PERSISTENT PAIN FOLLOWING ROOT CANAL THERAPY:
A NESTED CASE SERIES STUDY

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Radwa Sobieh
DEDICATION

To my mother (Enayat) for teaching me that hard work and determination will fulfill my dreams and for the sense of security she continues to provide me,

To my husband (Wael) for supporting me every step of the way,

To my girls (Nadine and Layla) for the happiness they bring into my life and for making life worth living,

To my sisters (Saly and Maha) for their unconditional love,

And to the brave Egyptian youth, who against all odds are not giving up on their dreams of a better future for their country and the new generations to come.

Thank you for being such an inspiration

"If anyone travels on a road in search of knowledge, God will cause him to travel on one of the roads of Paradise. The angels will lower their wings in their great pleasure with one who seeks knowledge. The inhabitants of the heavens and the Earth and (even) the fish in the deep waters will ask forgiveness for the learned man. The superiority of the learned over the devout is like that of the moon, on the night when it is full, over the rest of the stars. The learned are the heirs of the Prophets, and the Prophets leave (no monetary inheritance), they leave only knowledge, and he who takes it takes an abundant portion.” Prophet Muhammad (peace be upon him)
Abstract

Introduction: Persistent pain following root canal treatment (RCT), a common dental procedure, can be either of odontogenic or nonodontogenic origin. The prognosis for patients experiencing such pain is dependent on differentiating patients into these 2 categories and deriving specific diagnoses, since appropriate treatment various dramatically. This study aims to present the proportions of specific diagnoses these patients have and provide information about their signs and symptoms, including radiographic findings.

Methods: This study was nested within a parent prospective observational study that followed up patients for 6 months following RCT. Patients meeting criteria for persistent pain at 6 months and living in Minnesota were considered eligible cases. Cone-beam Computed Tomography (CBCT) and dental radiographs were obtained and patients were individually evaluated by an endodontist and an orofacial pain practitioner to derive consensus diagnoses.

Results: A total of 38 patients met the criteria, of which 19 were evaluated. Odontogenic reasons for persistent pain occurred less frequently than nonodontogenic reasons (42% vs. 53% respectively). There was an overlap of odontogenic and nonodontogenic reasons in 10% of the patients. About 16% reported some level of pain that seemed to be related to normal “healing”. Of patients with odontogenic reasons, about one third was related to the previously treated tooth and the other two thirds were related to adjacent teeth. Temporomandibular pain disorder (TMD) was the most common nondontogenic reason for pain, comprising 42% of all patients and 80% of those with nonodontogenic pain. Persistent dento-alveolar pain disorder (PDAP) was less common, comprising 10% of all patients and 20% of those with nonodontogenic pain.

Conclusion: Data from this study help in quantifying the frequency of odontogenic versus nonodontogenic reasons for persistent pain following RCT.
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INTRODUCTION

Pain is defined as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage (1). Pain in the orofacial region is very common to the human condition, and tooth-related pain is the most prevalent of such pains (2). Lipton et al (3) surveyed 45,711 American households and reported that nearly 22% of the general population experienced at least one of five types of orofacial pain in the past 6 months with the most common type being toothache, reported by 12% of the population. Such patients, often treated with endodontic procedures, are known to experience moderate amounts of pain (4) which may interfere with daily activities [unpublished data, Nixdorf et al], something that directly affects productivity. General health-related work losses are estimated to cost US employers more than $260 billion each year (5), with tooth pain related work losses being a component, making this a significant social problem.

Treatment of odontogenic pain

Tooth pain is the most common reason why patients seek dental care (6). Odontogenic causes of tooth pain include inflammatory disease of the pulp or periodontal tissues. Once a definitive diagnosis of irreversible pulpitis or pulpal necrosis is established by a clinician, orthograde root canal therapy (RCT) is the most commonly performed procedure for treating these types of dental pathosis (7, 8). RCT has been demonstrated to successfully treat tooth-related pain intensity and duration (4) [unpublished data, Nixdorf...
et al], and therefore thought to be the initial treatment of choice for such odontogenic pain.

**Persistent pain following RCT**

Research in this area, although limited by design and numbers, suggests a frequency of occurrence to be between 3% to 12% for persistent post-root canal pain (9-11). A systematic review identified 26 studies (5,777 teeth enrolled) that had reported participants’ pain status, regardless of etiology, at 6 months or later following root canal treatment. This research estimated all types of persistent “tooth” pain to be 5.3% (95% CI: 3.5%-7.2%; p < 0.001) (12). This is significant because 16.4 million root canals are performed annually in the United States (8), which extrapolates to approximately 875,000 endodontic patients experience persistent “tooth” pain every year – making this a public health concern. These patients may seek care from multiple healthcare providers in their attempts to address their symptom of persistent pain, thus potentially incurring high medical bills and missed workdays (13) [Nixdorf et al 2012-abstract from IADR meeting in Seattle]. Such pain carries with it a largely unknown individual and societal burden.

**Differential diagnosis of persistent pain following RCT**

Persistent tooth-related pain can be associated with odontogenic etiologies, such as missed canals, incompletely obturated canals, failed coronal seal, root fracture, and unresolved periapical infection (14). There may also be nonodontogenic reasons for pain being perceived in the region of a tooth (15). This may include referred myofascial pain
(16), neurovascular pain (a.k.a. headache disorders) (17), what is thought to be neuropathic pain (18), “psychogenic toothache”, and pathologic processes referring pain to the dentoalveolar regions (19-22). Given this array of potential diagnoses, and underlying etiologies, it is difficult to accurately determine the origin of this persistent pain problem (15, 23).

Although nonodontogenic pain persisting after RCT has been thought to be rare (24), there are estimates that range from 3 to 12% (9, 10, 25). A systematic review and meta-analysis of nine articles containing data regarding both odontogenic and nonodontogenic causes of tooth pain estimated the frequency of patients having a nonodontogenic reason for this persisting pain to be approximately 56% (44/78 cases) with an estimated 3.4% occurrence (26), which suggests the outcome of nonodontogenic tooth pain is not as rare as previously assumed.

Published literature on the topic of differential diagnosis of patients with nonodontogenic pain is typically case series from tertiary-referral centers (27-31). However, tertiary care studies do not represent typical dental patients receiving root canal therapies, or the typical dental office, which is where the majority of root canal therapies are provided, or. Thus, these studies are limited in their capacity to accurately estimate proportions of endodontic patients with various nonodontogenic pains. Moreover, these studies often presented their data in aggregate form, making it impossible to determine proportions of different types of nonodontogenic pain. To our knowledge there have been no studies that
followed up cases of pain persisting following RCT to determine the actual diagnosis, and presumed etiology, for the symptom of pain. For these reasons, it is currently impossible to derive a credible estimate that answers the following questions:

- What are the diagnoses, and presumed underlying etiologies, for patients who have persistent pain at 6 months following RCT?

- Of the people who have persistent pain following RCT, what proportion is due to inflammatory-based dental pathosis and, therefore, would be amenable to endodontic retreatment and what proportion is of nonodontogenic origin and, therefore, would not be amenable to endodontic retreatment?

- What are the pain characteristics these patients’ experience that can help differentiate those with odontogenic etiologies from those who have nonodontogenic etiologies?

For these reasons, more research focused at determining the diagnoses, as well as underlying etiologies, is needed to guide clinical dental care. This study aims to provide specific diagnoses and information about the presumed etiologies for patients with pain present at 6 months following RCT, as well as present the proportions of the various diagnoses and pain characteristics. Our study was nested within a prospective observational study that was designed to determine the proportion of patients, drawn from local community-based dental practices, that experience pain present at 6 months following RCT (details described elsewhere,(32)).
METHODS

Background

This study originated from a large-scale prospective longitudinal cohort study following patients that received RCT performed by dentists enrolled in the National Dental Practice-Based Research Network (National Dental PBRN or network). The National Dental PBRN is a group of dental practices that have been linked together to investigate research questions and to share experiences and expertise. Details about this network are on its website (http://www.nationaldentalpbrn.org). Applicable ethics approval was garnered from the various institutions involved in this parent study.

The aim of the parent study, which is relevant to this research, was to estimate the frequency of patients reporting pain at 6 months following RCT and to describe the impact of this pain. Sixty-two dentist practitioner investigators in 5 geographic regions: Alabama/Mississippi, Florida/Georgia, Minnesota, Permanente Dental Associates in Oregon/Washington, and Denmark and Sweden were trained regarding the standardized study protocol. Enrollment and baseline data collection occurred over 6 months with follow up at 6 month after RCT. Patients and dentists completed questionnaires before and immediately after treatment visits. Patients also completed questionnaires at 1 week, 3 months, and 6 months after RCT completion. A total of 708 patients were enrolled in the study with 651 patients providing follow up data at 6 month. For more details of this parent study, see below and the Methods publication of this study published in the Journal of Endodontics, Nixdorf et al, 2012 (32).
Selection criteria of the parent study

Inclusion criteria included; patients aged 19 to 70 years and patients with a permanent tooth requiring initial orthograde RCT. Exclusion criteria included; evidence of treatment having initiated for an iatrogenic pulpal exposure (cases with a carious exposure of the pulp were not excluded), previous in this study (each patient could only contribute 1 tooth to the study), previous endodontic treatment that would make it unclear whether pain was associated with the prior treatment or attempt at treatment, obvious cognitive impairments (e.g. previous stroke with communication deficits, dementia or mental disability), the inability to read, understand, and complete the baseline patient questionnaire, and the anticipated inability to provide 6-month follow-up information.

Primary outcome measure of parent study

In the parent study, all enrolled patients were asked to complete a follow-up patient survey at 6 months following the obturation of the RCT treated tooth. The primary outcome measure of pain persistent at this time point was defined by 2 questions: “How many days in the past month have you had pain in the area that was treated with a root canal?” and “In the past month, on the average, how intense was your tooth pain rated on a 0 to 10 scale where 0 is ‘no pain’ and 10 is ‘pain as bad as could be’?” The latter question is part of the Graded Chronic Pain Scale (GCPS) questionnaire that has been shown to be a reliable and valid pain measurement tool and is used extensively in epidemiological studies (33, 34). A positive response to both questions, which was a \( \geq 1 \) response to each question, was the criteria for being a case of persisting pain in this
parent study. Patients that did not meet these criteria, by providing a response to either question or failing to respond to one of these questions, were defined as non-case. This included patients providing discordant responses (e.g., patients that reported having pain for more than one day in the past month, but reported an average pain level of zero).

**Eligibility criteria and enrollment for nested study**

This study was nested within the parent study, meaning those patients meeting the criteria for persistent pain would become eligible to enter this study. For feasibility reasons, namely local proximity, only patients within the Midwest region, that is Minnesota, of the network were considered for inclusion in this study so that patients could travel for evaluations to be held in one central location. A total of 390 patients in the parent study were enrolled in this region. Of these patients, 38 patients fit the eligibility criteria for having persistent pain (thus, defined as a case) and, therefore, were the target patient sample to be contacted for participation in the nested study. Of particular interest, patients enrolled in the parent study were consented to be followed up but not necessarily to participate in this study. Therefore, research staff from the parent study contacted those eligible patients and obtained verbal consent of their interest to be referred on to the nested study. When a willing response was obtained, contact details were passed from the parent study to the investigators of the nested study and used to contact these patients. This recruitment process, including handling and transfer of contact information, was reviewed and given approval by the University of Minnesota’s research ethics board.
Setting and evaluators for nested study

This study was conducted in the Oral Health Clinical Research Center (OHCRC) at the University of Minnesota, School of Dentistry, Minneapolis, Minnesota. The OHCRC maintains a fully equipped multi-purpose research clinic consisting of 10 dental operatories. Radiographic images, namely cone-beam Computed Tomography (CBCT) and dental radiographs, were obtained from the facilities within the Division of Oral and Maxillofacial Radiology, which was proximal to OHCRC. All patients attending the OHCRC were independently evaluated by a board certified Endodontist, Dr. Alan Law, and a board certified Orofacial Pain practitioner, Dr. Donald Nixdorf.

Nested study protocol and data collection

Each evaluator performed a complete history and physical examination independently following their specific data collection processes. The resultant data was recorded on the clinical forms of their respective disciplines (Appendices 1 & 2). Radiographs were also reviewed independently, with findings being documented (Appendix 3). Both clinicians derived their own impression for the diagnoses and, via discussion, arrived at consensus diagnoses for each of the diagnostic categories (Appendix 4). This same consensus-based methodology has been used successfully at the recent RDC/TMD Validation Project (35).

The process of obtaining the required data followed accepted clinician practices (15). The diagnoses rendered followed diagnostic criteria, classifications, and terminology established for periapical/ periradicular disease (36-38), orofacial pain (16, 39-41),
headaches (17, 42, 43), and temporomandibular disorders (TMD) (44, 45) (unpublished data, Schiffman et al, under review with the Journal of Orofacial Pain). Additional information about each participant was collected during this study. This included information about oral health quality of life, using Oral Health Impact Profile-14 (OHIP-14), pain quality and intensity using McGill Pain Questionnaire, oral function using the Jaw Functional Limitation Scale (JFLS), and anxiety and depression using the Hospital Anxiety and Depression Scale (HADS). Data from these questionnaires is not presented here since it is beyond the scope of this thesis. Figure 1 diagrams the study protocol and the steps involved in data collection process for the parent and the nested studies.

**Data management and statistical analyses**

The data was recorded on paper forms during the evaluations within the OHCRC. Data was inputted, using a double-checking process between two different research members, into an Excel spreadsheet (version 14.3.2 for Mac, Microsoft, Seattle, WA). Descriptive analyses, such as means, 95% confidence intervals, t-tests, and chi-square tests, were performed using the same Excel software. Data that was missing was noted when it occurred, and no attempts were used to impute values.
RESULTS

The parent research study enrolled 390 patients at baseline within the Minnesota region. Of those, 354 (91%) returned data at 6 months and comprised the study sample this nested study had available to follow. Of those 354 patients, 38 (11%) met criteria for pain at 6 months following RCT, and were considered eligible cases. A total of 20 patients of these 38 patients (50%) agreed to participate in the nested study and were evaluated at the University of Minnesota. One patient was excluded from data analysis because he/she did not meet both criteria for being a case because the patient responded positively to one question and negatively to the other so that the case definition was not clear. The removal of this patient resulted in a final study sample of 19 patients that were evaluated at the University of Minnesota OHCRC (Figure 1).

Patients’ characteristics

Table 1 shows the demographic characteristics of the study patients. The mean age of cases was 49 years. The majority of patients was female (84%), white (95%), and had at least some college education (79%). Eighty-four percent were employed at the time of the evaluation and 47% of cases reported an annual household income equal or greater than $50,000 per year.

Characteristics of study RCT teeth

Maxillary teeth comprised 53% of treated teeth with the 89% being posterior teeth. Soft tissue assessment of all teeth was within normal limits. As expected, no positive pulp
testing was noted on teeth that had previous root canal treatment. No mobility or cracks were detected on any of the teeth. Of the 19 root canal treated, 16 teeth (84%) were restored with permanent crowns. Most of the teeth (79%) showed no signs of periodontal disease with probing pocket depths less than or equal to 3mm. Only one tooth showed significant periodontal bone loss, with a probing depth of 6mm (Table 2).

Pain related characteristics

The majority of patients with an odontogenic reason for their persistent pain 66% (N=4/6) reported a “0” pain intensity at the time of the evaluation in OHCRC and subsequently described their pain as intermittent pain, while the majority of patients with a nonodontogenic reason for their persistent pain 62% (N=5/8) had a pain intensity of “1-2/10” at the time of the evaluation. “Dull and achy” was the most used description for the pain quality, regardless of the diagnosis. There was a significant difference noted in the report of pain localization, with 83% (N=5/6) of patients with an odontogenic diagnosis describing their pain as “well localized” versus only 25% (N=2/8) of patients with a nonodontogenic diagnosis using the same description.

The majority of patients in our study 63% reported a history of overall chronic pain, including neck, shoulder, knee, ankle and pelvic pain, and one case of multiple sclerosis, regardless of the diagnosed reasons for their persistent pain. Surprisingly 75% of patients with nonodontogenic reasons for their pain, which was mainly TMD, reported no previous history of TMD diagnosis. Table 3 diagrams in details the pain characteristics in relation to different diagnoses.
**Physical findings related to pain**

Physical findings supporting an odontogenic diagnosis of persistent pain included responding positively to tenderness to percussion as well as pain to biting on a tooth sleuth on the study tooth or/and the adjacent tooth in 83% of patients diagnosed with an odontogenic reason for their pain. The palpation test seemed to be not as sensitive to complaints of persistent pain, since only 17% of patients with odontogenic pain reporting tenderness to palpation of the apical area over the tooth. No maxillary-mandibular arch referral was noted.

Physical findings supporting a nonodontogenic diagnosis included tenderness to palpation on the masseter, temporalis, and lateral pterygoid muscles, as well as the temporalis tendons reproducing a component of the patient’s complaints of persistent pain were diagnosed with TMD. One patient with a pre-existing diagnosis of multiple sclerosis believed her pain to be related to symptoms of recurrence of her trigeminal neuralgia pain. Her persistent pain was duplicated by palpation of the lateral pterygoid muscles and the temporalis tendons, which was bilateral in presentation and unlike her pretreatment trigeminal neuralgia pain; therefore her pain was also diagnosed with TMD.

A positive response to sensory testing, such as pain to probing and pain to touch (allodynia), suggested the presence of nerve dysfunction and, therefore, supported a diagnosis of persistent dento-alveolar pain disorder (PDAP) in 2 cases. One of the two patients diagnosed with PDAP reported that the sensory testing findings were consistent with those she reported were present for years prior to RCT. On the other hand the
second patient diagnosed with PDAP had no such report and therefore was believed to represent a new onset of sensory nerve dysfunction. See table 4 for details on physical signs related to pain.

**Radiographic findings**

The majority of patients with an odontogenic reason for their persistent pain demonstrated significant findings on their PA films and CBCT scans. A total of 67% of patients had significant findings on their PA films while 100% of patients had significant findings on their CBCT scans. Examples of the findings were missed canals, C-shaped canal, and overfilled/underfilled canals of either the study tooth or an adjacent tooth. Three cases with odontogenic reasons for their pain had no findings on their PA films but findings were revealed on their CBCT scans.

On the other hand, patients with nonodontogenic reasons for their pain had fewer findings on their PA films and CBCT scans. The radiographs of most patients (75%) with a nonodontogenic diagnosis were normal, while only 25% revealed periapical radiolucencies. Pre-operative radiographs were not available to compare whether there was radiographic evidence of “healing” in these patients. Table 5 shows the distribution of radiographic findings in relation to the diagnosis.
Comparing all RCT patients with persistent pain at 6 months to those evaluated in our study

There is a great similarity noted in the baseline characteristics between all RCT patients with persistent pain at 6 months (N=38) to those who participated in our study (N=19) in regards to the average age of patients, as well as the predilection of the female gender. Also, in both groups maxillary posterior teeth made up for the majority of cases. The average pain intensity at 6 months, number days in pain with in the last month, number of patients taking medications for pain as well as number of days with lost activity due to pain were also very close between groups (Table 6).

Experts’ consensus diagnoses for persistent pain

Evaluation of cases in this study revealed that 32% (N=6) had exclusively odontogenic reasons for their persistent pain, 42 % (N=8) had exclusively nonodontogenic reasons, 10% (N=2) had mixed odontogenic/ nondontogenic reasons, while 16% (N=3) had “delayed healing”. Figure 2 diagrams the experts’ consensus diagnoses with detailed etiological factors for their persistent pain.

1. Exclusively odontogenic pain group

This group comprised of 6 cases (32%, 95% CI: 11%-53%) being diagnosed with inflammatory-based dental pathosis as the reason for their pain. The diagnosis was either related to persistent pathosis of the RCT tooth as a result of missed canals in 50% of cases (N=3), or related to the adjacent tooth as a result of pulpal/apical pathosis or
persistent pathosis associated with a previous RCT in an adjacent tooth in the other 50% of cases (N=3).

2. Exclusively nonodontogenic pain group

This group comprised of 8 cases (42%, 95% CI: 20%-64%) being diagnosed with nonodontogenic reason as the sole etiological factor for their pain. TMD was the most common diagnosis within this group, with 7 out of the 8 patients (88%). Only one patient was diagnosed with PDAP as the sole etiological factor for persistent pain. None of the patients had Trigeminal Neuralgia presenting as “tooth” pain. Also no patients were diagnosed as having either a headache disorder or distant pathosis presenting as “tooth” pain.

3. Mixed odontogenic/nonodontogenic pain group

This group comprised of 2 cases (10%) being diagnosed with both an odontogenic and a nonodontogenic diagnoses as both reproduced a component of their chief complaint. In this group, one patient had signs and symptoms of TMD as well as pulpal pathosis in an adjacent tooth while the second patient was diagnosed with PDAP and pulpal pathosis in an adjacent tooth. In these cases it was believed that both diagnoses were contributing to the presence of persistent pain.
4. “Delayed healing” group

Sixteen percent of patients (N=3) were not diagnosed with neither odontogenic nor nonodontogenic reason for their persistent pain. It was thought that these patients were experiencing “delayed healing” of the RCT tooth which in one of the patients in this group may have been related to her chronic history of Lupus Erythematosus (46) since there were no significant findings on her radiographs. On the other hand radiographs of the remaining two patients revealed apical radiolucency and an overfilled root canal. No other medical conditions were reported by the remaining two patients.
DISCUSSION

This nested study determined that about 3 of 10 patients reporting pain 6 months following RCT had an odontogenic reason for this pain and about 4 of 10 had a nonodontogenic. Half of the remaining patients had both odontogenic and non-odontogenic reasons while the other half had no specific diagnosis and therefore where referred to as experiencing “delayed healing” as a reason for their pain (figure 3).

*Odontogenic group*

Of all patients that were diagnosed with odontogenic reasons for “tooth” pain, only 3 patients (16%) were determined to have been caused by persistent pathosis associated with the RCT tooth, likely related to failure to remove all the pulpal tissue in the case of missed canals, or possibly extruded root canal filling/debris (47).

The other 2/3s of patients with an odontogenic diagnosis were due to symptomatic pathosis in adjacent teeth. The diagnoses of adjacent teeth with symptomatic pathosis were either apical periodontitis or persistent pathosis associated with a previous RCT. This presentation of dental-related disease in adjacent tissues should not be unexpected because factors related to the presentation of oral disease are known to have local effects, both to the site of disease and to the person experiencing the disease, such as caries secondary to inadequate oral hygiene (48) and pulpal necrosis secondary to trauma; thus supporting the observation of adjacent teeth being affected.
Nonodontogenic group

The most common nonodontogenic reason for “tooth” pain was TMD, which involved 42% of all patients with pain 6 months following RCT. The subtype of TMD related to this type of pain being referred to the RCT tooth was myofascial pain and involved the masseter, temporalis, and lateral pterygoid muscles, as well as the temporalis tendons. Patients’ perception of their TMD symptoms as “tooth pain” can be explained as the concept of referred pain. It has been well established that patients with TMD often report referred craniofacial pain arising from palpation of the head and neck region. In a study evaluating referred craniofacial pain patterns in patients with TMD the most common referred pain source to the teeth in the craniofacial region was from palpating the masseter muscle, followed by the lateral pterygoid muscle and the temporalis muscle (49).

However, this study cannot address the questions of whether the initial symptoms of pain may have been misdiagnosed as odontogenic in origin (50-52), whether odontogenic pathosis sensitized the somatosensory system and contributed to the initiation of TMD that was maintained while the pathosis was adequately treated (53-55), or whether the onset of TMD was more related to the provision of RCT because the patient’s mouth was open wide for a protracted period of time (56).

PDAP, which many feel has underlying dysfunction of the somatosensory system (18, 57-59), was diagnosed in 2 patients, which represents 11% of those presenting with pain 6 months following root canal therapy. The criteria used to determine these diagnoses
followed published criteria (39, 60) and seems to have face validity with the comprehensive assessment by 2 different expert clinicians that arrived at a consensus agreement. One of the 2 patients diagnosed with PDAP had long standing symptoms consistent with PDAP, likely secondary to a prior midfacial fracture, and therefore can be considered to be a pre-existing comorbid diagnosis. The other patient diagnosed with PDAP appeared to have had a new onset of this pain disorder, thus fitting the definition of being an incidental case of PDAP.

**Mixed odontogenic/nonodontogenic group**

The presence of a mixed odontogenic/nonodontogenic pain group is very important because the proper diagnosis and management requires a wide range of knowledge, like that required for the separate presentation, but the co-presentation makes it hard to separate the symptom of pain from pathosis and that from a somatosensory pain disorder. These are examples where the assumption that the complaint of pain does not necessarily involves a single reason (23). Research estimating the frequency for the proportions of odontogenic pain and nonodontogenic pain following RCT suggested that it was split half and half (26). This estimate was limited by the dichotomous nature of the data collection process in the review, something that is made obvious by this study that identified 10% of patients in the mixed odontogenic/nonodontogenic group.
“Delayed healing” group

One patient in the “delayed healing” group had a chronic history of Lupus Erythematosus, which could have contributed to the delayed healing of the RCT tooth (46). The 2 other patients in this group had apical radiolucencies and an overfilled root canal but reported a pain intensity of “0/10” and no tenderness to percussion or other pain-related finding. This lead to the opinion that their symptoms of pain following RCT may have extended for longer periods due to a foreign body reaction or periradicular inflammation related to the presence of gutta percha in the periradicular area (61), however their symptoms may have resolved by the time they presented for their clinical evaluation.

Since baseline characteristics and other pain related data were very similar for the 19 patients that were evaluated in this study and the total number of patients reporting pain at 6 months (i.e. 38) (Table 6), the identification of 4 prevalent cases and 2 incident cases would be expected. Given the sample that these 2 cases, 1 hypothetical and 1 observed, came from 390 patients from the Minnesota region, the calculated prevalence is 1.0% and incidence is 0.5%.

Findings related to pain characteristics

Due to the small sample size it was difficult to draw accurate conclusions regarding certain pain characteristics that can help differentiate those with odontogenic reasons for their pain from those with nonodontogenic reasons. However, it is worth mentioning that
patients with in the nonodontogenic group that were diagnosed with TMD had no prior official diagnosis of TMD. This highlights the importance of performing a thorough TMD evaluation to patients with pain 6 month following RCT and warns against relying solely on the absence of pre-existing TMD diagnosis or on patient’s reports of previous history of jaw pain.

**Findings related to radiographs**

The fact that CBCT scans revealed more findings, which were significant in rendering a diagnosis, compared to the PA films demonstrates its value. This finding is also consistent with previous research (62). While this study is not longitudinal in nature, it none the less suggests that there is importance for using CBCT, in selected instances, to assess the integrity of RCT when pain persists 6 months after treatment. These findings are in line with findings from a study investigating the value of adding CBCT imaging to PA films for patients diagnosed with PDAP (63).

**Strengths of the study**

*i. Minimizing bias:* The nested case-series design of this study provides an added benefit since the sample and the methods for which patients were drawn are superior to that of other case series. The nested design with in the longitudinal cohort parent study helped minimize bias in case selection since eligibility criteria for being a case was pre-determined and study investigators were not involved in the enrollment process, but independent dentists and endodontists were. Cases were enrolled from regular clinical
practices and, therefore, were not subject to bias associated with secondary and tertiary referral patterns.

The consensus expert driven diagnosis was reached after independent evaluations by two specialists in the two fields of interest (i.e. endodontics and Orofacial pain), thus rendering reliable results and minimizing bias.

**ii. Generalizability of the results to the typical endodontic patient:** Original recruitment of subjects in the mother study through the National Dental PBRN offered the advantage of recruiting large numbers of patients from various geographic areas and multiple practices including both general dentists and endodontists. Most endodontic studies report data from patients treated by endodontists (64), although, according to dental surveys, the majority of patients needing RCT are treated by their general dentist (8). Recruitment through the National Dental PBRN allowed for a better representation of the average patient and the common practice situation, rather than patients seen in obscure [i.e. university] clinics, such as those dominating the published literature, thus improving the generalizability of the results (65) to the general population receiving RCT.

The mean age of the study subjects was 48 years old (standard deviation = 13), with a range of 19 to 70 years. This is similar to the ages of patients seen by both general dentists and endodontists in the United States (8). There was a majority female representation of 63%, versus only 37% males. An annual income greater than $30,000 was reported by 73% of the subjects, and 79% reported having at least some college
education. These results were expected, as dental patients who receive RCT are substantially different from dental patients in general, being predominantly white and female with a higher socioeconomic level (66). Most teeth treated in this study were posterior teeth (91%) with the majority being maxillary teeth (56%), which is very close to similarly designed studies and Dental surveys (8, 67). All of the above also suggests generalizability and applicability of the results to the general population receiving RCT.

Also the addition of CBCT imaging as a radiographic modality improved the diagnostic certainty compared to sole use of periapical radiographs (62, 68).

Limitations of the study

Even with large numbers, 11% prevalence of pain at 6 months results in a small sample of patients in the Minnesota region from which to draw. This is a limitation of studies that aim to describe infrequent outcomes. This can be improved upon by increasing the original samples size, such as enrolling more patients in the Minnesota region of the parent study or having other sites in the parent network conduct the nested study protocol.

The low recruitments rate, 19/38 (50%) of those who reported pain at 6 months, was likely related to not having this nested study involved within the initial consenting process of the parent study, since it was conceived and initiated after approval of the parent study was being implemented. This resulted in patients not being aware that they
could be asked to participate in this follow up study and it made the transfer to, and consenting for, the nested study cumbersome since the exchange of information involved 2 institutions. This may not have had a major negative effect on the study results since it appears that the 19 patients recruited and evaluated at OHCRC have similar baseline characteristics to those who did not participate.

A stronger study design would have been a nested case-control study, which benefits from the prospective observational study as well as the case-control design, meaning having patients without pain at 6 months as a comparison group. This was the initial planned study design but was not feasible to conduct due to the same problems articulated above regarding recruiting patients with pain plus

- The lack of desire for patients without pain to seek information about pain that doesn't apply to them.

- Matching criteria, that being gender, age (+/- 3 years) and tooth (+/- 2 teeth but same arch and type) resulted in few controls in the parent study to draw from.

- Focusing on first enrolling patients with pain, and then matching controls to those with pain, resulted in a delay in contacting them and passing the follow-up time deadline, that being 3 months after their 6 months report.

In future studies the previously mentioned problems can be avoided by adding this study into the consent process of the parent study and streaming the “pass-off”, making the matching criteria less stringent, and initiating the enrollment of controls early.
Finally, the lack of pre-operative information specifically that needed for driving an initial diagnosis for initiation of RCT limits the ability to assess healing following RCT. Having pre-operative radiographs could have allowed for assessment of longitudinal changes, such as increased or decreased size of the periapical radiolucency and changes in the lamina dura.
CONCLUSION

Given the 10% overlap of reasons for pain presenting 6 months following RCT, in our sample odontogenic reasons for this pain occurred less frequently than nonodontogenic reasons (42% vs. 53% respectively) and about 16% reported some level of pain that seemed to be related to "delayed healing". Of patients with odontogenic reasons about 1/3 was related to the previously treated tooth and the other 2/3s were related to adjacent teeth. TMD, presenting as reproduction of familiar “tooth” pain when various muscles of mastication are palpated, was the most common nondontogenic reason for pain, comprising 42% of all patients and 80% of those with only nonodontogenic pain. PDAP was less common, comprising 10% of all patients with pain at six months and 20% of those with only nonodontogenic pain. No patients were found to have a headache disorder or distant pathology as a reason for their pain in our sample of patients.
<table>
<thead>
<tr>
<th>Demographic Characteristics</th>
<th>Cases (19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number (%) or Mean (SD)</td>
<td></td>
</tr>
</tbody>
</table>

**Gender**
- Male (%): 3 (16)
- Female (%): 16 (84)

**Age**
- 20-30: 2 (10)
- 30-40: 3 (16)
- 40-50: 1 (5)
- 50-60: 10 (53)
- 60-70: 3 (16)

**Ethnicity**
- Non Hispanic or Latino: 19 (100)

**Race**
- White: 18 (95)
- Other: 1 (5)

**Marital Status**
- Married: 7 (37)
- Divorced: 4 (21)
- Single (Never married): 5 (26)
- Significant other in household: 3 (16)

**Education**
- High School: 2 (10.5)
- Some or completed College: 15 (79)
- More than a college degree: 2 (10.5)

**Work Status**
- Employed: 16 (84)
- Non-Employed: 3 (16)

**Income**
- Less than $10,000 to 29,999: 4 (21)
- $30,000 to $59,999: 5 (26)
- $60,000 to $80,000 or more: 9 (47)

*Missing income data for 1 patient.*
Table 2. Characteristics of study RCT teeth

<table>
<thead>
<tr>
<th>Tooth related data</th>
<th>Cases</th>
<th>Number (%)</th>
</tr>
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<tbody>
<tr>
<td>Arch</td>
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</tr>
<tr>
<td>Maxillary</td>
<td>10</td>
<td>(53)</td>
</tr>
<tr>
<td>Mandibular</td>
<td>9</td>
<td>(47)</td>
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<tr>
<td>Tooth type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior</td>
<td>2</td>
<td>(11)</td>
</tr>
<tr>
<td>Premolars</td>
<td>4</td>
<td>(20)</td>
</tr>
<tr>
<td>Molars</td>
<td>13</td>
<td>(69)</td>
</tr>
<tr>
<td>Restoration type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crown</td>
<td>16</td>
<td>(84)</td>
</tr>
<tr>
<td>Amalgam restoration</td>
<td>2</td>
<td>(11)</td>
</tr>
<tr>
<td>Composite restoration</td>
<td>1</td>
<td>(5)</td>
</tr>
<tr>
<td>Periodontal probing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\leq 3) mm</td>
<td>15</td>
<td>(79)</td>
</tr>
<tr>
<td>4-5 mm</td>
<td>3</td>
<td>(16)</td>
</tr>
<tr>
<td>(\geq 6) mm</td>
<td>1</td>
<td>(5)</td>
</tr>
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</table>
Table 3. Subjects’ pain related characteristics in relation to diagnoses

<table>
<thead>
<tr>
<th>Pain intensity</th>
<th>Odontogenic (study &amp; adjacent teeth) Number (%)</th>
<th>Nonodontogenic (TMD &amp; PDAP) Number (%)</th>
<th>Mixed Odontogenic/Nonodontogenic Number (%)</th>
<th>Delayed Healing Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4/6 (66)</td>
<td>2/8 (25)</td>
<td>0</td>
<td>2/3 (67)</td>
</tr>
<tr>
<td>1-2</td>
<td>1/6 (17)</td>
<td>5/8 (62.5)</td>
<td>1/2 (50)</td>
<td>1/3 (33)</td>
</tr>
<tr>
<td>3-4</td>
<td>1/6 (17)</td>
<td>1/8 (12.5)</td>
<td>1/2 (50)</td>
<td>0/3</td>
</tr>
<tr>
<td>Pain quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No pain</td>
<td>1/6 (17)</td>
<td>1/8 (12.5)</td>
<td>0</td>
<td>2/3 (67)</td>
</tr>
<tr>
<td>Dull achy</td>
<td>3/6 (50)</td>
<td>4/8 (50)</td>
<td>1/2 (50)</td>
<td>1/2 (33)</td>
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<tr>
<td>Sharp</td>
<td>2/6 (33)</td>
<td>1/8 (12.5)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Throbbing</td>
<td>0</td>
<td>2/8 (25)</td>
<td>1/2 (50)</td>
<td>0</td>
</tr>
<tr>
<td>*Pain localization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No pain</td>
<td>1/6 (17)</td>
<td>3/8 (37.5)</td>
<td>0</td>
<td>2/3 (67)</td>
</tr>
<tr>
<td>Well localized</td>
<td>5/6 (83)</td>
<td>2/8 (25)</td>
<td>0</td>
<td>1/3 (33)</td>
</tr>
<tr>
<td>Diffuse</td>
<td>0</td>
<td>2/8 (25)</td>
<td>2/2 (100)</td>
<td>0</td>
</tr>
<tr>
<td>*Temporality of pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No pain</td>
<td>1/6 (17)</td>
<td>2/8 (25)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Intermittent</td>
<td>3/6 (50)</td>
<td>2/8 (25)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Constant</td>
<td>2/6 (33)</td>
<td>2/8 (25)</td>
<td>1/2 (50)</td>
<td>1/3 (33)</td>
</tr>
<tr>
<td>Variable</td>
<td>0</td>
<td>1/8 (12.5)</td>
<td>1/2 (50)</td>
<td>2/3 (67)</td>
</tr>
</tbody>
</table>

History of Orofacial pain

TMD

<table>
<thead>
<tr>
<th>History of Orofacial pain</th>
<th>Odontogenic (study &amp; adjacent teeth) Number (%)</th>
<th>Nonodontogenic (TMD &amp; PDAP) Number (%)</th>
<th>Mixed Odontogenic/Nonodontogenic Number (%)</th>
<th>Delayed Healing Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>3/6 (50)</td>
<td>2/8 (25)</td>
<td>1/2 (50)</td>
<td>0</td>
</tr>
<tr>
<td>Absent</td>
<td>3/6 (50)</td>
<td>6/8 (75)</td>
<td>1/2 (50)</td>
<td>3/3 (100)</td>
</tr>
</tbody>
</table>

HA & Sinusitis

<table>
<thead>
<tr>
<th>History of Orofacial pain</th>
<th>Odontogenic (study &amp; adjacent teeth) Number (%)</th>
<th>Nonodontogenic (TMD &amp; PDAP) Number (%)</th>
<th>Mixed Odontogenic/Nonodontogenic Number (%)</th>
<th>Delayed Healing Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>3/6 (50)</td>
<td>5/8 (62.5)</td>
<td>1/2 (50)</td>
<td>1/3 (33)</td>
</tr>
<tr>
<td>Absent</td>
<td>3/6 (50)</td>
<td>3/8 (37.5)</td>
<td>1/2 (50)</td>
<td>2/3 (67)</td>
</tr>
</tbody>
</table>

**History of other overall chronic pain

<table>
<thead>
<tr>
<th>History of Orofacial pain</th>
<th>Odontogenic (study &amp; adjacent teeth) Number (%)</th>
<th>Nonodontogenic (TMD &amp; PDAP) Number (%)</th>
<th>Mixed Odontogenic/Nonodontogenic Number (%)</th>
<th>Delayed Healing Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>4/6 (77)</td>
<td>6/8 (75)</td>
<td>2/2 (100)</td>
<td>2/3 (67)</td>
</tr>
<tr>
<td>Absent</td>
<td>2/6 (33)</td>
<td>2/8 (25)</td>
<td>0</td>
<td>1/3 (33)</td>
</tr>
</tbody>
</table>

*1 patient with missing data for nonodontogenic group

**Other overall chronic pain included: neck, shoulder, knee, ankle and pelvic pain, and one case of multiple sclerosis.
Table 4. Physical findings related to persistent pain

<table>
<thead>
<tr>
<th>Clinical signs</th>
<th>Exclusively Odontogenic (study &amp; adjacent teeth) Number (%)</th>
<th>Exclusively Nonodontogenic (TMD &amp;PDAP) Number (%)</th>
<th>Mixed (Odontogenic/Nonodontogenic) Number (%)</th>
<th>Delayed healing Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Percussion testing, vertical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tender</td>
<td>5/6 (83)</td>
<td>5/8 (62.5)</td>
<td>2/2 (100)</td>
<td>1/3 (33)</td>
</tr>
<tr>
<td>Nontender</td>
<td>1/6 (17)</td>
<td>3/8 (37.5)</td>
<td>0</td>
<td>2/3 (67)</td>
</tr>
<tr>
<td><strong>Palpation testing (apical tissue, buccal to tooth)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tender</td>
<td>1/6 (17)</td>
<td>3/8 (37.5)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nontender</td>
<td>5/6 (83)</td>
<td>5/8 (62.5)</td>
<td>2/2 (100)</td>
<td>3/3 (100)</td>
</tr>
<tr>
<td><strong>Pain with biting on tooth sleeve</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tender</td>
<td>5/6 (83)</td>
<td>3/8 (37.5)</td>
<td>1/1 (50)</td>
<td>1/3 (33)</td>
</tr>
<tr>
<td>Nontender</td>
<td>1/6 (17)</td>
<td>3/8 (37.5)</td>
<td>1/1 (50)</td>
<td>1/3 (33)</td>
</tr>
</tbody>
</table>

*Missing data for 2 patients in the exclusively nonodontogenic group and for 2 patients in the delayed healing group.
Table 5. Radiographic findings in relation to diagnoses

<table>
<thead>
<tr>
<th></th>
<th>PA films</th>
<th></th>
<th>CBCT scans</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal Number (%)</td>
<td>Radiolucency Number (%)</td>
<td>Normal Number (%)</td>
<td>*Significant Number (%)</td>
</tr>
<tr>
<td><strong>Odontogenic</strong>&lt;br&gt;(RCT tooth, adjacent tooth)</td>
<td>2/6 (33)</td>
<td>4/6 (67)</td>
<td>0/6 (0)</td>
<td>6/6 (100)</td>
</tr>
<tr>
<td><strong>Nonodontogenic</strong>&lt;br&gt;(TMD &amp;PDAP)</td>
<td>6/8 (75)</td>
<td>2/8 (25)</td>
<td>7/8 (89)</td>
<td>1/8 (11)</td>
</tr>
<tr>
<td><strong>Mixed odontogenic/Nonodontogenic</strong></td>
<td>1/2 (50)</td>
<td>1/2 (50)</td>
<td>1/2 (50)</td>
<td>1/2 (50)</td>
</tr>
<tr>
<td><strong>Delayed Healing</strong></td>
<td>1/3 (33)</td>
<td>2/3 (67)</td>
<td>1/3 (33)</td>
<td>2/3 (67)</td>
</tr>
</tbody>
</table>

* Significant findings included missed canals, C-shaped canals, overfilled and/or underfilled canals.
Table 6. Comparing baseline characteristics of all RCT patients with persistent pain at 6 months to those evaluated in our study

<table>
<thead>
<tr>
<th></th>
<th>Age in Years (SD)</th>
<th>Female Gender N (%)</th>
<th>Teeth N (%) of subjects</th>
<th>Arch Location Mx.</th>
<th>Mn.</th>
<th>Ant.</th>
<th>Post.</th>
<th>Ave. Pain Intensity at 6 Months 0/10 (SD)</th>
<th># Days in Pain last Month N (SD)</th>
<th>Taking Meds for Pain N (%)</th>
<th># Days with Lost Activity N (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCT Pts with Pain at 6 months [N=38]</td>
<td>45 (13)</td>
<td>31 (82)</td>
<td>22 (58)</td>
<td>16 (42)</td>
<td>6 (16)</td>
<td>32 (84)</td>
<td>2.9 (2.0)</td>
<td>9.1 (9.3)</td>
<td>21 (55)</td>
<td>0.5 (1.6) [3 patients]</td>
<td></td>
</tr>
<tr>
<td>RCT Pts with Pain at 6 months &amp; Evaluated [N=19]</td>
<td>49 (13)</td>
<td>16 (84)</td>
<td>10 (53)</td>
<td>9 (47)</td>
<td>2 (11)</td>
<td>17 (89)</td>
<td>2.8 (1.6)</td>
<td>11.3 (9.8)</td>
<td>11 (58)</td>
<td>0.6 (2.0) [2 patients]</td>
<td></td>
</tr>
</tbody>
</table>
Figure 1. Study protocol and data collection process for the parent and nested study

- Participants enrolled in the National Dental PBRN parent study: N=708

- Participants enrolled in primary study in MN: N=390

- Participants with data at 6 months after treatment: N=354

- Eligible cases for recruitment reporting pain on “patient survey 6 months after treatment”: N=38 (11%)

- Not enrolled:
  - Patients refusing to participate in study
  - Staff unable to contact patients: N=18

- Total number of subjects consenting to participate: N=20

- Total number of subjects enrolled: N=19

- Experts’ Consensus diagnosis

- Clinical evaluation: ORF and Endodontic History and physical evaluation + Diagnostic Imaging: CBCT & PA

- Participants excluded during data analysis:
  - Patient reported pain in only 1 of the 2 pain questions: N=1
Figure 2. Experts’ consensus diagnoses of cases

19 patients meeting criteria for persistent tooth pain

- Exclusively Odontogenic
  - Pathology related to adjacent tooth
    - N=6 (32%)
  - Study tooth N=3
  - Adjacent tooth N=3

- Exclusively Nonodontogenic
  - N=8 (42%)
  - TMD N=7
  - PDAP N=1

- Mixed Odontogenic/nonodontogenic
  - N=2 (10%)
  - Adjacent + TMD N=1
  - Adjacent + PDAP N=1

- “Delayed healing”
  - N=3 (16%)
  - Adjacent tooth N=3
Figure 3. Diagram outlining etiology of patients’ pain complaints

- Exclusively Odontogenic: 32%, N= (6)
- Exclusively Nonodontogenic: 42%, N= (8)
- Mixed: 10%, N= (2)
BIBLIOGRAPHY


**Appendix 1**

**ENDODONTIC FORM**

**Patient**

**Tooth #**

**Pt #**

**SUBJECTIVE FINDINGS:**

- **PAIN (Circle All Appropriate):** Level (0-10)
  - Well-localized
  - Spontaneous
  - Elicited (cold/hot/chewing)
  - Constant
  - Sharp Shooting
  - Throbbing

- **Onset**
  - Progression F/I/D

- **Aggravating Factors**

- **Relieving Factors**

- **PMH**

- **Medications**

- **Allergies**

**TOOTH HISTORY** (Circle and Date All Appropriate):

- Caries/Restoration
- Carious/Mechanical Exposure
- Pulp Cap (Direct or Indirect)
- Pulpotomy/Pulpectomy/Debridement
- Root Canal Treatment
- Trauma

**OBJECTIVE SIGNS & TESTS:**

- **SWELLING (Circle All Appropriate):**
  - Well Localized
  - Lymphadenopathy
  - Infiltrated
  - Location

- **Sinus Tract:**

- **Location**

**PULP TESTING (+, - , NA):**

- If thermal, indicate short (S) or prolonged (P) response

  - Tooth #
  - Restoration
  - EPT
  - Thermal

**APICAL TESTS**

- None (+), Mild (+), Moderate (++), Severe (+++)
- Percussion
- Palpation
- Cheewing/Bite

---

**PERIO**

- **B**
  - #
  - #
  - #

- **L**

- **Mobility (I/II/III)**
  - Cracks/Fractures
  - Yes
  - No
  - N/A

- **Radiographic Interpretation**
  - Normal
  - Caries
  - Periodontal
  - Lateral Radiolucency
  - Immature Apex
  - Furcal Radiolucency
  - Root Fracture
  - Calcification
  - Previous RCT
  - Apical Radiopacity
  - Perforation
  - External Resorption
  - Canal Obstruction
  - Internal Resorption
  - Developmental Abnormality
  - Other

**DIAGNOSIS**

- **Pulpal:**
  - Normal
  - Reversible Pulpitis
  - Symptomatic Reversible Pulpitis
  - Asymptomatic Reversible Pulpitis
  - Necrosis
  - Previously Treated
  - Previously Initiated Therapy

- **Apical:**
  - Normal
  - Symptomatic Apical Periodontitis
  - Asymptomatic Apical Periodontitis
  - Acute Apical Abscess
  - Chronic Apical Abscess
  - Condensing Osteitis

**Pre-Treatment Prognosis:**

- **Favorable**
- **Questionable**
- **Unfavorable**

<table>
<thead>
<tr>
<th>Canal</th>
<th>Reference</th>
<th>EWL</th>
<th>CWL</th>
<th>MAF</th>
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<tr>
<td></td>
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</tr>
</tbody>
</table>

**Post-Obturation Prognosis:**

- **Favorable**
- **Questionable**
- **Unfavorable**

- If not favorable, why?

**Doctor Signature:**

---

**rev 7/10**
# Appendix 2

**University of Minnesota**  
**TMJ & Orofacial Pain Clinic**

## Initial Eval & Assessment
- **Pt. Name:**
- **MR#:**
- **DOB:**

### PROBLEM, VITALS & MEDICATION FLOWSHEET

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
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<th>Primary Insur.</th>
<th>Secondary Insur.</th>
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<table>
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<td>Add</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Date Last Visited: |            |
|--------------------|
|                    |

## Initial Assessment Diagnosis:

1. 
2. 
3. 
4. 

### Other Conditions/Diseases:

- Injury Date (m/d/y): __________
- Type: ___ MVA ___ WC ___ Other

### In Litigation?: ___ Y ___ N

#### Contributing Factors:

- Chronic Pain
- Oral Habits
- Stress
- Bruxism Day / Night
- Depression / Anxiety
- Postural Habits
- Systemic Disease
- Clenching Day / Night
- Gum Chewing
- Rest Jaw in Hand
- Other:
- Clenching / Diet
- Object Chewing
- Sleep Dysfunction

### DRUG ALLERGIES / REACTIONS:

- **K Nicaragua Adverse:**
  - **Ht:** ___
  - **Wt:** ___
  - **BP:** ___

### REVIEWED / UPDATED

**Dr. Initials:**

### MEDICATIONS

#### DOSE

- **Check** = Could Use  **B/C** = Discourned  **Dose Chng**

- **Pt. is not taking any Medications**

## University of Minnesota School of Dentistry

Pt. Name:  
Impression & Plan

Self Care: TUTA, Pain Diary, Heat / Ice, Oral Habits, Exercises

Imaging: __ Pan, __ CT, __ MRI

To Evaluate:

PT: Eval / Tx:
- __ ROM __ Exs __ Posture __ Conditioning
- __ Mod __ US __ ISO __ E-Stim __ Tract

BT: Eval / Tx:
- __ CBT-Habit Reversal __ Tx Compliance

Splint: __ MX, __ Ma Flat Plane, __ Repositioning, __ Modify Existing Splint
- __ Impressions Taken

Meds: __ Rx, __ OTC (Drug / Qty / Dose)

Procedure

Counseling: >50% TT = CT

TT: __ min.

CT: __ min.

Prognosis: __ Excellent __ Good __ Fair __ Guarded __ Poor

F/U:

Resident: ___________________________________________ Date: ____________________________

________________________________________________________

________________________________________________________

Faculty: ___________________________________________ Date: ____________________________

SOD: TMJ Med Probl List, 5/4/11
### HISTORY OF PRESENT ILLNESS

**CC & HPI:** Location, Duration, Timing, Quality, Intensity, Context, Min. & Aggrav. Factors, Assoc. Signs & Sxs

<table>
<thead>
<tr>
<th><strong>CC:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

**HA:** Dizziness - Numhness  

**Taste:** Small Chugs.  

**Neck:** Back - Other Jt. Pain  

**TMJ:** Tooth Pain - Sensitivity  

**Dry Mouth:** Snoring  

**Post Nasal Drip:** Sinus Ph.  

**Ear:** Tinnitus - Noise Sens.  

**Fever:** Chills - Wt Loss / Onin  

**Lymph:** Swollen Nodes  

**Eye:** Light Sensitiv. - Dry Eyes  

**N/V:** Heartburn  

**Dx:** Depressed - Anxious - Stress Chug.  

**Envir. Allergies:** Freq. Illness  

**Sweats:** Heat - Cold Intoler.  

**Skin:** Rashes - Lesions  

**Resp:** SOB - Cough  

**CF:** Chest Pain

### MUSCLE DYSFUNCTION

- TMJ Noise: **__Y__ N**  
- Locking: **__Y__ N**  
- Lid Opening: **__Y__ N**  
- Pain Chewing: **__Y__ N**  
- A.M. Pain: **__Y__ N**  
- Bite Chugs.: **__Y__ N**

### PARAFUNCTIONS

- Clenching: **__Day__ Night**  
- Bixism: **__Day__ Night**  
- Chews: **__Gum__ Objects**  
- Bites: **__Lips__ Cheeks__ Nails**

- Jaw Posture
- Rests Jaw in Hand
- Sleep Position

### RDC History Questions

- Pain in the face, jaw, temple, in front of the ear in the ear in the past month?  
  - Y  
  - N

- Ever had your jaw lock or catch so that it wouldn't open all the way? If yes.  
  - Y  
  - N

- Was this limitation in jaw opening severe enough to interfere with your ability to eat?  
  - Y  
  - N

### TRAUMA HISTORY

- Injury:  
- Date:
<table>
<thead>
<tr>
<th>Medical Hx:</th>
<th>See Health Hx Questionnaire</th>
<th>Current Medications &amp; Drug Allergies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgeries:</td>
<td>Psych:</td>
<td></td>
</tr>
<tr>
<td>Hospitalized:</td>
<td>Dental:</td>
<td></td>
</tr>
<tr>
<td>Family Med. Hx:</td>
<td>Y N Arthritis OA RA Other</td>
<td>__ Y __ N Cancer (type):</td>
</tr>
<tr>
<td>Social Hx:</td>
<td>Age: Gender: __ M __ F Marital Status:</td>
<td>______________________</td>
</tr>
<tr>
<td>Relationships:</td>
<td>Tobacco:</td>
<td>Alcohol:</td>
</tr>
<tr>
<td>Education:</td>
<td>Occupation:</td>
<td>Chemical use:</td>
</tr>
<tr>
<td>Stress:</td>
<td>Sleep:</td>
<td>Diet:</td>
</tr>
<tr>
<td>H2O Intake:</td>
<td>Exercise:</td>
<td>Caffeine:</td>
</tr>
</tbody>
</table>
### General Appearance

- **NAD**
- **Anxious Appearing**
- **Obese**
- **Thin**
- **Other Observation:**

### Max ROM

<table>
<thead>
<tr>
<th></th>
<th>Pain</th>
<th>Muscle</th>
<th>TMJ</th>
<th>Dup. Pn.</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unassisted opening w/o pain</td>
<td>mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. unassisted opening</td>
<td>mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. assisted opening</td>
<td>mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right lateral excursive</td>
<td>mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left lateral excursive</td>
<td>mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protrusive excursive</td>
<td>mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TMJ Noise & Function

<table>
<thead>
<tr>
<th></th>
<th>Rt (L)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Joint Sounds</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Reciprocal Click</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Opening Click Only</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Closing Click Only</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Non-Reproducible Click</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Laterotrusive Click</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Protrusive Click</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Coarse Crepitus</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Fine Crepitus</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

- **Auscultated Lt. w/ Stethoscope?** □ __Y__ __N__
- **Pain w/ Noise?** __Y__ __N__
- **Noise dup. pain?** __Y__ __N__

### Jaw Deviation on Opening

<table>
<thead>
<tr>
<th></th>
<th>Rt (L)</th>
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</thead>
<tbody>
<tr>
<td>Straight</td>
<td>□</td>
</tr>
<tr>
<td>Correlated</td>
<td>□</td>
</tr>
<tr>
<td>Left</td>
<td>□</td>
</tr>
<tr>
<td>Right</td>
<td>□</td>
</tr>
<tr>
<td>Irreg</td>
<td>□</td>
</tr>
</tbody>
</table>

### Factal Palpation

<table>
<thead>
<tr>
<th></th>
<th>Rt (L)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Y Dup. Pn.</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Masseter m.</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Temporalis m.</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Submandibular m.</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Post. Mandibular m.</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Lat. Pterygoid m.</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Med. Pterygoid m.</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Temporallis tendon</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>TMJ Lat. Pole</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>TMJ Post. Pole</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

**Jaw loading test:** ________

### Cervical Palpation

<table>
<thead>
<tr>
<th></th>
<th>Rt (L)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Y Dup. Pn.</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Splenius Capitis</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Trapezius Insertion</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Upper Trapezius</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>SCM - Superior</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>SCM - Middle</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>R L (N Y)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Flexion</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>□ Extension</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>□ R-Lateral</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>□ L-Lateral</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>□ R-Rotation</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>□ L-Rotation</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
### EXTRAORAL EXAM

<table>
<thead>
<tr>
<th>Skin Inspection*</th>
<th>Explain Abn Findings</th>
<th>Salivary Glands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conjunctiva Insp.*</td>
<td></td>
<td>Tongue</td>
</tr>
<tr>
<td>Ext Ear/Nose Insp.</td>
<td></td>
<td>Ridding</td>
</tr>
<tr>
<td>Sinus Palpation</td>
<td></td>
<td>Lesions</td>
</tr>
<tr>
<td>Lips Inspection</td>
<td></td>
<td>Oral Mucosa*</td>
</tr>
<tr>
<td>Neck Palpation</td>
<td></td>
<td>Ridding</td>
</tr>
<tr>
<td>Parotid/SubMs Glld Palp</td>
<td></td>
<td>Lesions</td>
</tr>
<tr>
<td>Cerv. Lymph Nodes*</td>
<td></td>
<td>Alveolar Ridge</td>
</tr>
<tr>
<td>Carotid Artery Palp.</td>
<td></td>
<td>Soft Palate</td>
</tr>
<tr>
<td>Temporal Artery Palp.</td>
<td></td>
<td>Tonsils/Oropharynx</td>
</tr>
<tr>
<td>Facial Asymmetry</td>
<td></td>
<td>Gingivitis</td>
</tr>
<tr>
<td>Masseter Hypertrophy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### DENTAL EXAM

<table>
<thead>
<tr>
<th>Missing teeth (X)</th>
<th>3M</th>
<th>2M</th>
<th>1M</th>
<th>2PM</th>
<th>1PM</th>
<th>C</th>
<th>L1</th>
<th>C1</th>
<th>C</th>
<th>1PM</th>
<th>2PM</th>
<th>1M</th>
<th>2M</th>
<th>3M</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICP Contacts (Circle)</td>
<td>3M</td>
<td>2M</td>
<td>1M</td>
<td>2PM</td>
<td>1PM</td>
<td>C</td>
<td>L1</td>
<td>C1</td>
<td>C</td>
<td>1PM</td>
<td>2PM</td>
<td>1M</td>
<td>2M</td>
<td>3M</td>
</tr>
</tbody>
</table>

- **Attrition:**  
  - Ant. | Post. | Horizontal Overlap: _________ mm
- **Tender to percussion:**  
  - Tooth #:   
  - Vertical Overlap: _________ mm
- **Sensitivity:**  
  - Cold | to hot | to biting
- **Decay:**  
  - Tooth #:   
- **Tooth mobility:**  
  - Tooth #:   
- **Cross Bite:**  
  - Ant. Post.Rt | Post.Lt
- **Open Bite:**  
  - Ant. Post.Rt | Post.Lt
- **Pretaxiality:**  
  - Ant. Post.Rt | Post.Lt
- **Slide to CO>2mm:**  
  - Ant. Post.Rt | Post.Lt
- **Excursive Interference:**  
  - Working | Non-Working

### CRANIAL NERVE EXAM

<table>
<thead>
<tr>
<th>Right</th>
<th>Unab</th>
<th>Explain Abn Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olfactory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II Optic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III Oculomotor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV Trochlear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V Trigeminal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VI Abdorms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VII Facial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIII Acoustic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IX Glossopharyngeal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X Vagus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XI Accessory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XII Hypoglossal</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### MOTOR-SENSORY EXAM

<table>
<thead>
<tr>
<th>Motor Testing:</th>
<th>Explain Abn Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN V &amp; VII</td>
<td></td>
</tr>
<tr>
<td>Sensory Testing:</td>
<td></td>
</tr>
<tr>
<td>Anesth.</td>
<td>Hyperesthesia</td>
</tr>
</tbody>
</table>

### PSYCH. EXAM

<table>
<thead>
<tr>
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<th>Explain Abn Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientaion</td>
<td></td>
</tr>
<tr>
<td>Memory</td>
<td></td>
</tr>
<tr>
<td>Mood/Affect:</td>
<td></td>
</tr>
<tr>
<td>Anxious</td>
<td>Agitated</td>
</tr>
<tr>
<td>Other:</td>
<td></td>
</tr>
</tbody>
</table>

**Abbrev. Key:**  
- Dp.Pn.: Duplicates Pain  
- Pulp.: Palpatio  
- Ms.: Maxillary  
- Mv/Md.: Mandible/Mandibular  
- Ant.: Anterior  
- Post.: Posterior
### PLAN

**Imaging:**
- Pan
- TMJ Tomo's
- TMJ MRI
- Vwd. Report
- Vwd. Images
- See XR Interp.
- Pt. Declined

- Findings:

<table>
<thead>
<tr>
<th>PT</th>
<th>Eval &amp; Tx:</th>
<th>Pt agreed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exer: ___</td>
<td>___ ROM</td>
</tr>
<tr>
<td></td>
<td>___ Rom</td>
<td>___ 6x6</td>
</tr>
<tr>
<td></td>
<td>___ Posture</td>
<td>___ Conditioning</td>
</tr>
<tr>
<td></td>
<td>Modality:</td>
<td>___ US</td>
</tr>
<tr>
<td></td>
<td>___ Ionto.</td>
<td>___ E-Stim.</td>
</tr>
<tr>
<td></td>
<td>___ Traction</td>
<td>___ Traction</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BT Referral</th>
<th>Eval / Tx:</th>
<th>Pt agreed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Habit Reversal</td>
<td>Stress Man.</td>
</tr>
<tr>
<td></td>
<td>___ Relax / Bio-FB</td>
<td>Sleep Man.</td>
</tr>
</tbody>
</table>

| Self Care | TUTA | Oral Habits | Exer: | Pain Diary | Heat | Ice | Other: |

<table>
<thead>
<tr>
<th>Splint</th>
<th>Flat Plane</th>
<th>Repositioning</th>
<th>Other:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>___ Flat Plane</td>
<td>___ Modify Existing Splint</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surgery / Procedure</th>
<th>Location &amp; Rationale:</th>
</tr>
</thead>
</table>

- TPIs
- Nerve Block
- TMJ Surgery

- Pt. Declined

- Pt. to Consider

- Pt. agreed

- Pt. to Consider

- Pt. agreed

- Pt. to Consider

- Pt. agreed

| Referral: |

| Consult: |

| Meds: NOTE: Rx or OTC / Med / Qty / Date |

| Counseling: |
| Disussed… |

| >50% TT-CT: |

| CT:  |

| TT:  |

| F/U: |

| For: |

| Prognosis: Excellent | Good | Fair | Guarded | Poor |

- SEE DICTATION FOR DETAILS ON ASSESSMENT & PLAN

- Dr. Gary Anderson
- Dr. Subha Giri
- Dr. Cory Hermann
- Dr. Mike John
- Dr. Mariona Mulet
- Dr. Don Nikodorm
- Dr. Eric Schaffman

| Faculty Signature |

| Date |

| Resident Signature |

| Date |

SOD: TMJ Init Eval; 5/4/11
### Appendix 3

#### CBCT checklist of findings

<table>
<thead>
<tr>
<th></th>
<th>Within Normal Limits</th>
<th>Abnormal-Unlikely to be contributing to symptoms</th>
<th>Abnormal-Likely to be contributing to symptoms</th>
<th>Abnormal-possibly contributing to symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Temporomandibular Joint</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Maxillary Bone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Nasal Bone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Mandible</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Frontal Bone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Teeth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Sinuses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Brain Stem</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Floor of mouth-soft tissues</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Muscles of mastication</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Periapical Radiograph checklist of findings

<table>
<thead>
<tr>
<th></th>
<th>Within Normal Limits</th>
<th>Abnormal-Unlikely to be contributing to symptoms</th>
<th>Abnormal-Likely to be contributing to symptoms</th>
<th>Abnormal-possibly contributing to symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Radiolucency</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Radioopacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Cracks/fractures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Over/underfilled tooth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Missed Canals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Coronal seal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Loss of Lamina dura</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
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### Appendix 4

**Consensus Diagnosis**

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<th>Confidence Level 0,1,2</th>
<th>Confidence Level 0,1,2</th>
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<tr>
<td></td>
<td>Dr. Alan Law</td>
<td>Dr. Donald Nixdorf</td>
</tr>
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<td>5.</td>
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**Comments:**