

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 varies 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 nonodontogenic 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 OHCR 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 were 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 purcha 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 within 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 streamlining 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 1. Demographic characteristics of study subjects

Demographic Characteristics	Cases (19) Number (%) or Mean (SD)
<i>Gender</i>	
Male (%)	3 (16)
Female (%)	16 (84)
<i>Age</i>	
20-30	2 (10)
30-40	3 (16)
40-50	1 (5)
50-60	10 (53)
60-70	3 (16)
<i>Ethnicity</i>	
Non Hispanic or Latino	19 (100)
<i>Race</i>	
White	18 (95)
Other	1 (5)
<i>Marital Status</i>	
Married	7 (37)
Divorced	4 (21)
Single (Never married)	5 (26)
Significant other in household	3 (16)
<i>Education</i>	
High School	2 (10.5)
Some or completed College	15 (79)
More than a collage degree	2 (10.5)
<i>Work Status</i>	
Employed	16 (84)
Non- Employed	3 (16)
<i>*Income</i>	
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

Tooth related data	Cases Number (%)
<i>Arch</i>	
Maxillary	10 (53)
Mandibular	9 (47)
<i>Tooth type</i>	
Anterior	2 (11)
Premolars	4 (20)
Molars	13 (69)
<i>Restoration type</i>	
Crown	16 (84)
Amalgam restoration	2 (11)
Composite restoration	1 (5)
<i>Periodontal probing</i>	
≤ 3 mm	15 (79)
4-5 mm	3 (16)
≥ 6 mm	1 (5)

Table 3. Subjects' pain related characteristics in relation to diagnoses

	Odontogenic (study & adjacent teeth) Number (%)	Nonodontogenic (TMD & PDAP) Number (%)	Mixed Odontogenic/ Nonodontogenic Number (%)	Delayed Healing Number (%)
<i>Pain intensity</i>				
0	4/6 (66)	2/8 (25)	0	2/3 (67)
1-2	1/6 (17)	5/8 (62.5)	1/2 (50)	1/3 (33)
3-4	1/6 (17)	1/8 (12.5)	1/2 (50)	0/3
<i>Pain quality</i>				
No pain	1/6 (17)	1/8 (12.5)	0	2/3 (67)
Dull achy	3/6 (50)	4/8 (50)	1/2 (50)	1/2 (33)
Sharp	2/6 (33)	1/8 (12.5)	0	0
Throbbing	0	2/8 (25)	1/2 (50)	0
<i>*Pain localization</i>				
No pain	1/6 (17)	3/8 (37.5)	0	2/3 (67)
Well localized	5/6 (83)	2/8 (25)	0	1/3 (33)
Diffuse	0	2/8 (25)	2/2 (100)	0
<i>*Temporality of pain</i>				
No pain	1/6 (17)	2/8 (25)	0	0
Intermittent	3/6 (50)	2/8 (25)	0	0
Constant	2/6 (33)	2/8 (25)	1/2 (50)	1/3 (33)
Variable	0	1/8 (12.5)	1/2 (50)	2/3 (67)
<i>History of Orofacial pain</i>				
<i>TMD</i>				
Present	3/6 (50)	2/8 (25)	1/2 (50)	0
Absent	3/6 (50)	6/8 (75)	1/2 (50)	3/3 (100)
<i>HA &amp; Sinusitis</i>				
Present	3/6 (50)	5/8 (62.5)	1/2 (50)	1/3 (33)
Absent	3/6 (50)	3/8 (37.5)	1/2 (50)	2/3 (67)
<i>**History of other overall chronic pain</i>				
Present	4/6 (77)	6/8 (75)	2/2 (100)	2/3 (67)
Absent	2/6 (33)	2/8 (25)	0	1/3 (33)

\*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

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

\*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

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

\* 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

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

Data in table 6 is derived from parent study (66) and from (unpublished data, Nixdorf et al).



Figure 1. Study protocol and data collection process for the parent and nested study

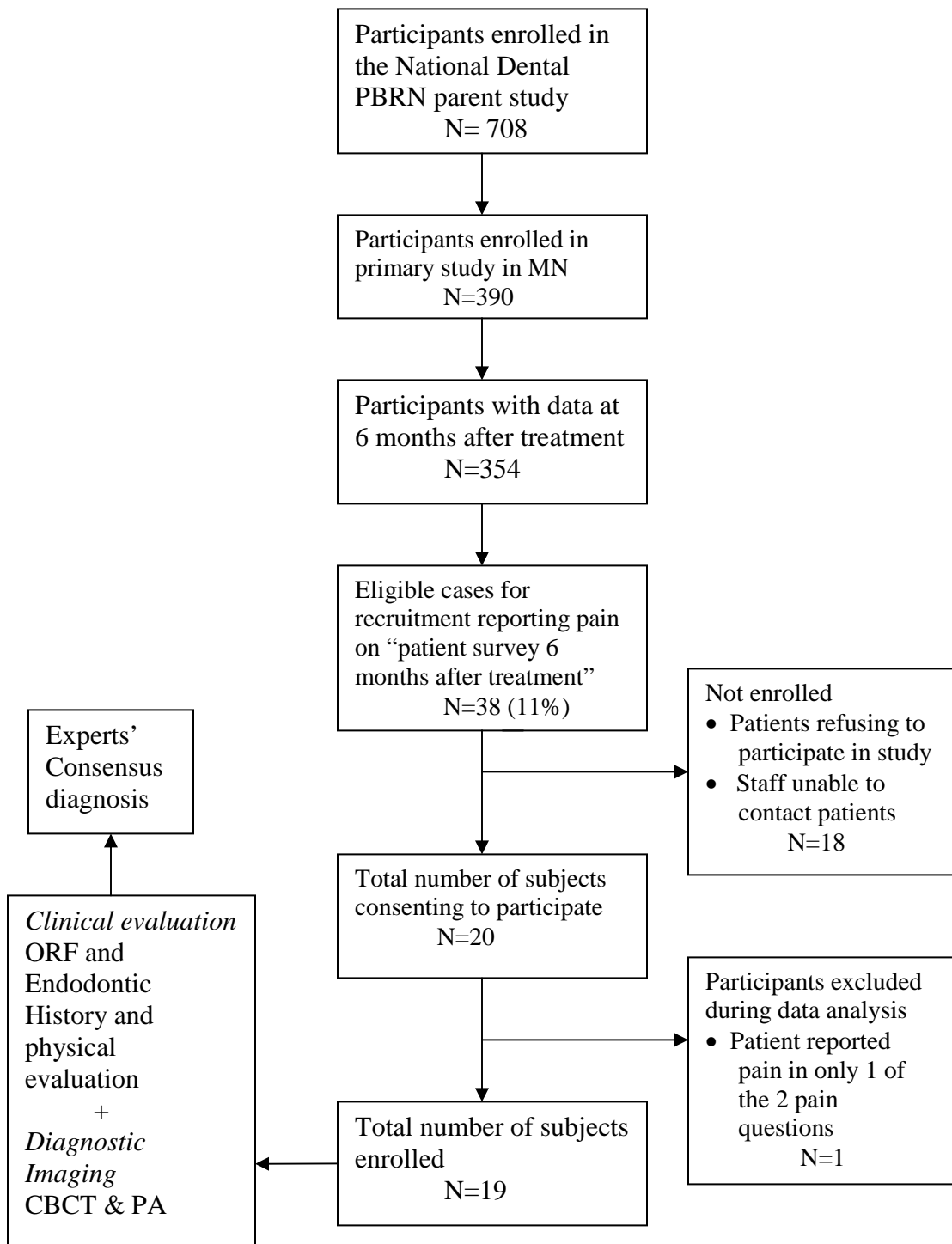


Figure 2. Experts' consensus diagnoses of cases

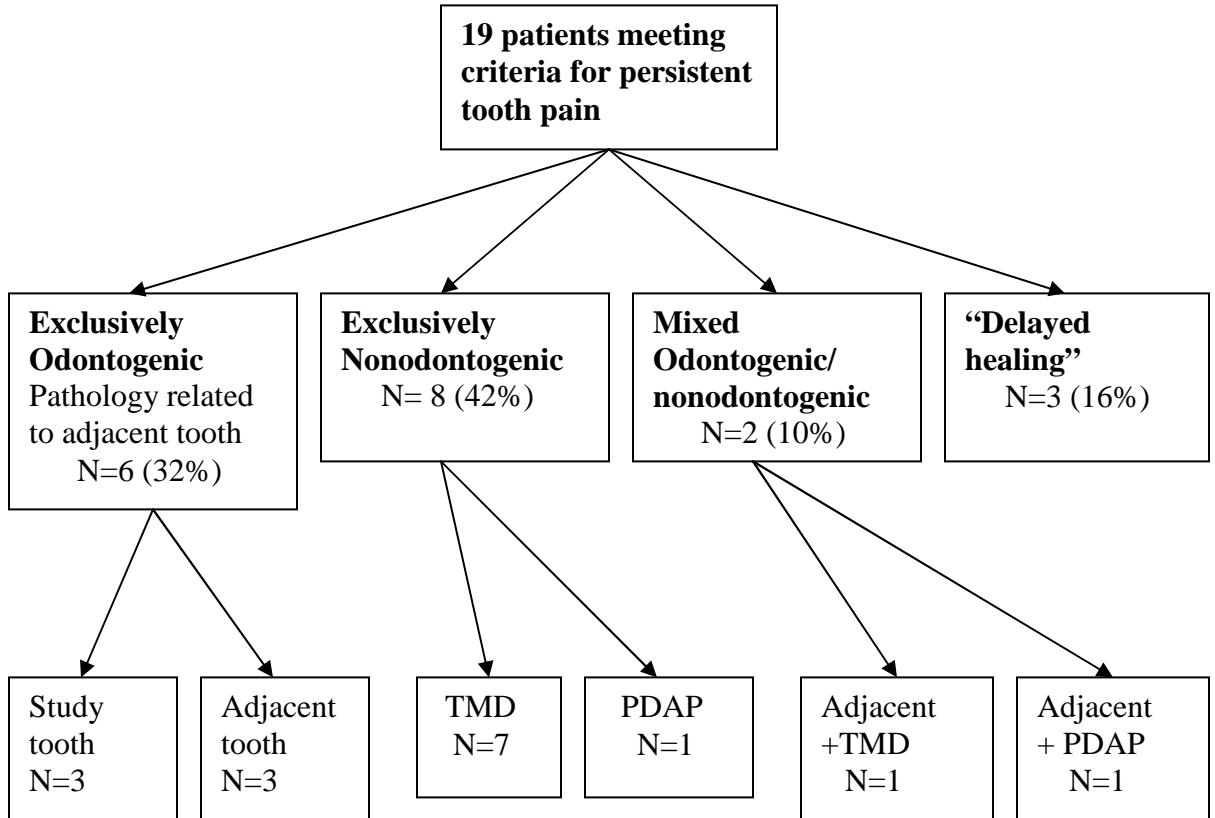
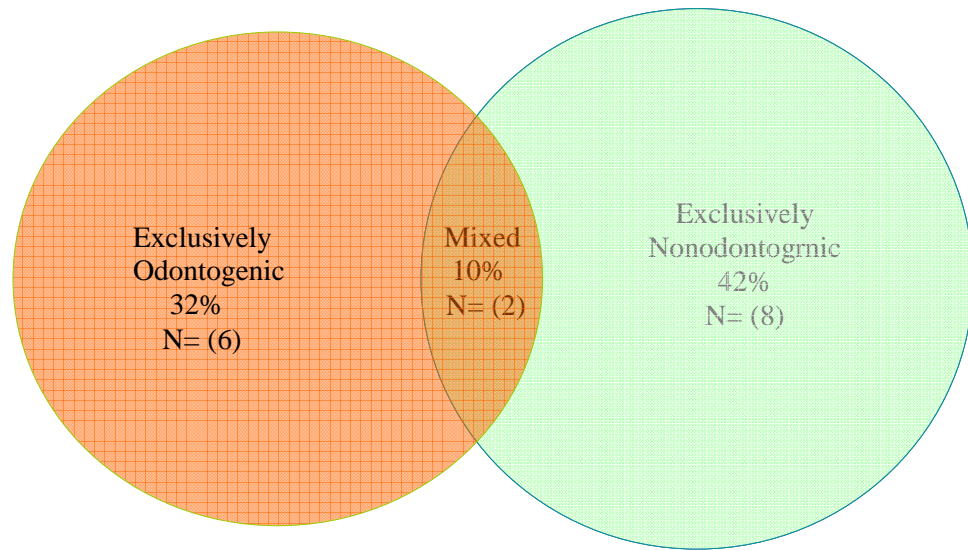


Figure 3. Diagram outlining etiology of patients' pain complaints



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# Appendix 1



## ENDODONTIC FORM

Patient \_\_\_\_\_ DOB \_\_\_\_\_  
 Tooth # \_\_\_\_\_ Pt # \_\_\_\_\_ Date \_\_\_\_\_

### SUBJECTIVE FINDINGS:

**PAIN** (Circle All Appropriate): Level (0-10)  
 Well-localized \_\_\_\_\_ Diffuse \_\_\_\_\_  
 Spontaneous \_\_\_\_\_ Elicited (*cold/hot/chewing*) \_\_\_\_\_  
 Constant \_\_\_\_\_ Variable \_\_\_\_\_ Intermittent \_\_\_\_\_  
 Dull Ache \_\_\_\_\_ 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 \_\_\_\_\_ Diffuse \_\_\_\_\_ None \_\_\_\_\_  
 Lymphadenopathy \_\_\_\_\_ Temp \_\_\_\_\_  
 Indurated \_\_\_\_\_ Fluctuant \_\_\_\_\_  
 Location \_\_\_\_\_  
**Sinus Tract:** Present \_\_\_\_\_ Absent \_\_\_\_\_  
 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 \_\_\_\_\_  
 Chewing/Bite \_\_\_\_\_

rev 7/10

**PERIO**  
 Probing # \_\_\_\_\_ # \_\_\_\_\_ # \_\_\_\_\_  
 B \_\_\_\_\_  
 L \_\_\_\_\_  
 Mobility (I,II,III) \_\_\_\_\_  
 Cracks/Fractures Yes \_\_\_\_\_ No \_\_\_\_\_ N/A \_\_\_\_\_  
 Explain (Transillumination) \_\_\_\_\_

### RADIOGRAPHIC INTERPRETATION

Normal \_\_\_\_\_ Caries \_\_\_\_\_  
 Apical Radiolucency \_\_\_\_\_ Periodontal \_\_\_\_\_  
 Lateral Radiolucency \_\_\_\_\_ Immature Apex \_\_\_\_\_  
 Furcal Radiolucency \_\_\_\_\_ Root Fracture \_\_\_\_\_  
 Calcification \_\_\_\_\_ Previous RCT \_\_\_\_\_  
 Apical Radiopacity \_\_\_\_\_ Perforation \_\_\_\_\_  
 External Resorption \_\_\_\_\_ Canal Obstruction \_\_\_\_\_  
 Internal Resorption \_\_\_\_\_ Developmental Anomaly \_\_\_\_\_  
 Other \_\_\_\_\_

### DIAGNOSIS

**Pulpal:** Normal \_\_\_\_\_  
 Reversible Pulpitis \_\_\_\_\_ Symptomatic Apical Periodontitis \_\_\_\_\_  
 Symptomatic Reversible Pulpitis \_\_\_\_\_ Asymptomatic Apical Periodontitis \_\_\_\_\_  
 Asymptomatic Irreversible Pulpitis \_\_\_\_\_ Acute Apical Abscess \_\_\_\_\_  
 Necrosis \_\_\_\_\_ Chronic Apical Abscess \_\_\_\_\_  
 Previously Treated \_\_\_\_\_ Condensing Osteitis \_\_\_\_\_  
 Previously Initiated Therapy \_\_\_\_\_

### Pre-Treatment Prognosis:

Favorable \_\_\_\_\_ Questionable \_\_\_\_\_ Unfavorable \_\_\_\_\_  
 If not favorable, why? \_\_\_\_\_

Canal	Reference	EWL	CWL	MAF	Rotary

### Post-Obturation Prognosis:

Favorable \_\_\_\_\_ Questionable \_\_\_\_\_ Unfavorable \_\_\_\_\_  
 If not favorable, why? \_\_\_\_\_

Doctor Signature: \_\_\_\_\_

## Appendix 2

University of Minnesota  
**TMJ & Orofacial Pain Clinic**  
*Initial Eval & Assessment*

See Dictated Report?:  Y  N

Pt. Name: \_\_\_\_\_  
 MR#: \_\_\_\_\_ Label  
 DOB: \_\_\_\_\_

**PROBLEM, VITALS & MEDICATION FLOWSHEET**

Age	Gender	Attending DDS	Primary Insur.	Secondary Insur.	SERVICE DATE			
	_F _M							
Referring Provider:		__ MD __ DDS	Add:		Ph #:			
Date Last Visited:					Fax#			
Primary Provider:			Add:		Ph #:			
Date Last Visited:					Fax#			
<b>Initial Assessment Diagnosis:</b>		<b>Other Conditions/Diseases:</b>			<b>Injury Related Information</b>			
1.					Injury Date (m/d/y):			
2.					Type: <input type="checkbox"/> MVA <input type="checkbox"/> WC <input type="checkbox"/> Other			
3.					In Litigation? <input type="checkbox"/> Y <input type="checkbox"/> N			
4.								
<b>Contributing Factors:</b>		<input type="checkbox"/> Chronic Pain		<input type="checkbox"/> Oral Habits	<input type="checkbox"/> Stress			
<input type="checkbox"/> Bruxism Day / Night		<input type="checkbox"/> Depression / Anxiety		<input type="checkbox"/> Postural Habits	<input type="checkbox"/> Systemic Disease			
<input type="checkbox"/> Clenching Day / Night		<input type="checkbox"/> Gum Chewing		<input type="checkbox"/> Rests Jaw in Hand	<input type="checkbox"/> Other:			
<input type="checkbox"/> Caffeine / Diet		<input type="checkbox"/> Object Chewing		<input type="checkbox"/> Sleep Dysfunction				
<b>DRUG ALLERGIES / REACTIONS:</b>		<b>VITALS</b>	Date	Date	Date	Date	Date	Date
<input type="checkbox"/> KNDA's		Ht:						
		Wt:						
		BP:						
		P:						
		P:						
<b>REVIEWED / UPDATED</b>		<b>Dr. Initials:</b>						
<b>MEDICATIONS</b>		<b>DOSE</b>		Date	Date	Date	Date	Date
Check = Cont'd Use D/C = Discont'd		△ Dose Chng						
<input type="checkbox"/> Pt. is not taking any Medications								
<b>REVIEWED / UPDATED</b>		<b>Dr. Initials:</b>						

University of Minnesota  
**School of Dentistry**

Pt. Name: \_\_\_\_\_  
 SOD:TMJMed.ProbList; 5/4/11

<b>IMPRESSION &amp; PLAN</b>	<input type="checkbox"/> SEE DICTATION FOR DETAILED ASSESSMENT & PLAN
<b>Self Care</b> ___ TUTA ___ Pain Diary ___ Heat / Ice ___ Oral Habits ___ Exercises	
<b>Imaging</b> ___ Pan. ___ CT ___ MRI ___: <span style="float: right;">Anat. Area of Interest: _____</span>	
To Evaluate: _____	
___ Vwd Images ___ Vwd Report <input type="checkbox"/> See Interp Report <span style="float: right;">Pt.: ___ Agreed ___ To Consider ___ Declined</span>	
<b>PT</b> <input type="checkbox"/> Eval /Tx: _____ <input type="checkbox"/> Exercises: ___ ROM ___ 6x6 ___ Posture ___ Conditioning <input type="checkbox"/> Modalities: ___ US ___ Ionto. ___ E-Stim. ___ Traction <span style="float: right;">Pt.: ___ Agreed ___ To Consider ___ Declined</span>	
<b>BT</b> <input type="checkbox"/> Eval /Tx: _____ CBT-Habit Reversal ___ Tx Compliance ___ Relax. Technqs. ___ Stress / ___ Sleep Mgmt. ___ Depress./Anxiety <span style="float: right;">Pt.: ___ Agreed ___ To Consider ___ Declined</span>	
<b>Splint</b> ___ Mx / ___ Mn Flat Plane ___ Repositioning ___ Modify Existing Splint ___: <input type="checkbox"/> Impressions Taken <span style="float: right;">Pt.: ___ Agreed ___ To Consider ___ Declined</span>	
<b>Meds</b> ___ Rx ___ OTC (Drug / Qty / Dose) <span style="float: right;">Pt.: ___ Agreed ___ To Consider ___ Declined</span>	
<b>Procedure</b> <span style="float: right;">Pt.: ___ Agreed ___ To Consider ___ Declined</span>	
<b>Counseling</b> >50%TT=CT <span style="float: right;">Discussed: _____</span>	
TT: _____ min. _____	
CT: _____ min. _____	
<b>Prognosis:</b> ___ Excellent ___ Good ___ Fair ___ Guarded ___ Poor	
<b>F/U:</b> _____	
Resident: _____ Date: _____	<input type="checkbox"/> Dr Gary Anderson <input type="checkbox"/> Dr Subha Giri <input type="checkbox"/> Dr Cory Herman <input type="checkbox"/> Dr Mike John <input type="checkbox"/> Dr Mariona Mulet <input type="checkbox"/> Dr Don Nixdorf <input type="checkbox"/> Dr Eric Schiffman
Faculty: _____ Date: _____	

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

Service Date:

Pt. Name:  
 Rec. #: *Label*  
 DOB:

**HISTORY OF PRESENT ILLNESS**

<b>CC &amp; HPI:</b> Location, Duration, Timing, Quality, Intensity, Context, Allev. & Aggrav. Factors, Assoc. Signs & Sx's		<b>Review of Systems</b>	
<b>CC:</b>		Circle -Pos. Slash / - Neg Blank - Not Asked	
		<b>Neur:</b> HA - Dizziness - Numbness	
		Taste - Smell Chngs.	
		<b>MS:</b> Neck - Back - Other Jt. Pain	
		<b>ENTM:</b> Tooth Pain - Sensitivity	
		Dry Mouth - Snoring	
		Post Nasal Drip - Sinus Pn.	
		Earache - Tinnitus - Noise Sens.	
		<b>Const:</b> Fever - Chills - Wt Loss / Gain	
		<b>Lymph</b> Swollen Nodes	
		<b>Eye:</b> Light Sensitiv. - Dry Eyes	
		<b>GI:</b> N / V - Heartburn	
		<b>Psy:</b> Depressed - Anxious - Stress Chng.	
		<b>Imm:</b> Envir. Allergies - Freq. Illness	
		<b>Endo:</b> Sweats - Heat - Cold Intoler.	
		<b>Skin:</b> Rashes - Lesions	
		<b>Resp:</b> SOB - Cough	
		<b>CV:</b> Chest Pain	
		<b>Mn. DYSFUNCTION</b>	
		TMJ Noise <input type="checkbox"/> Y <input type="checkbox"/> N	
		Locking <input type="checkbox"/> Y <input type="checkbox"/> N	
		Ltd Opening <input type="checkbox"/> Y <input type="checkbox"/> N	
		Pain Chewing <input type="checkbox"/> Y <input type="checkbox"/> N	
		A.M. Pain <input type="checkbox"/> Y <input type="checkbox"/> N	
		Bite Chngs. <input type="checkbox"/> Y <input type="checkbox"/> N	
<b>Past Tx:</b>		<b>PARAFUNCTIONS</b>	
		Clenching: <input type="checkbox"/> Day <input type="checkbox"/> Night	
		Bruxism: <input type="checkbox"/> Day <input type="checkbox"/> Night	
		Chews: <input type="checkbox"/> Gum <input type="checkbox"/> Objects	
		Bites: <input type="checkbox"/> Lips <input type="checkbox"/> Cheeks <input type="checkbox"/> Nails	
		Jaw Posture	
		Rests Jaw in Hand	
		Sleep Position	
<b>RDC History Questions</b>		<b>TRAUMA HISTORY</b>	
Pain in the face, jaw, temple, in front of the ear/ in the ear in the past month?		N	Y
		<input type="checkbox"/> Y	<input type="checkbox"/> N
Ever had your jaw lock or catch so that it wouldn't open all the way? If yes:		N	Y
		<input type="checkbox"/> Y	<input type="checkbox"/> N
Was this limitation in jaw opening severe enough to interfere with your ability to eat?		N	Y
		Date:	

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

Pt. Name:  
 Rec. #: *Label*

SOD:TMJInit.Eval; 5/4/11



Pt. Name: \_\_\_\_\_  
 Rec. #: \_\_\_\_\_ *Label*  
 DOB: \_\_\_\_\_






Service Date: \_\_\_\_\_

**HPI (cont'd)**


**MEDICAL, FAMILY, SOCIAL HISTORY**

<b>Medical Hx:</b>	<input type="checkbox"/> See Health Hx Questionnaire	<b>Current Medications &amp; Drug Allergies</b>	<input type="checkbox"/> See Med. Flowsheet in front of chart
<b>Surgeries:</b>		<b>Psych:</b>	
<b>Hospitalized:</b>		<b>Dental:</b>	
<b>Family Med. Hx:</b>		<input type="checkbox"/> Y <input type="checkbox"/> N Arthritis <input type="checkbox"/> OA <input type="checkbox"/> RA <input type="checkbox"/> Other	
		<input type="checkbox"/> Y <input type="checkbox"/> N Cancer (type):	
		<input type="checkbox"/> Y <input type="checkbox"/> N Auto-Immune D/O:	
<b>Social Hx:</b>	Age: _____	Gender: <input type="checkbox"/> M <input type="checkbox"/> F	<b>Marital Status:</b> <input type="checkbox"/> Single
<b>Relationships:</b>			<input type="checkbox"/> Partner
			<input type="checkbox"/> Married
			<input type="checkbox"/> Divorced
			<input type="checkbox"/> Widowed
<b>Education:</b>		<b>Tobacco:</b>	
<b>Occupation:</b>		<b>Alcohol:</b>	
		<b>Chemical use:</b>	
<b>Stress:</b>			
<b>Sleep:</b>		<b>Diet:</b>	
		<b>H2O Intake:</b>	
<b>Exercise:</b>		<b>Caffeine:</b>	

**EXAM** Service Date: \_\_\_\_\_

<b>GEN'L APPEARANCE*:</b>																
___ NAD ___ Anxious Appearing ___ Obese ___ Thin ___ Other Observation: _____																
<b>Mn ROM*</b>																
Unassistd opening w/o pain	_____ mm	<b>Pain</b>		<b>Muscle</b>		<b>TMJ</b>		<b>Dup.Pn.</b>		<b>Comments</b>						
Max. unassisted opening	_____ mm	N	Y	R	L	R	L	N	Y	___ Masseter m. ___ Temp. m.						
Max. assisted opening	_____ mm	N	Y	R	L	R	L	N	Y	___ Other m.:						
Right lateral excursive	_____ mm	N	Y	R	L	R	L	N	Y							
Left lateral excursive	_____ mm	N	Y	R	L	R	L	N	Y							
Protrusive excursive	_____ mm	N	Y	R	L	R	L	N	Y							
<b>TMJ NOISE &amp; FUNCTION</b>																
<b>Rt</b>		<b>Lt</b>		<b>Comments</b>				<b>Jaw Deviation on Opening</b>								
<input type="checkbox"/> No Joint Sounds	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>													
<input type="checkbox"/> Reciprocal Click	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> Opening Click Only	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> Closing Click Only	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> Non-Reproducible Click	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> Laterotrusive Click	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> Protrusive Click	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> Coarse Crepitus	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> Fine Crepitus	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
								Auscultated Jt. w/ Stethoscope? ___Y___N								
				Pain w/ Noise? ___Y___N												
				Noise dup. pain? ___Y___N												
<b>FACIAL PALPATION</b>																
<b>Rt</b>		<b>Lt</b>		<b>Comments</b>												
N	Y	Dup.Pn.	N	Y	Dup.Pn.											
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>											
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>											
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>											
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>											
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>											
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>											
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>											
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>											
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>											
						Jaw loading test: _____										
<b>CERVICAL PALPATION</b>																
<b>Rt</b>		<b>Lt</b>		<b>Comments</b>				<b>Ltd</b>		<b>Pain</b>						
N	Y	DupPn	N	Y	DupPn					N	Y	N	Y	DupPn		
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Abbrev. Key: Dup.Pn. -Duplicates Pain Palp. -Palpation Mx- Maxillary Mn/Md - Mandible/Mandibular Ant. -Anterior Post. -Posterior

Service Date:

EXTRAORAL EXAM		INTRAORAL SOFT TISSUE EXAM	
<b>Nml Abn</b>	<i>Explain Abn Findings</i>	<b>Nml Abn</b>	<i>Explain Abn Findings</i>
<input type="checkbox"/> <input type="checkbox"/> Skin Inspection *	_____	<input type="checkbox"/> <input type="checkbox"/> Salivary Glands	_____
<input type="checkbox"/> <input type="checkbox"/> Conjunctiva Inspect.*	_____	<input type="checkbox"/> <input type="checkbox"/> Tongue	_____
<input type="checkbox"/> <input type="checkbox"/> Ext Ear/Nose Inspect.	_____	___Ridging	_____
<input type="checkbox"/> <input type="checkbox"/> Sinus Palpation	_____	___Lesions	_____
<input type="checkbox"/> <input type="checkbox"/> Lips Inspection	_____	<input type="checkbox"/> <input type="checkbox"/> Oral Mucosa *	_____
<input type="checkbox"/> <input type="checkbox"/> Neck Palpation	_____	___Ridging	_____
<input type="checkbox"/> <input type="checkbox"/> Parotid/SubMn Gland Palp	_____	___Lesions	_____
<input type="checkbox"/> <input type="checkbox"/> Cerv. Lymph Nodes*	_____	<input type="checkbox"/> <input type="checkbox"/> Alveolar Ridge	_____
<input type="checkbox"/> <input type="checkbox"/> Carotid Artery Palp.	_____	<input type="checkbox"/> <input type="checkbox"/> Soft Palate	_____
<input type="checkbox"/> <input type="checkbox"/> Temporal Artery Palp.	_____	<input type="checkbox"/> <input type="checkbox"/> Tonsils/ Oropharynx	_____
<input type="checkbox"/> <input type="checkbox"/> Facial Assymetry	_____	<input type="checkbox"/> <input type="checkbox"/> Gingivitis	_____
<input type="checkbox"/> <input type="checkbox"/> Masseter Hypertrophy	_____		
<b>DENTAL EXAM *</b>			
Missing teeth (X)		3M 2M 1M 2PM 1PM C LI CI - CI LI C 1PM 2PM 1M 2M 3M	
ICP Contacts (Circle)		3M 2M 1M 2PM 1PM C LI CI - CI LI C 1PM 2PM 1M 2M 3M	
N Y			
<input type="checkbox"/> <input type="checkbox"/> Attrition: ___ Ant. ___ Post.		Horizontal Overlap: _____ mm	
<input type="checkbox"/> <input type="checkbox"/> Tender to percussion:   Tooth #:	_____	Vertical Overlap: _____ mm	
<input type="checkbox"/> <input type="checkbox"/> Sensitivity: ___to cold ___to biting		Angle's Class:       Rt: I II/1 II/2 III	
<input type="checkbox"/> <input type="checkbox"/> Decay:                    Tooth #:	_____	Lt: I II/1 II/2 III	
<input type="checkbox"/> <input type="checkbox"/> Tooth mobility:         Tooth #:	_____	(Circle)	
<input type="checkbox"/> <input type="checkbox"/> Cross Bite                ___ Ant. ___ Post.Rt ___ Post.Lt		Dentures: ___ None ___ Mx Full ___ Mx Part'l	
<input type="checkbox"/> <input type="checkbox"/> Open Bite                ___ Ant. ___ Post.Rt ___ Post.Lt		___ Mn Full ___ Mn Part'l	
<input type="checkbox"/> <input type="checkbox"/> Prematurity              ___ Ant. ___ Post.Rt ___ Post.Lt			
<input type="checkbox"/> <input type="checkbox"/> Slide to CO>2mm       ___ Ant. ___ Post.Rt ___ Post.Lt			
<input type="checkbox"/> <input type="checkbox"/> Excursive Interferenc. ___ Working ___ Non-Working			
<b>CRANIAL NERVE EXAM*</b>		<b>PSYCH. EXAM*</b>	
<b>Right</b>	<b>Left</b>	<i>Explain Abn Findings</i>	
<b>Nml Abn</b>	<b>Nml Abn</b>		
<input type="checkbox"/> <input type="checkbox"/> I Olfactory	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> Orientation	
<input type="checkbox"/> <input type="checkbox"/> II Optic	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> Memory	
<input type="checkbox"/> <input type="checkbox"/> III Oculomotor	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> Mood/Affect:	
<input type="checkbox"/> <input type="checkbox"/> IV Trochlear	<input type="checkbox"/> <input type="checkbox"/>	___ Anxious ___ Agitated ___ Depressed	
<input type="checkbox"/> <input type="checkbox"/> V Trigeminal	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> Other: _____	
<input type="checkbox"/> <input type="checkbox"/> VI Abducens	<input type="checkbox"/> <input type="checkbox"/>		
<input type="checkbox"/> <input type="checkbox"/> VII Facial	<input type="checkbox"/> <input type="checkbox"/>	<b>MOTOR-SENSORY EXAM</b>	
<input type="checkbox"/> <input type="checkbox"/> VIII Acoustic	<input type="checkbox"/> <input type="checkbox"/>	Motor Testing: _____	
<input type="checkbox"/> <input type="checkbox"/> IX Glossopharyng.	<input type="checkbox"/> <input type="checkbox"/>	<b>Nml Abn</b> (CN V & VII)	
<input type="checkbox"/> <input type="checkbox"/> X Vagus	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	
<input type="checkbox"/> <input type="checkbox"/> XI Accessory	<input type="checkbox"/> <input type="checkbox"/>	Sensory Testing: _____	
<input type="checkbox"/> <input type="checkbox"/> XII Hypoglossal	<input type="checkbox"/> <input type="checkbox"/>	<b>Nml Abn</b>	
		<input type="checkbox"/> <input type="checkbox"/> ___ Anesth. ___ Hyperaesthesia ___ Allodynia	

Abbrev. Key: Dup.Pn. -Duplicates Pain Palp. -Palpation Mx- Maxillary Mn/Md - Mandible/Mandibular Ant. - Anterior Post. -Posterior

SOD:TMJInit.Eval;5/4/11



Service Date: \_\_\_\_\_

**PLAN**

<b>Imaging:</b>	___ Pan. ___ TMJ Tomo's ___ TMJ MRI ___;		<input type="checkbox"/> Vwd. Report
<input type="checkbox"/> Panogram <input type="checkbox"/> TMJ Tomo's <input type="checkbox"/> TMJ MRI <input type="checkbox"/> Other:	Reason: _____ Findings: _____	<input type="checkbox"/> Vwd. Images <input type="checkbox"/> See XR Interp. ___ Pt. Declined	
<b>PT</b>	<input type="checkbox"/> Eval & Tx: _____		___ Pt. agreed ___
<input type="checkbox"/> Exercises: ___ ROM ___ 6x6 ___ Posture ___ Conditioning ___ :	<input type="checkbox"/> Modalities: ___ US ___ Ionto. ___ E-Stim. ___ Traction		___ Pt. to Consider ___ Pt. Declined
		___ x's/Wk for ___ Wks.	
<b>BT Referral:</b>	<b>Eval. / Tx:</b> _____		___ Pt. agreed ___
___ Habit Reversal ___ Stress Mngmt. ___ Depression / Anxiety ___ Other:	___ Relaxtn / Bio-FB ___ Sleep Mngmt. ___ Compliance w/ Tx		___ Pt. to Consider ___ Pt. Declined
<b>Self Care:</b>	___ TUTA ___ Oral Habits ___ Exercises ___ Pain Diary ___ Heat ___ Ice ___ Other:		
<b>Splint:</b>	___ Mn Flat Plane ___ Repositioning ___ Other:		
	___ Mx Flat Plane ___ Modify Existing Splint		<input type="checkbox"/> Impressions Taken Today
<b>Surgery/ Procedure</b>	___ TPT's ___ Nerve Block ___ TMJ Surgery ___ Other:		___ Pt. agreed ___
	Location & Rationale: _____		___ Pt. to Consider ___ Pt. Declined
<input type="checkbox"/> Referral:			
<input type="checkbox"/> Consult:			
<b>Meds.</b>	NOTE: Rx or OTC/ Med / Qty / Dose		
<b>Counseling:</b>	Discussed...		
>50% TT=CT			
CT:	_____ min.		
TT:	_____ min.		
	<input type="checkbox"/> Obtain records:		
<b>F/U:</b>	For: _____		Prognosis: ___ Excellent ___ Good ___ Fair ___ Guarded ___ ___ Poor
<input type="checkbox"/> SEE DICTATION FOR DETAILS ON ASSESSMENT & PLAN			
Resident Signature _____		Date _____	___ Dr. Gary Anderson ___ Dr. Subha Giri ___ Dr. Cory Herman ___ Dr. Mike John ___ Dr. Mariona Mulet ___ Dr. Don Nixdorf ___ Dr. Eric Schiffman
Faculty Signature _____		Date _____	

### Appendix 3

#### CBCT checklist of findings

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

#### Periapical Radiograph checklist of findings

	Within Normal Limits	Abnormal- Unlikely to be contributing to symptoms	Abnormal- Likely to be contributing to symptoms	Abnormal- possibly contributing to symptoms
1. Radiolucency				
2. Radioopacity				
3. Cracks/fractures				
4. Over/underfilled tooth				
5. Missed Canals				
6. Coronal seal				
7. Loss of Lamina dura				

Appendix 4

**Consensus Diagnosis**

	Confidence Level 0,1,2	Confidence Level 0,1,2
	Dr. Alan Law	Dr. Donald Nixdorf
1.		
2.		
3.		
4.		
5.		

**Comments:**