. The patient did not report any past history of trauma. One periapical radiograph was taken and showed a large radiolucency involving the apical area of tooth #29 and #28 (Figure 1).

Dental caries was observed radiographically on a bitewing radiograph and clinically on the disto-occlusal portion of #29 (Figure 2). Pulpal testing was performed and revealed a normal non-lingering response to cold for teeth #28, 29 and 30. Palpation, percussion and periodontal probings were within normal limits. No bone expansion was noted.

At this time, the patient was presented with the treatment recommendation of excavating the caries on #29 along with the risk of carious exposure and the necessity for endodontic therapy. However, these clinical findings could not explain the presence of the radiolucency and the patient was referred for consultation with the oral surgery department. After consultation, a biopsy was deemed necessary with a differential diagnosis for the radiolucent lesion of traumatic bone cyst, cyst of non-endodontic origin, and central giant cell granuloma. It was also recommended to the patient that endodontic therapy

Figure 2: Bitewing radiograph showing the proximity of the carious lesion to the pulpal tissue of tooth #29

Figure 3: Periapical radiograph showing the master cone fit
should be performed on tooth #28 due to the high likeliness of subsequent pulp necrosis following excisional biopsy.

The patient accepted treatment as outlined above and was appointed in the endodontic department for root canal therapy on tooth #28 and #29. Caries excavation was achieved on tooth #29 with carious exposure of the pulp space. Endodontic therapy was performed under rubber dam isolation, with rotary instrumentation to size 35/04. Continuous 5.25% NaOCL irrigation was utilized during instrumentation and 17% EDTA was used as the final rinse. Obturation was completed using warm vertical condensation and resin sealer (Figure 3). A fiber post and composite core was placed in #29 and #28 was restored with a composite core as a final restoration (Figure 4). The patient was then referred to the oral surgery department for biopsy.

During the biopsy procedure, close proximity of the lesion to the mental foramen was noted, with an exceedingly high risk of permanent paresthesia. It was decided to do an incisional biopsy to avoid paresthesia and determine the origin of the lesion before performing such a traumatic procedure. The specimen was collected and sent for histologic evaluation to the oral pathologist. The oral biopsy report confirmed a cemento-osseous dysplasia as the final diagnosis (Figure 6a and 6b). Following a diagnosis of cemento-osseous dysplasia, there is usually no need

**Figure 3:** Cropped panoramic radiograph following completion of endodontic treatment on #28 and #29 showing the well delimitated radiolucent lesion in the apical region of #28 and #29.

**Figure 4:** Final radiograph of root canal treatment of teeth #28 and #29. A tapered fiber post was placed in #29 and a direct composite restoration was placed on #28.
for further treatment as the lesion is benign and rarely produces any symptoms [5]. However, follow-up radiographic examination with a panoramic radiograph is recommended every 2 to 3 years to ensure that the lesion still displays benign features.

In retrospect, knowing the final diagnosis and that only an incisional biopsy was going to be performed, the endodontic treatment on tooth #28 might not have been necessary.

**Acknowledgments**

The author thanks Dr. Carla Y. Falcon and Dr. Joseph Rinaggio for their help.

**References**


**Figure 6a**: At 100x proliferating fibrous connective tissue with numerous irregular trabeculae can be observed within the lesion (H&E)

**Figure 6b**: Bone trabeculae exhibits peripheral areas of osteoid and newly incorporated osteocytes (H&E, 400x)
The Use of Corticosteroid Injections in the Management of Post Traumatic Trigeminal Neuropathy Secondary to Neuroma Formation

Naruthorn Tanaiutchawoot, DDS
Resident, Department of Diagnostic Sciences, Center for TMDs and Orofacial Pain

Post-traumatic trigeminal neuropathy (PTTN) is proposed as a diagnosis of neuropathic pain resulting from peripheral trigeminal nerve damage. This neuropathic pain condition can present after tooth extraction, apicoectomy, root canal treatment, macro trauma or implant placement [1]. One of the pathophysiological mechanisms that can cause PTTN is a traumatic neuroma. A neuroma was first described in 1811 as a tangled mass of nerve endings that, when palpated lightly can reproduce the chief complaint of pain that is felt by the patient [2]. The neuromas develop as a result of a failure of the normal reparative process after nerve injury. They occur if the regenerating process of nerve fibers is interrupted by a chronic irritation, pressure, stretch, or other interference factors. Studies show that the onset of neuroma development is typically around 6-10 weeks post injury, but clinically they appear within 1-12 months after the initial injury or surgery [2].

Previous studies have revealed the presence of pro-inflammatory mediators, for example TNF-α and IL-1β, along with anti-inflammatory mediators such as IL-10 were found within the neuroma [3-5]. Some studies also show an accumulation of inflammatory cells within the neuroma formation. Studies have demonstrated that CD68 accumulates in almost every neuroma specimen collected from human lingual nerve after surgical extraction of a mandibular third molar. All specimens showed CD45 accumulation observed by immunohistochemistry [3, 4].

Due to multiple evidences supporting the involvement of inflammation in neuromas, steroid injections are commonly used in the management of neuropathy patients who present with a neuroma formation.

Accordingly, the aim of this study was to evaluate the effect of steroid injection in management of PTTN secondary to traumatic neuroma formation in terms of the level of pain relief, the duration of pain relief, and the amount of steroid used.

Methods

In this retrospective chart review, a series of nine cases of patients who were diagnosed with PTTN secondary to neuroma formation after trigeminal nerve
injury, were studied. All patients were given the corticosteroid injection at the neuroma site. Pain assessment was performed before and after injection, and at the follow up visit using a Visual Analogue Scale (VAS).

Results

Mean age of the patients recruited in this study is 59.1 ± 3.4 years old. The mean onset of pain is 15.5 ± 3.3 months, which shows a chronic condition. The mean number of days until pain relief was achieved post-injection is around 2 weeks, 14.4 ± 6.0 days. And overall pain improvement, measured as a percentage of baseline, is 52.9 ± 17.4 % (Table 1). Six patients had overall pain relief after injection and five patients were completely relieved from pain at the injected area after the first injection. However, after the second injection, another two patients were completely relieved from pain at the neuroma area. The pain intensity went down approximately 50% on the VAS scale, from 6/10 to 3/10, after first visit. After the second visit moderate pain went down to mild pain after the second injection (Figure 1).

Discussion

To our knowledge, this study is the first clinical study showing the effect of steroid injection in PTTN secondary to traumatic neuroma intraorally, on pain level. Previous studies were done on other body regions. The single steroid injection shows 50% pain reduction in the treatment of interdigital neuroma and the effect increased up to 80% with a series of injections [2]. A prospective study about treatment of the painful Morton’s neuroma by using ultrasound-guided steroid injection shows short term pain...
relief. The effect of the injection is more significant and lasts longer in smaller neuromas (less than 5 mm.) [6].

Conclusions
These results suggest that the steroid injections can be an effective method to manage pain in patients with PTTN secondary to traumatic neuroma formation. More long-term studies are needed to further study the results beyond the initial injections. We hope the results of this preliminary study will lead to a long term prospective study.

Acknowledgements
I appreciate the help, guidance and support from Dr. Julyana Gomes Zagury, Dr. Cibele Nasri-Heir, Dr. Junad Khan, Dr. Davis Thomas, Dr. Sowmya Ananthan, and Dr. Gary M. Heir.

References


Neuropathic pain (NP) has been recently re-defined as “pain arising as a direct consequence of any lesion or disease affecting the somatosensory system” [1].

Neuropathic orofacial (or craniofacial) pain (NOP) [2] is an umbrella term which includes a group of entities that are included in the most recent classification of the International Headache Society (IHS) [3]. One of which is Painful Traumatic Trigeminal Neuropathy (PTTN).

## Painful Traumatic Trigeminal Neuropathy (PTTN)

PTTN is a diagnostic term for neuropathic pain resulting from damage occurring at the level of the peripheral branch of a neuron, that is painful. It may occur following major craniofacial or oral trauma [4, 5], but may also be induced by relatively minor dental interventions [6]. This entity has been termed phantom tooth pain, atypical odontalgia or atypical facial pain, anaesthesia dolorosa and orofacial complex regional pain syndrome (CRPS).

### How Common is PTTN?

Traumatic injuries to the trigeminal nerve largely result in either no residual deficit or in a non-painful neuropathy. A minority of these injuries develop into a painful neuropathy. Interestingly, when following identical injuries, the onset of PTTN and its characteristics vary from patient to patient. Such variability is probably due to a combination of environmental, anatomical, psychosocial and genetic factors.

#### Macrotrauma

- In patients with zygomatic complex fractures residual, mild hypoesthesia of the infraorbital nerve is common but chronic neuropathic pain developed in only one out of 30 patients (3.3%) followed up for 6 months [4].
- This compares with about 5-17% in other body regions [7, 8].

#### Implants

- The incidence of post implant PTTN is unclear, but some studies suggest around 8%. Post implant PTTN may appear in 4 inter-related groups.
1. Clear and documented injury to a nerve, usually the inferior alveolar nerve. These patients usually complain of immediate postoperative and significant sensory dysfunction in the target organ of innervation e.g. the lower lip.

2. Persistent pain, but no complaint of sensory dysfunction, associated with implants not in the area of a large nerve trunk, as in most implants placed in the maxilla. Theoretically these cases may be due to direct injury to small nerve branches and inflammation is involved.

3. In patients with no history of intraoperative injury and no evidence of the implant itself causing damage, but where there is proximity between the implant and a large nerve trunk.

4. Patients with implant placement that was characterized by a good postoperative course. However, on implant-loading the patients complain of ongoing pain and "sensitivity" to mechanical (chewing, brushing) and often thermal stimuli. Radiographs usually show good osseointegration.

- In some of these patients, pain appears on implant loading and disappears when unloaded, or a temporary restoration is in place.
- In others, pain continues regardless of loading or type of restoration.

**Mandibular Third Molars**

- Disturbed sensation may persist in the lingual or inferior alveolar nerve for varying episodes and has been found in 0.3-1% of cases [9].

  - Inferior alveolar nerve injuries are more common than lingual nerve damage [10-12] but the latter may commonly occur in certain extraction techniques, involving nerve retraction (up to 4%) [13].

  - Complaints of tongue dysesthesia after injury may remain in a small group of patients (0.5%)

**Root Canal Therapy**

Nerve injury may be a result of apical infection or inflammation [14, 15], accidental injection of hypochlorite [16-18], and extrusion of filling materials [19, 20] that may cause chemical injury in addition to the physical insult.

- Persistent pain after successful endodontics was found in 3-13% of cases [6, 21, 22].
- In surgical endodontics chronic neuropathic pain may reach 5% of cases [23].
- Factors significantly associated with persistent pain are:
Chronic preoperative pain, marked symptomatology from the tooth, previous chronic pain problems or a history of painful treatment in the orofacial region and female gender [24, 25].

Recently a reduced endogenous ability to inhibit pain was found to be involved [26], but it is still unclear if this is a risk factor for, or a response to chronic pain.

Local Anesthetic Injections

Local anesthetic injections may induce nerve injury secondary to physical trauma by the needle or by chemical insult from the anesthetic solution [27-29].

• Commonly found in the areas of the delivery of blocks to the inferior alveolar and lingual nerves. Probably due to the anatomical features.

• Findings suggest that lingual nerve injuries are more permanent than inferior alveolar nerve injuries [30]. And it is more common following repeated injections and when the injection was reported as painful [30].

There has been discussion of the possibility that different local anesthetic agents in use (e.g. lidocaine, prilocaine, mepivicaine, articaine) may induce varying degrees of nerve toxicity [31, 32], but results had been equivocal.

• A paper published in 2011 showed that articaine 4% was significantly associated with nerve injury and clinical symptoms [33]. Particularly when given as an inferior alveolar nerve block [33].

• Based on this it would seem prudent to limit the use of 4% articaine, particularly for blocks.

PTTN: Clinical Features

• Age at onset is typically around 45-50 years and female predominant [34-37].

• Pain occurs in the area of injury, or at the distal dermatome of an injured nerve [35].

• Accompanied by demonstrable sensory dysfunction, particularly if a major nerve branch has been injured [35].

• Unilateral pain that may be precisely located to the dermatome of the affected nerve [35]. Pain can become diffuse and spread across dermatomes, but rarely, if ever, crosses the midline.

• Pain is of moderate to severe intensity (VAS 5-8) and usually burning or shooting [36, 38-40].

• PTTN cases with a clear “triggering-like” mechanism have been seen but are relatively rare [35]. Pain is not accompanied by a latency or refractory period unlike trigeminal neuralgia.

• Usually continuous, lasting most of the day and on most days [35].

• Paroxysmal pain may be spontaneous or initiated by touch or function [40].
• A clinical phenotype involves positive (e.g. dysaesthesia) and negative neurologic symptoms (e.g. numbness) [35, 36, 41].

  o If hyperalgesia and other sensory changes found in extratrigeminal sites, more extensive changes in central somatosensory processing are suggested [42-44].

  o Thermal modalities are usually preserved [37, 44].

• A complaint of swelling (not always verifiable clinically), foreign body, hot or cold, local redness or flushing [35, 40].

• Severe pain demonstrates elevated levels of depression and pain catastrophizing, as well as substantially reduced quality of life (QoL) and coping efficacy levels [45].

• Poor prognosis

  o About one third of patients report improvement, while only 10-20% improve significantly [36, 46]. About half reported the same or worsened pain.

[Assessing and Diagnosing PTTN]

The symptomatology of PTTN including positive sensory symptoms (e.g. hyperalgesia) and/or negative (e.g. numbness) should be assessed and recorded [47]. Some of these, for example, thermal and mechanical allodynia are frequently associated with PTTN [48].

• Sensory testing should be performed, preferably with quantitative and dynamic assessment [41, 42].

  o Quantitative sensory testing (QST): Advanced QST apparatus is not usually available in dental clinics, so dental instruments may be adapted to test gross changes. For example a dental probe to test pin-prick sensation, warm/cool instruments for thermal sensation and cotton wool for mechanosensation may be employed.

  o Affected areas should be carefully mapped, marked and photographed to facilitate documentation, evaluation and follow-up of the patient.

• Thorough clinical and imaging evaluation of orofacial structures is needed.

  o The choice of plain radiography or cone beam computerized tomography (CBCT) depends entirely on the case.

  o Trauma cases should be carefully assessed to detect fractures and other injuries.

[Pathophysiology of PTTN]

The pathophysiology of PTTN is time dependent and involves a cascade of progression from the peripheral to the central nervous system.

[Peripheral sensitization]

• Tissue inflammation develops commonly after nerve injury. It can cause an
activation or sensitization of nociceptors and induce mechanosensitivity, but these symptoms are reversible.

- If inflammation is allowed to persist, secondary nerve damage may ensue.

- Peripheral sensitization is characterized by hyperalgesia (increased pain to a normally painful stimulus) and/or allodynia (ordinarily nonpainful stimuli induce pain).

  - Common examples include irreversible pulpitis where application of cold, normally mildly painful, now induces extreme pain (hyperalgesia) and periapical periodontitis where tooth sensitivity to percussion represents allodynia.

**Nerve Injury and Ectopic Activity**

- Healing of nerve injury may involve disorganized sprouting of nerve fibers that form a neuroma.

- Neuroma formation is dependent on the degree and type of nerve damage and usually occurs when the perineurium is cut.

  - These regions are characterized by ectopic neuronal discharge, which partly explain spontaneous neuropathic pain.

**Phenotypic changes**

- Neuropeptide expression is altered in the trigeminal ganglion following nerve injury indicating functional modification.

- For example, Aβ fibers usually transmit innocuous stimuli, but due to inflammation or injury results in the expression of substance-P [49]. Therefore, they acquire the ability to induce painful sensations in response to peripheral stimulation and may underlie the phenomenon of allodynia.

**Novel Sensitivity to Catecholamines**

- Pain related to stress or anxiety possibly due to upregulation of -adrenoreceptors causing increased sympathetic activity.

- Sprouting of sympathetic fibers around the neuronal cell bodies within the dorsal root ganglion augments sensory-sympathetic interactions.

**Central Sensitization**

- Sensitization of CNS due to repeated primary nociceptive afferent input resulting in amplified responses, a phenomenon termed ‘wind up’.

- This condition is termed central sensitization and accounts for increased pain and spread to adjacent structures in patients with severe facial pain.

Ongoing pain leads to sensitization and changes in the peripheral and central nervous systems that may help establish chronic pain. Therefore, the intervention is most effective within an early time frame and prevention is clearly a primary objective.
Can we Prevent PTTN?

Preventive analgesia, previously referred to as pre-emptive analgesia aims to avert persistent post surgical pain. Although there is no reliable data indicating that the incidence of chronic pain can be reduced [50], it would seem sensible in selected procedures and patients to provide a preventive strategy.

This strategy could include:

♣ Minimize tissue damage and nerve involvement by avoiding nerve stretching, crushing, or cutting.

♣ Adequate (dosing and duration) of preoperative anti-inflammatories and analgesics.

♣ Deep local or regional anaesthesia to ensure no intraoperative pain.

♣ Suitable postoperative analgesic cover.

Management of PTTN

Pharmacotherapy

PTTN is extremely difficult to manage [51]. The mainstays of pharmacologic treatment of PTTN remain the antiepileptic drugs (AEDs) and the tricyclic antidepressants (TCAs) [52-54]. In contrast to the traditional 50% pain reduction for clinical significance, research has shown that about a 30% reduction represents meaningful pain relief for NP patients [55].

Based on the current evidence pharmacotherapy of PTTN should progress as follows [52-54]:

♣ Begin with tricyclic antidepressant (e.g. amitriptyline and nortriptyline) or serotonin and noradrenaline reuptake inhibition (e.g. venlafaxine and duloxetine) [56, 57].

♣ If the patient’s medical history precludes the use of an antidepressant, the anticonvulsants such as pregabalin and gabapentin are good alternatives.

♣ Failure of either of the above strategies is an indication to begin a trial of the alternate drug, if the medical status of the patient allows - i.e. move patients on antidepressants to the anticonvulsants and vice versa.

♣ Failure of this second phase is an indication to try combined therapy, if the medical status of the patient allows.

- Duloxetine or amitriptyline may be combined with one of the anticonvulsants [58] [59].

- If the above strategy fails, opioids and opioid combinations may be a viable alternative.

- Gabapentin-oxycodone [60].

- Gabapentin-morphine [61].

Important to bear in mind that opioid prescription practices have been under
intense scrutiny due to their addictive and abuse potential.

This protocol has been tested in an open study on a cohort of PTTN patients [51]. Only 11% of PTTN patients achieved a ≥50% reduction in pain intensity and higher pain intensity scores were associated with a significantly reduced response to therapy. This is in line with response rates of other, similar painful neuropathies [54] and underscores the need for new drugs and other treatment options targeting chronic neuropathic pain.

Topical treatments carry the benefit of minimal side effects but affected areas are not always amenable to treatment [62].

• Evidence based topicals include lidocaine or capsaicin (low and high concentrations) patches and locally injected botulin toxin A.

Cognitive Behavioral Therapy

Neuropathic pain, like many other chronic pains, is associated with comorbid anxiety and depression. This would suggest that psychosocial therapy (e.g. cognitive behavioral (CBT)) might be beneficial.

Surgery

The efficacy of surgery for painful trigeminal neuropathies is unclear. Further peripheral surgical procedures for PTTN may result in more pain. Unless there are specific indications we advise patients with painful traumatic neuropathies not to undergo further surgery.

Carefully considered surgical interventions for PTTN patients may be justified and include:

• Exploration, release of scar tissue, decompression and neuroma excision [63].
• In cases of nerve repair and restoration of sensation in larger nerve branches (e.g. lingual nerve), some improvement in pain may also be attained.

O f f ending Implants: Remove or Leave?

There are no prospective studies that indicate whether removing is better than leaving the implant as is. Each situation needs to be weighed according to the degree of nerve injuries, type of injury and time elapsed since insertion.

Clinical experience and published case reports suggest that if the implants are removed or replaced early after placement (<24-48 hours) there is a reduced incidence of neuropathy and pain [63, 64]. Iatrogenic and accidental resections of nerve bundles (e.g. inferior alveolar), should have an oral surgery consult to discuss the possibility of microsurgical repair.

Management of early nerve injury beyond the above modalities should be aimed at controlling associated inflammation. The situation is different for of f ending implants that have osseointegrated. The
removal of implants must be weighed against the potential tissue damage and dental handicap of removing the implants. Improvement of such cases has not been seen. Use of anti-inflammatory drugs at a late stage does not seem to be indicated. In patients with neuropathic pain pharmacotherapy should be offered as discussed above.

**Controlling Injury-Associated Inflammation**

The involvement of inflammation in a clinical painful neuropathy is a clear indication for anti-inflammatory therapy.

- In mild cases or in cases where surgical or endodontic therapy is planned to further relieve inflammation consider the use of:
  - Standard NSAIDs (e.g. naproxen 500mg bid, ibuprofen 400mg tds).

- Severe cases with marked pain and/or sensory changes, or in milder cases where adjuvant therapy is impractical:
  - Steroids may be warranted (prednisone 40-60mg initially then tapered over 7-10 days, dexamethasone 12-16mg initially then similarly tapered).
  - Tapering is aimed at reducing side effects from consistently high dosages.
  - Common side effects include facial flushing, dyspepsia and sleeplessness so treatment should be as short as possible. Antacids may be co-prescribed.

  - If treatment is successful, patients can be switched to NSAIDs with an antacid and continue treatment for another 7-10 days.

**Central Surgery**

Anecdotal evidence suggests that central procedures may be useful for recalcitrant PTTN cases [65, 66]. The primary choice of operation should be minimally invasive, such as computed tomography (CT)-guided percutaneous trigeminal tractotomy-nucleotomy (surgical division of the descending fibres of the trigeminal tract in the medulla), effectively ablating pathways that carry sensation from the face. Trigeminal dorsal root entry zone (DREZ) operation (surgical damage to a portion of neurons in the trigeminal nerve root at the brainstem level), may subsequently be performed for failures [66].

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Will a Change in the Radiographic Prescription Algorithms for Endodontic Treatment Lead to Lower Doses of Ionizing Radiation?

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Department of Diagnostic Sciences, Division of Oral and Maxillofacial Radiology

Radiographic imaging is an essential component of endodontic diagnosis, treatment planning and follow up.\textsuperscript{1} Conventional two dimensional (2-D) radiography is the first choice of imaging method used in endodontics, due to its low cost, low dose, easy availability and diagnostic efficacy.\textsuperscript{2} However, there is substantial risk of under diagnosis in certain cases when using conventional radiographic techniques.\textsuperscript{3} Image interpretation can be confounded by two inherent phenomena of plain film projectional imaging. First is the superimposition of both the teeth and surrounding dentoalveolar structures. As a result of superimposition, periapical radiographs reveal only 2-D view of three-dimensional (3-D) anatomy. In addition to this, there is often geometric distortion of the anatomical structures occurs, due to technique errors and non-parallel anatomic features.\textsuperscript{4} Diagnostic challenges, as a result of the limitations of two-dimensional imaging may often be overcome by utilizing small volume cone beam computed tomography techniques, which is a 3-D imaging modality.\textsuperscript{5} CBCT uses a divergent or “cone”- shaped source of ionizing radiation and a 2-D area detector fixed on a rotating gantry to acquire multiple sequential projection images in one complete scan around the area of interest. The x-ray source and detector rotate around a fixed fulcrum within the region of interest. During the rotation, multiple exposures are made at fixed intervals, providing single projection images known as basis images. The complete series of basis images is referred to as the projection data.\textsuperscript{6} Software programs incorporating sophisticated algorithms are applied to these projection data set that are used to provide primary reconstruction images in three orthogonal planes (facial, sagittal and coronal).\textsuperscript{1, 7} Small field of view (FOV) CBCT images require a higher dose of ionizing radiation than 2-D images, as well as additional expense. The purpose of the study is to determine if there are certain presenting conditions in endodontics for which CBCT should be employed initially and in lieu of plain film radiography, potentially limiting the overall dose of ionizing
radiation to patients while providing adequate diagnostic information.

**Methods and Materials**

After IRB approval, 200 patient referral forms for small FOV CBCT scans, prescribed for diagnostic and treatment planning purposes, were randomly selected from the Oral and Maxillofacial Radiology clinic at RSDM for this retrospective study. Thirty cases of referrals from the postdoctoral endodontic clinic were selected and reviewed. The data taken from referral form included tooth number, reason for referral and the endodontic clinical condition under investigation. Scans were exposed on a CS9000 (Carestream, Rochester, USA) CBCT scanner using a 5cm x 5 cm FOV. After collecting data from referral form, the axiUm electronic health record (EHR) (Exan, Vancouver, CA) and MiPACS picture archiving and communications system (Medicor Imaging, Charlotte, USA) of the included patients were reviewed for number of periapical radiographs that were exposed prior to prescribing CBCT for a single endodontic procedure. Inclusion criteria included patients above the age of 18 of any gender, who underwent small FOV CBCT scans at our institution. Exclusion criteria included patients under 18 years of age, as well as patients with no previous periapical radiographs or CS9000 images in their electronic health record. Data analysis: Data was collected on an Excel form (Microsoft Corporation, Redmond, USA) and descriptive analysis and t test were performed.

**Results**

![Reason for Referral](image1.png)

**Figure 1:** Reasons for referral of an endodontic case to the Post-Graduate Endodontic Clinic

![Frequency of Treated Teeth](image2.png)

**Figure 2:** Frequency of teeth treated at the Post-Graduate Endodontics Clinic
The majority of the cases that were referred for endodontic purposes gave evaluation of root canal anatomy (30%) followed by apicoectomy evaluation (26%) as the purposes of the examinations (Figure 1). The least common reasons for referral were apical inflammatory lesions and perforations (3.3%). The most common tooth cited for endodontic referral was tooth #14 (Figure 2). The highest number of the radiographs that have been taken prior to prescription of CBCT is 10 periapical radiographs.

Average number of periapical radiographs taken prior to CBCT is 5.0±2.38, yielding an average dose for each periapical radiographs of 7.55 (µSv), with the average added dose per CBCT examination exposure of 20.6 µSv (Figure 3) Total dose is 28.15 uSv. The t-test for differences of mean values of this total and CBCT alone is t= -2.007 p= .049, which is significant.

Discussion

With increased availability of small FOV, high resolution CBCT, endodontic applications of CBCT have increased. Evaluation of root canal system, identification of apical inflammatory lesions, visualization of postoperative treatment complications, and visualization of the sequelae of dental trauma, detection of root fractures, internal and external resorption and presurgical planning for apicoectomy are all current endodontics-related applications for this imaging modality. Prescription of CBCT (and all imaging) in endodontics should always be justified in order to reduce the effective dose to the patient while obtaining the appropriate diagnostic information. In this study total effective dose of ionizing radiation for each patient was calculated. Total effective dose is the sum of effective CBCT dose and effective dose for periapical radiographs taken. In this study, CS9000 was the machine used for small FOV CBCT scans. According to table 1, the effective dose of each CBCT scan is area specific. For example, the effective dose for the anterior maxilla varies from that of the effective dose for the anterior mandible.

Therefore, it can be concluded that the total effective dose can also vary according to the area under consideration. For example, a CBCT scan of the maxillary molars yields an effective dose is 10µSv,
while that for mandibular molars is 38µSv. Additionally, the number of periapical radiographs taken prior to CBCT was counted. The main purpose of the study was to determine certain presenting endodontic conditions for which CBCT can be prescribed prior to conventional 2-D radiographs and thus potentially reducing the amount of ionizing radiation to which the patient is exposed. In this study, the average dose of periapical radiographs that have been taken prior to prescribing CBCT is 7.55 µSv and the average dose for CBCT is 20.70 µSv. Therefore, approximately one-third of the total dose can be reduced, if, for certain endodontic conditions, CBCT is taken initially rather than periapical radiographs. The majority of all radiographic referrals in our study for which a CBCT scan was prescribed gave root canal anatomy evaluation (particularly to locate MB2) as a justification for the examination. The least encountered reason for referral was for periapical inflammatory lesions. There are few prior studies that investigated the reason for referral for CBCT for endodontic purposes and have also measured the total effective dose of ionizing radiations. According to the joint statement released by American Academy of Oral and Maxillofacial Radiology and American Academy of Endodontics, CBCT can be used as an adjunct to 2-D radiographs and while prescribing CBCT, the potential benefits of the scan should outweigh the risks of the ionizing radiation that the patient will receive. Small volume CBCT scans usually provides approximately the same radiation dose as multiple 2-D images. Small volume CBCT can provide images of several teeth from approximately the same radiation dose as two periapical radiographs, and may provide a dose savings over multiple traditional images in complex cases where radiographs taken from different angulations are common. Since our study included only thirty cases, result may be different with increased sample size, particularly when seen in the light of the reason for referral for CBCT. For future directions, increased sample size and different CBCT units may yield different results.

Increasing availability of advanced imaging technology provides the practitioner with

<table>
<thead>
<tr>
<th>Technique</th>
<th>Effective Dose in µSv</th>
<th>Dose as multiple of average Panoramic Dose†</th>
<th>Days of per capsule background</th>
<th>Probability of x in a million fatal cancer</th>
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<tr>
<td>Max Right Posterior</td>
<td>10</td>
<td>0.6</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Max Anterior</td>
<td>5</td>
<td>0.3</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>Maxillary stitched arch</td>
<td>25</td>
<td>1.6</td>
<td>5</td>
<td>2.1</td>
</tr>
<tr>
<td>Mand Left Posterior</td>
<td>38</td>
<td>2.4</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>Mand Anterior</td>
<td>22</td>
<td>1.3</td>
<td>3</td>
<td>1.2</td>
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<td>Mandibular stitched arch</td>
<td>98</td>
<td>6.1</td>
<td>12</td>
<td>5.4</td>
</tr>
</tbody>
</table>

*ICRP 2007 calculation
† Average of 5 units: Sirona - Orthophos XG, Planmeca - ProMax, Kodak - 9000, SCANORA 3D, Instrumentarium - OIP 200 VT

Table 1: Effective dosages of varying radiographic modalities
a modality capable of providing a 3-D representation of complex anatomic structures. CBCT is a valuable, task-specific imaging modality, producing minimal radiation to the patients and providing maximal information to the clinician.

Acknowledgement

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References

This article aims to emphasize the value of Cone Beam computed tomography (CBCT) in the diagnosis and treatment planning in a case of Dens Invaginatus (DI) in a maxillary lateral incisor. The imaging was used to visualize and confirm canal morphology and the etiology of a large periapical lesion, as well as to plan treatment that included non-surgical endodontic therapy.

Endodontists are confronted with the challenges of detecting developmental teeth anomalies and planning optimal treatment to preserve patients’ dentition. This case report highlights the value of CBCT in diagnosing the developmental tooth problem, DI.

CBCT is a modern diagnostic tool that enables three dimensional (3D) visualization of the hard tissue structures of the maxillofacial region. Despite the benefits of 3-D imaging, two dimensional (2D) imaging modalities are still widely considered as the gold standard in endodontic imaging.

Although CBCT is associated with higher cost and dosage than 2D imaging, the average dose of a small volume CBCT examination in the anterior maxilla region is approximately 5µSv versus approximately 0.05µSv for a single oral radiograph. The following case illustrates the importance of CBCT.
Case presentation: A 14-year-old male presented upon referral from a private endodontic office for the evaluation of tooth #7 at the Rutgers School of Dental Medicine Post-Graduate Endodontic Clinic. The patient’s chief complaint was of pain for the last two weeks with increases tooth mobility. History of tooth #7 included endodontic treatment 2 months prior. Periapical radiographs were taken at the time of treatment. The pain resolved on taking a course of clindamycin. Medical history was noncontributory. Intraoral inspection revealed a normal looking crown of tooth #7, with the prominent lingual groove slightly obscured by the composite filling material. A periapical radiograph of tooth #7 was obtained when the patient presented to our clinic, for comparison to the post-operative radiograph.

Differential diagnosis: 2D imaging revealed a large radiolucent periapical lesion associated with tooth #7, with the some of the obturation material extruded near the apex of the tooth. Some signs of poorly defined radiolucency were detected along the path of the root canal within the root structure. Diagnosis included a persistent or resolving apical inflammatory lesion. Since the cause of the lesion could not be definitively identified, a small volume CBCT examination of the anterior maxilla was acquired. Several differential causative factors were considered, including root fracture, although there was no history of dental trauma, perforation, or excess root canal filling material.

Diagnosis and Management: In the CBCT examination, teeth # 5,6,7,8,9,10 were visualized. Tooth # 7 had been endodontically treated with a single canal obturated. The axial projections of the tooth allowed visualization of the dens in dente and the accompanying accessory canal, which was positioned to the mesial

Figure 1: Patient’s first radiograph in the initial evaluation showing large periapical radiolucency and radiolucency around the restored root canal.
of the previously filled canal. Further, the large periapical lesion was better visualized than by using the 2D radiograph. The periapical lesion was described as irregularly-shaped and moderately demarcated with dimensions of 11mm x 13mm x 12mm. The border was non-corticated and surrounded by a uniform hypodense lesion at the apex of tooth #7.

Following the radiological and clinical findings, the periapical lesion was diagnosed as chronic apical periodontitis, secondary to a type 2 DI with suspicious internal resorption. The treatment plan included endodontic therapy in newly found dens and the main root canal in tooth #7, followed by a direct composite restoration to seal the access.

Treatment was initiated after adequate anesthesia was given and rubber dam isolation attained. Endodontic access preparation was made distally to where the dens was located. The communication was made with the file between the blind dens sac and the distal portion of the pulp.

**Figure 2:** Axial view of the CBCT, at the level of crown.

**Figure 3:** The CBCT reveals clear DI Type 2 (Oehler’s Classification) Non-communicating.
Root canal length was determined using an H file ISO no.10-25 (DB= 23mm, MB= 23mm). Intracanal medicament (CaOH) was placed at the conclusion of the first visit. At the second visit, warm vertical condensation with Roth sealer and thermoplastic Gutta Percha backfill was used. It was followed by cotton and a glass ionomer restoration (Ketac, ESPE, Germany) to seal the endodontic access. The patient was sent back to the referring dentist for a definitive composite restoration on the lingual surface. After a three-month recall, the patient stated that he received a permanent restoration and did not experience any pain or discomfort. A follow-up radiograph demonstrates significant healing of the periapical lesion. During a clinical examination, no mobility was noted. Palpation and percussion were negative. After a six-month recall, the patient reported no pain or discomfort. Clinical and radiographic exams indicate healing completed of the periapical lesion associated with tooth #7.

Discussion
DI is a developmental anomaly resulting from the invagination of the enamel organ into the dental papilla before biological mineralization. This infolding extends coronally or to the radicular portion of the affected tooth. Common occurrence of this condition is in permanent maxillary lateral incisors (usually bilateral), central incisors, premolars, canines and less frequently in molars.

The prevalence of DI ranges from 0.04–12%. Occurrence may be symmetrical. The anomaly is very rare in the mandible.

**Etiology**

There are a number of theories proposed pertaining to the etiology of the DI:

i. “The growth pressure of the dental arch causes the buckling of the enamel organ,

ii. the dental lamina degenerates, with a rapid and aggressive proliferation of the enamel epithelium which invades the tooth germ,

iii. infection or trauma during ontogeny,

iv. genetic factors: the lack of signaling proteins may be responsible for dental abnormalities (e.g., absence of arm chromosome 7q32 is associated with dens invaginatus and hypodontia).”

**Types**

Depending on the depth of the enamel invagination, DI is classified into 3 types. The most popular classification was proposed by Oehlers in 1957 as shown in Figure 6:

1. **Type I**: An enamel-lined minor form occurring within the confines of the crown not extending beyond the cemento-enamel junction.

2. **Type II**: An enamel-lined form which invades the root but remains confined as a blind sac. It may or may not communicate with the dental pulp.

3. **Type III A**: A form which penetrates through the root and communicates laterally with the periodontal ligament space through a pseudo-foramen. There is usually no communication with the pulp, which lies compressed within the root.

4. **TYPE III B**: A form which penetrates through the root and perforating at the apical area through a pseudo-foramen. The invagination may be completely lined by Enamel, but frequently cementum will be found lining the invagination.”

According to Capar et al., type I is the most prevalent and it is found 65.9% of the time. Type II is found 29.5% of the time and Type III, the least frequently observed type, is found 4.6% of the time.
Diagnosis

Clinical Appearance
DI demonstrates variable clinical features. The crown can present with normal morphology, or it can show greater buccolingual dimension, peg-shaped, barrel-shaped, conical shapes, and talon cusps, or a deep foramen caecum. 

Radiographic Analysis
Although 2D radiographs are the gold standard for endodontics, they do not provide detailed structural information about this malformation, as they provide a two-dimensional image of a three-dimensional structure. The introduction of Cone Beam Computed Tomography, CBCT, has proven to provide accurate interpretation of the complicated canal anatomy in teeth with endodontic lesions. Therefore, CBCT aids in the treatment planning, obtaining of an accurate diagnosis, therapy, and outcome of various dental treatments.

Sequelae
The often hypomineralised enamel lining of the dens and the several channels permit easy access for irritants to reach pulp. This malformation often leads to:

1. Pulp necrosis
2. Apical abscesses
3. Parodontal abscesses
4. Internal resorptions
5. Cysts

Figure 6: Oehler’s Classification of Dens Invaginatus
Hence it is beneficial to have early diagnosis and treatment to prevent the affected teeth from being jeopardized by infection. Due to the communication between the invagination and the oral cavity, the dens allows the bacteria to penetrate the pulp and the periapical tissues more easily, causing increased occurrence of pulpal and periapical infections. Even if an asymptomatic DI tooth presents with a large periapical radiolucency, it can lead to complicated case profile and cause further extensive bone loss if not diagnosed.

**Management of DI**

“The treatments options are:

1. Prophylactic preventive sealing of the invagination
2. Root canal treatment
3. Endodontic apical surgery
4. Intentional replantation
5. Extraction" 7
6. Endodontic regeneration 5

The treatment plan depends on the type of DI, its symptoms, and the age of the patient. Nonsurgical root canal treatment has proven to have positive results through numerous studies, thus should be considered the first treatment option before turning to surgical treatment. 5, 13

If the invagination is not communicating with the root canal, efforts should be made to preserve the pulp vitality. For this reason, early radiological diagnosis and a prophylactic conservative treatment are important. 13

Once diagnosed, if the tooth is vital with no signs of pathology, prophylactic treatment should be initiated immediately, as follows:

a. Prepare invagination entrance and place amalgam or fissure sealant for type I invagination. 7
b. For Type II, after gaining full access of invagination with the recommended endodontic magnification, high-speed handpiece burs and ultrasonic instruments, obturate the dens with MTA, and seal the access cavity with the composite. 7
c. Monitor the tooth regularly for pulp vitality loss. 7

If the pulp becomes non vital, perform root canal treatment, with antiseptic control using calcium hydroxide, triple antibiotic paste. If the tooth has an open apex an apical plug should be made with calcium hydroxide or MTA. 7
There are limitations for the non-surgical endodontic methods for complete debridement due to limited accessibility and varied morphology of the root canal system. There are different approaches in treating the type II DI non-communicating. For example, Holtzman and Lezion et al. approached the inaccessible canal space beneath the dens by filling the root canal with calcium hydroxide in an effort to heal the periapical lesion. Er et al. used triple antibiotic paste as an alternative to calcium hydroxide and also reported to have complete periapical healing.

Access to the root canal system can be achieved by removal of the tooth structure intervening between the dens and the root canal system to gain straight line access. Elham et al. removed the central part by a fissure bur under surgical microscope for better access and to enable complete debridement and obturation. In the present case of a Type II DI non-communicating, the communication was made through the barrier between the blind dens sac and the main root canal with finger tapping pressure on the file.

Calcium hydroxide, used in the present case, is known for its antimicrobial effect and for the removal of the pulpal tissue remnants. It heals periradicular lesions by increasing the pH of the periapical environment through providing calcium ions for the repair process. It also has a denaturing effect on the pro-inflammatory mediators such as interleukin 1 and tumor necrosis factor. The irrigating method of ultrasonics has been recommended to increase the efficacy of the disinfection process.

Warm lateral condensation with gutta percha was used in this case. Rotstein et al. and Nallapati recommended the thermoplastic technique as a successful method to achieve a sufficient seal and fill the root canal irregularities.

The size of periapical lesion does not affect the outcome of the non-surgical endodontic method. The present case supports this method, as there was tremendous healing of the large periapical lesion.

For the type III DI vital tooth with periodontal inflammation, the invagination can be treated as a separate entity to maintain pulp vitality. For a necrotic type III case, the dens can be treated with endodontic therapy alone or combined with surgical therapy. There is also a report of removing the dens with ultrasonics to ease endodontic therapy.
For teeth with complex tooth anatomy and endodontic treatment is not an option, extraction is recommended.\(^7\)

Intentional replantation has also been used for the very complex forms of Dens invaginatus. For wide open apices and blunder bass, MTA and Gutta Percha can be used for the post-apical portions.\(^7\)

Revascularisation can be performed for the teeth that do not heal after endodontic therapy, apexogenesis, apexification or partial pulpotomy and have a poor prognosis, provided that the teeth have thin walls and a wide open apex for a stronger and better longterm outcome.\(^5\)

DI is a developmental anomaly that presents a challenge to the endodontist. This case report presents successful nonsurgical endodontic management of a maxillary lateral incisor with type II DI with the aid of CBCT. The tooth had an inadequate previous root canal treatment. The complex morphology was diagnosed and confirmed with cone-beam computed tomography imaging. Non-surgical endodontic treatment resulted in successful healing of the periapical lesion. CBCT thus proves to be an excellent diagnostic tool for management of teeth with unusual anatomy, allowing way for successful conservative endodontic treatment.

**Conclusion**

In this clinical case, CBCT was an effective diagnostic method for revealing the internal anatomy of a tooth with DI, leading to the successful nonsurgical endodontic therapy and follow up of periapical healing.

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21 Table courtesy of Dr. John B. Ludlow.
The fit of a dental prosthesis such as a crown or a bridge is critical to the success and longevity of the restoration. Numerous factors in the dental prosthesis fabrication process including the impression material, stone cast, and die spacer affect the fit. Computer-aided design and computer-aided manufacturing (CAD/CAM) facilitates dental treatment planning and prosthesis fabrication. An extra-oral 3D scanner such as Nobel Procera 1G Scanner can scan the working cast to create a virtual model to fabricate the prosthesis in a laboratory with CAD/CAM technology.

As colored lasers have specific wavelengths, the laser wavelength may interact with the stone color of the model and affect the accuracy of the virtual model image. The scanner’s accuracy to create a virtual model depends on the dental stone’s color. The stone color affects how the scanner captures surface roughness; darker materials show higher roughness than lighter colored materials.

Type IV dental stones, which have high strength and low expansion, can be used to make fixed prosthodontics dies. Vel-Mix die stone is commonly used to make dies for traditional casting but is also used for scanning. Diamond Die Scan Stone and Optic Scanning Stone are manufactured specifically for scanning and are marketed to have superior characteristics over traditional die stones. The three type IV die stones used in this study have different colors. The aim of the study was to test if one colored die stone is superior to the others for 3D scanning.

**Materials and Methods:**

A typodont tooth was prepared for a complete veneer crown, and a metal coping was fabricated in base metal alloy with sharp lines and point angles. The metal coping was cemented onto the typodont tooth as the master die. Custom trays were fabricated for the master die using Triad light cure custom tray material. For each of the three stone materials, ten impressions were taken using medium body polyvinyl siloxane (PVS) to replicate the master die. Each material (Diamond Die Scan Stone, Optic Scan Stone, and Vel-Mix stone) was mixed with water as
per the manufacturer’s guidelines, and poured in the impressions of the master die. The stone dies were removed from the impression after allowing full setting of the stone. The scans were performed 24 hours after the dies had been created to allow for full expansion of the stone material.

The Nobel Procera IG Scanner was used to scan the master die, as well as the thirty stone dies, using the measuring tool in the scanner software.

Ten dimensions of each sample were recorded. In addition, to evaluate whether the position of the die affects the scanning accuracy, one occlusal site and one palatal site were selected for each group. The scanner software’s measurement tool error was calibrated using a 10mm plastic ruler.

**Results**

The calculated measurement error was \(-0.011\) mm. A two-way ANOVA with factors of color and location was used to compare the scanned dimensions of the three stones with the master die. There was no statistical significance in the dimensions among the three stones compared to the control (the master die). In addition, there was no statistical significance in the accuracy of the dimensions at either occlusal or gingival areas of either the master die and the dies from the stone materials.

**Conclusion**

Most private practice dentists do not own an intra oral scanner due to the cost, and the laboratory often pours the cast, scans the dies, and mills the restoration. Dentists and laboratories must be aware of the materials used for scanning and the effect these materials may have on the virtual model, and thus the fit of the prosthesis. The scanner’s measurement technology had accuracy within 11 microns. The three type IV die stones’
color and setting expansion did not influence the dimensions of the virtual model, and no one type IV dental stone demonstrated superior characteristics for making models of the impression. The laser scanner was able to accurately scan both the occlusal and the gingival portions of the die, and therefore the proximity to the scanner did not affect the accuracy of the virtual model.

**References**


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Dr. Saul Weiner advised Dr. Verma on her thesis project for the Master of Dental Sciences degree.
Affinity of Silver Diamine Fluoride on Carious versus Intact Dentin and on Deep versus Superficial Demineralized Dentin

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Department of Oral Biology.

In previous investigations, Silver Diamine Fluoride (SDF) was observed to form silver-rich particles on dentin surfaces. SDF has also been used in the past in clinical studies including non-invasive dental treatments in impoverished communities in South America, resulting in the successful arresting of active dentinal caries. It is also used clinically in order to prevent tooth sensitivity and treat root caries.

We aimed to determine if carious dentin surfaces have a higher affinity for silver particles, as found in SDF, than intact dentin. If so, the second objective is to determine if the silver particles preferentially bind to deeper and demineralized dentin over shallower and intact dentin. The SDF solution used in this experiment (Fluoroplant NAF laboratories, Argentina) is a known antimicrobial agent.

Materials and Methods: IRB approval to use human teeth in research was obtained (Protocol #0120050074.) Seven human third molars having small occlusal carious lesions were sectioned using a low speed saw (Isomet, Buehler Ltd., IL, USA).

Figure 1: (a) Superficial demineralized SEM images were taken of a SDF-treated superficial dentin slice at 20x magnification. (b) Image at 2000x. (c) The areas representing SDF are displayed in red and analyzed using ImageJ software to calculate percent area of silver particles in each sample.

Dentin slices from the teeth that contained carious areas were etched and treated with a commercially available SDF (Fluoroplant NAF laboratories, Argentina) solution for 60 seconds. They were then rinsed with distilled water for 15 seconds. These discs were placed in a desiccator for 24 hours, and then analyzed with Scanning Electron Microscopy (SEM). Images from both carious and non-caries spots were taken from each disc. These images were analyzed with the ImageJ image analysis program (public domain.) Using the dot-counting and image-contrast functions of
the program, the particles containing silver from the solution (as confirmed by elemental analysis) were counted and compared on both carious and intact dentin.

After the original ImageJ image analysis was completed, further investigation was conducted to determine the degree of affinity of silver particles to both deeper, demineralized dentin and shallower, intact dentin. Extracted molars were collected and sectioned into thin slices at varying depths. These dentin slices were sectioned at superficial, middle and deeper depths utilizing a low speed microtome. The occlusal surface of each dentin slice was sanded and then polished to remove the ‘smear layer’ or any debris that may occlude and diminish visibility of the dentinal tubules. Slices of dentin were then segregated into two groups. To simulate dentinal caries, one group of dentin slices was treated and demineralized with lactic acid for two weeks. To simulate healthy, intact/non-demineralized dentin, the other group of dentin slices was submerged in saline solution for two weeks. Dentin slices from both groups were removed from their respective solutions.

As a simulation to how it would be completed in a clinical setting, the slices were then treated with the Silver Diamine Fluoride solution using the accompanying micro-brush for approximately 30 seconds, as per the manufacturer’s instructions. All of the dentin slices were then rinsed with saline, affixed to an SEM specimen mount and then gold plated using a gold sputtering machine. Images of each dentin slice were taken at 35x and 2000x power using a Scanning Electron Microscope.
(Hitachi, S-3500N). The images taken at 2000x power were then analyzed with various brightness and color/contrast threshold features on the ImageJ program to determine the percent area coverage of Silver Diamine Fluoride.

**Results:** For the first part of the experiment, particle counts are expressed as mean ± standard deviations. There were 120.52 ± 154.5 Silver Diamine particles in the 9 areas of carious dentin analyzed, as opposed to 12.49 ± 9.75 particles in areas of intact dentin from the same discs. A significant T-test result of 0.0045 was obtained.

For the second part of the experiment, percent area counts are expressed as means and standard deviations. There was 58.65% ± 14.05 percent area Silver Diamine in the areas of deeper dentin analyzed, as opposed to 12.43% ± 6.10 percent area of SDF in areas of superficial dentin from the same discs. A significant T-test result of 7.72826E-06 was obtained.

**Discussion:** SDF has already been approved by the FDA for use in clinical settings, and is currently used in the Rutgers School of Dental Medicine Pediatric Department to treat deep decay approaching the pulpal chamber in primary teeth. Other intended future applications of SDF include being used for special care and pediatric patients who tend to be more difficult to perform invasive dental procedures on. Furthermore, SDF can be used to prevent tooth sensitivity, to treat root caries, and to be placed under restorations in order to prevent recurrent decay, and in conjunction with liners to perform indirect pulp caps. One fallback of SDF is that it tends to stain dentin black, which limits it from being used in situations...
where esthetics is a concern. With further research, SDF has potential to revolutionize the field of dentistry as we know it.

**Conclusion:** Silver particles resulting from Silver Diamine Flouride treatment have affinity for both carious and non-carious dentin. However, as we originally predicted, the particles had a much higher affinity for the carious dentin. Furthermore, the silver particles resulting from Silver Diamine Flouride appeared to have a much higher affinity for the deeper dentin than the superficial dentin. It is hypothesized that Silver Diamine Flouride, which is positively charged, binds more readily to deeper dentin due to it having less mineralization and higher negative charge than superficial dentin. Our findings are consistent with the material being effective in arresting dentin caries.

**References**


**Figure 6:** Silver particles were more frequent in the deep demineralized dentin.