Dentofacial Considerations in Genioplasty
Majid Jamali, D.M.D.
Different scenarios and deformities in the maxillofacial complex that can affect the chin position and shape of its overlying soft tissue are illustrated. Includes recommendation that patients be made aware of underlying skeletal issues and alternative treatments.

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For patients presenting with preoperative pain, most will continue to experience pain after root canal treatment. A review of symptoms and classification of irreversible pulpitis, incidence of postoperative pain following treatment, factors influencing postoperative pain, prevention and pharmacological management.
Be That Guy (or that Woman)

Twenty years of preparation have brought a new editor to the helm of The NYSDJ.

You do things for a reason. Usually. Sometimes, people plan and God laughs. Occasionally, your decisions provide you with the opportunity of a lifetime. I chose to enroll in law school after 10 years in private dental practice. The application required an essay on my reasons for selecting law as a career. I relished the chance to explain myself, since I knew exactly what I intended to do with a law degree. I wrote, in so many words, that I wanted to be “that guy” who bridges the gap between the diverse interests and forces of the legal, business, administrative and political worlds and the noble profession of dentistry and its duty to act in the best interests of patients. Yikes! Sounds like a tall order—maybe an unreachable goal—but a worthwhile endeavor.

In order to meet the challenge, for over 20 years, I have taught and written about the issues facing dentistry. I want to now thank the New York State Dental Association and you, its members, for offering me the opportunity of my lifetime: to be that guy as the editor of our New York State Dental Journal.

Our Journal must educate, inform and provoke debate on significant and timely topics. In addition, I will gauge its success, in part, on how well The Journal can inspire each of you, individually, to define what it means to be “that guy” or that woman for your patients, organized dentistry and our profession. Your definition of what this means will vary with your particular skill set and with the myriad challenges you face. Let our editorial staff’s responses to the varied and changing issues facing our diverse membership serve as a springboard to your own involvement. In doing so, The Journal content should facilitate dialogue among our members essential to its growth and relevance.

Fortunately, I succeed outgoing editor, classmate and good friend Kevin Hanley, who, along with Managing Editor Mary Stoll, has elevated The New York State Dental Journal to one of the premier state journals in the country. Moving forward, I want our publication to help chart the itinerary for your journey into service and leadership. Find out what it means to be “that guy (woman)” and hop on board.

As dentists, we often lead multidimensional professional lives with divergent concerns. Some of us teach, administrate, perform research, or treat patients in various forms of public or private practice. Each facet of our careers influences our opinions on or response to any given issue. Although my training as an attorney will always shape my views, I find I still analyze problems through the prism of my over 30 years of ownership of a private dental
practice, including my current part-time general practice. In addition, during this same time, my experiences as clinical assistant professor teaching law and ethics and as a clinical instructor at the University at Buffalo School of Dental Medicine keep me in touch with the needs of the new dentist and culturally diverse groups. No doubt, my role in dental education plays a significant part in how I function as “that guy.”

In the end, an effective editor listens. When any player in the oral health care delivery system takes a position on a significant or controversial subject, dentistry should hear it, understand its impact and, when necessary, frame a cogent response. As your editor, I will listen for these voices of change and present a fair and balanced commentary. Most importantly, I will listen for your guidance on how The New York State Dental Journal can help clarify what being “that guy (woman)” means for each of you.
Dentofacial Considerations in Genioplasty

Majid Jamali, D.M.D.

ABSTRACT

Chin augmentation, particularly with implants, has become popular in recent years. For the most part, the focus is on the position of the pogonion. The rest of the mid-face, including the maxilla and mandible, are usually ignored. In this article, different scenarios and deformities in the maxillofacial complex that can affect the chin position and shape of its overlying soft tissue are illustrated. It is the author’s view that a number of genioplasty augmentation procedures should be deferred. Discussion of alternative treatments should take place with patients regarding their underlying skeletal issues.

Facial profile enhancement is becoming increasingly common. In addition to the nose, the chin plays an important role in the overall esthetic appearance of the face; and chin augmentation has become an integral component of facial rejuvenation.

Genioplasty, primarily by means of implants, has become a popular procedure to enhance a receding chin. In younger patients, this procedure is typically performed during rhinoplasty to give harmonious balance to the face. In older patients, it is usually performed simultaneously with facial and neck rhytidectomy to give definition to the jaw line and improve the pre-jowl sulcus. In this article, emphasis is placed on the importance of considering the whole face when evaluating the chin. Problems observed in the chin area could be, and usually are, a component of abnormalities of the maxilla-mandibular complex. These abnormalities may include such underlying issues as a divergent skeletal pattern, maxillary excess, short mandibular ramus, or condylar disease.

With proper diagnosis and treatment of chin abnormalities, the clinician and patient can be rewarded with superior results that are esthetically pleasing. Knowledge of osteology and muscle attachments, understanding and assessment of dental occlusion, as well as maxilla and mandibular anatomy and function, are all key to treatment planning, as these structures are all interrelated. Cephalometric analysis should be used to assist and to confirm the clinical findings. The clinician must be aware that true micrognathia, or a small chin, is rare.

Chin Origin and Significance

In human anatomy, the chin area, which is the lowest part of the face, is also known as the mental region (Figure 1). The chin evolved in the Middle and Late Pleistocene periods, anatomically distinguishing modern humans from their archaic counterparts. The origin of the chin and its biomechanical significance are somewhat controversial. As the chin allows for minute movements of the lips associated with speech, it is theorized that the chin evolved to uphold the jaw from the stresses associated with chewing and speech. Because
the chin differs in shape, depending upon gender, being more triangular in females and more square in males, it has also been hypothesized that sexual selection played a part in its evolution.

In many modern human cultures, a prominent chin is thought to represent a confident person.

**Anatomy**

**Osteology**
The chin has an external and internal surface. On the external surface, the ridge on the anterior midline is formed in utero by fusion of the mandible. This ridge divides inferiorly and surrounds the mental protuberance. On each side of the protuberance, slightly raised mental tubercles form. Proximal to the tubercles and inferior to the second premolar, the inferior alveolar nerve exits the mental foramen on each side.

**Myology**
Seven muscles attach to the chin. The muscles on the anterior surface include the mentalis, depressor labii inferioris, depressor anguli oris (partially) and platysma (Figure 2A). Mobilization of the lower lip is accomplished by these muscles. The geniohyoid, genioglossus and anterior belly of the digastric muscles arise from the posterior surface of chin (Figure 2B). These muscles oppose the downward pulling of the strap (infra-hyoid) muscles during speech and swallowing.
Physical Evaluation

After eliciting a medical history and chief complaint, the expectations and degree of motivation of the patient should be evaluated. To create an appropriate treatment plan, radiographs (such as panoramic X-rays and cephalograms) and photographs are invaluable; it is highly recommended that they be obtained. Physical palpation of the mentum area for diagnosing the underlying problem is important but not sufficient. Once all of the data are gathered, it is the duty of the clinician to not only listen to the chief complaint but also to educate and guide the patient toward the proper treatment.

Clinical assessment begins with the patient’s head in the Frankfurt horizontal, teeth in occlusion and lips in a relaxed position (i.e., in repose). The simple task of relaxing the mentalis musculature might be difficult for some patients. Many times, they have been subconsciously constraining these muscles for years in an attempt to appear normal (Figure 3). Therefore, if this is noticed, a few moments should be devoted to explaining and demonstrating proper relaxation of the lips and perioral musculature. A lateral cephalogram and photographs are subsequently obtained, with the lips in the same position.

When the above examination and diagnostic testing is completed, a sequential evaluation begins. Specific information that must be gathered when evaluating the chin includes the following:

- Mid-face appearance.
- Maxillary incisor show.
- Shape and appearance of the labiomental fold and soft tissue envelope.
- Dental occlusion.
- Position of the chin relative to the forehead.
- Shape of the chin.

Mid-face Appearance

From the profile view, the mid-face should appear round. Deficiencies in the anterior-posterior position of the maxilla result in a mid-face that appears flat and yields a mandible that appears pseudo-prognathic, making the labiomental fold obtuse.

Maxillary Incisor Show

The incisor show is a guide to assessing the vertical position of the maxilla. With a normal upper lip length at rest, 2 mm to 3 mm of incisors should be visible. Inadequate or excessive exposure of the incisors may represent vertical insufficiency or overgrowth of the maxilla. Influenced by the position and angulation of the maxilla, the mandible rotates around the condyles and dictates the final position of the pogonion of the chin.

Shape and Appearance of Labiomental Fold and Soft Tissue

The labiomental fold should have a gentle S-shape curve. The vertical position and angulation of the upper and lower incisors, and the anterior-posterior position of the mandible, the maxilla and the chin itself, play a role in shaping this fold.

Dental Occlusion

The molar class relationship and the occlusal and incisal an-
Radiation should be adjusted to allow the soft-tissue profile of the face to be evaluated, in addition to the bony structures. Similar to clinical evaluation and photography, the cephalogram should be obtained with the patient’s teeth in occlusion and the lips in repose. A posterior-anterior cephalogram is useful in patients with asymmetry. Once the cephalogram is obtained, the analysis begins. There are several views regarding the proper position of the chin. A popular view suggests that the ideal position of the chin is where a vertical line perpendicular to the Frankfurt plane passes the vermillion of the lower lip and meets the pogonion (Figure 5). This analysis is ideal in a person with a Class I occlusion and properly angulated incisors. For instance, in Class II malocclusion, where the mandibular incisors are proclined, the lip is pushed forward by these teeth. As a result, the chin would appear posterior and micrognathia could be easily misdiagnosed as microgenia. Hence, the position of the lower lip alone should not be the deciding factor when determining the position of the chin.

**Shape of Chin**
The soft tissue drape overlying the mentum is esthetically more important than the position of the pogonion. The teeth and shape of the bone should give a gentle curvature to the soft tissue, making the labiomental fold appear as a gentle S-shaped curve.
Dentofacial Deformities and the Chin

Surgical and Orthodontic Considerations

A youthful, natural-looking face is supported by a well-balanced skeleton. The facial skeleton plays a major role in supporting the overlying soft tissue; therefore, when the skeleton is deficient, deep creases may form. As a result, aging can become more pronounced and occur at an earlier age, thereby requiring cosmetic procedures (such as fillers) to substitute for the skeletal deficiency.

Orthodontic treatment has been successful in creating optimal dental occlusion in patients who present with malocclusion. As discussed earlier, in mild skeletal deformities, good occlusion can camouflage the underlying facial deformities. Overlooking such signs as mid-face deficiency, a nasal dorsal hump, lack of nasal tip support, a large interlabial gap or a receding chin will result in suboptimal function and esthetics post-treatment. Young patients and their parents are usually satisfied with a masking procedure; however, many of these patients will be disappointed with their facial appearance when they reach adulthood.

In addition to poor esthetics, obstructive sleep apnea is an important condition that could result from retrusionia that has been untreated since an early age (Figures 6 A,B). The combination of sliding genioplasty and orthognathic surgery is a more effective treatment in sleep apnea patients than either surgery alone. Because most patients start their treatment by seeing an orthodontist, the responsibility rests with the orthodontist to educate patients about the necessity of surgery and the benefits of having it performed at a young age.

There are several types of dentofacial deformities that require treatment by means of orthodontics and orthognathic surgery instead of genioplasty alone. Some of the most common scenarios are discussed below. Many retrusive patients tilt their chin upward to normalize the esthetics and open the posterior airway. Placement of the head in the Frankfurt horizontal position with the lips in repose will assist in diagnosing and treating a high-angle mandible. In these situations, rotation of the maxillo-mandibular complex will generally produce the best esthetics (Figure 7).

Occlusal Angle Abnormalities

The occlusal angle can cause major disharmony in the esthetics of the lower third of the face (Figure 8). A low occlusal angle may cause collapse of the lower third of the face and a protruding chin. A C-shape or concave face is usually observed in these patients; most will desire a smaller chin. By contrast, individuals with a large angle usually have a receding mandible or pseudo-microgenia. Examples can be seen in patients who present with condyle disorders or hemifacial microsomia. Guided by the amount of maxillary incisor tooth showing, maxillary and mandibular osteotomies are usually the best solutions to correct either a small or large occlusal angle.

Malocclusion

Class II

Division I: In this division, an increase in over-jet is seen, and the upper molar is anterior to the mesiobuccal groove of the lower molars (Figure 9). The anterior teeth are proclined, and the labiomental fold is acutely folded because of the upper incisors.

Division II: In this division, the molar relationship is the same as above, but the maxillary anterior teeth are retroclined. Usually a deep bite exists (Figure 10). With collapsed occlusion and a deep overbite, the posterior region of the mandible appears broad and the chin appears pointed and narrow. The chief complaint is usually the presence of a broad-shaped face and short, V-shaped chin. Advancing the mandible surgically increases the occlusal height and height of the lower third of the face, eliminating the need for genioplasty. Most patients with this condition would not be fully satisfied with genioplasty alone. Presurgical orthodontic treatment planning includes leveling the occlusion, with possible removal of teeth to decompensate for the proclined anterior mandibular teeth. Because the surgeon uses the new dental over-jet to advance the mandible and to place the pogonion in the correct position, esthetics are not sacrificed.

Class III

In this class, the upper molar is posterior to the lower molar’s buccal groove. The over-jet is negative, and the lower incisors are in front of the upper incisors. The labiomental fold becomes flat, with a protruding mandible. Decompensation of the teeth and mandibular setback are ideal. In general, shaving of the protruding chin should be avoided.

Vertical Maxillary Excess

Vertical maxillary excess (VME) causes the mandible to rotate around the condyles in a clockwise fashion (Figure 11). The pogonion, therefore, is placed in a posterior and inferior position, increasing the lower facial height and interlabial gap. Clinically, excessive exposure of maxillary incisors and a large interlabial gap will be seen. Genioplasty to close the interlabial gap is not completely successful. Proclining or intruding the incisors orthodontically may mask VME, but this orthodontic treatment is usually not stable. And it will not produce the best esthetic outcome in the mid-face region. Recently, the use of Botox has become popular for treating this condition. By paralyzing the perioral musculature, the lips become elongated and the gummy smile is hidden. However, this treatment inhibits all perioral musculature animation, so use of Botox in this region requires careful consideration.

The only treatment that can produce a multitude of beneficial effects is osteotomy. Superior positioning of the maxilla surgically can produce long-lasting, natural-appearing results. When surgery is chosen, orthodontic decompensation of the incisors to reveal the maxillary excess cannot be overemphasized. Only then
can the bony VME be truly appreciated and proper correction performed by superior positioning of the maxilla surgically. This procedure would restore the height of the lower face to a normal range, close the interlabial gap and remove excess gingival show. The condyles will be rotated and place the pogonion in a superior, anterior position, possibly eliminating the need for a genioplasty.

**Anterior Open Bite**

Similar to VME, anterior open bite will also result in a large interlabial gap. Most patients with an anterior open bite present with a Class II or Class III malocclusion. The shape of the chin and its position may be normal. Again, if the patient’s lips are not in repose during the examination, the labial fold would disappear, and the clinician might consider augmentation. Augmenting an otherwise normal chin would deepen the labiomental fold and produce highly unaesthetic results.

**Mentoplasty**

Sliding genioplasty and implants have been used frequently to augment a weak chin or enhance the effects of rhinoplasty. We suggest performing any chin or jaw surgery prior to rhinoplasty, because advancing these structures can make the nose appear smaller in an anterior-posterior direction. Recently, cosmetic fillers have become popular; however, they are temporary and the degree of augmentation is limited. Autografts have been tried in the past, but they have become unpopular because of their relatively high morbidity.

With the advent of improved biomaterials, the use of implants has increased. Implants can be used to successfully augment soft or hard tissue. They have a high safety margin, and the insertion can be completed in minutes under local anesthesia. The types of alloplastic materials include mesh polymers, expanded polytetrafluoroethylene, polymethacrylate, polyethylene and silicone. Among these, solid silicone has gained in popularity because of its low toxicity and ease of placement and removal. After several months, a fibrous tissue capsule is formed around the implant. When placed incorrectly, implants can cause infection, and seromas and might migrate to the overlying dermal layer. Extended anatomic mandibular implants, which are available in four sizes, tend to migrate less than central implants. Bony resorption of up to 5 mm is commonly observed on radiographs, especially with larger implants.

The first transoral sliding genioplasty was described by Trauner and Obwegeser. Sliding genioplasty is a simple and effective procedure. One of its most useful advantages is the ease with which it can be moved. When the osteotomy is completed, the segment can be moved or reshaped in any direction the clinician wants. Conversely, an implant cannot increase the vertical height and should not be placed in the inferior section of the mandible. Implants placed in this area may cause discomfort, since the over-

[Figures 10 A-C. Patient with Class II deep bite. Patient initially wanted longer, lower face with protruding chin. (A) Photo showing deep fold, unattractive “bulgy” chin as result of implant. Note already deep labiomental fold that implant worsened. Large chin implant had been placed below pogonion to accomplish this. Implant placed in presence of deep overbite, low occlusal plane and retrognathia will create unsightly, acute labiomental fold. If orthognathic surgery is deferred, sliding genioplasty with down-grafting can be performed to give more esthetically appealing soft-tissue chin. Bulging of misplaced implant revealed submental scar. Patient’s main complaint was constant mild pain in area that often occurs with migration of chin implant. Erythema, which cannot be appreciated in preoperative photograph, disappeared few days after surgery. (B) Radiograph showing displaced implant below pogonion. (C) Gentler shape of chin postoperatively.]

[Figures 11 A-C. Patient presented with chief complaint of long chin. (A) Patient with maxillary excess. Large interlabial gap, midface deficiency can be appreciated. (B) Radiograph confirming clinical findings. In radiograph, note proclined maxillary teeth. Vertical maxillary excess was diagnosed, accompanied by large interlabial gap at repose. Orthognathic surgery was deferred by patient, as he only desired shorter chin. Wedge of bone was removed during osteotomy and segment was repositioned in anterior-superior direction. (C) Interlabial gap did not improve significantly after surgery; however, chin was shortened by 3 mm. Chin segment was anteriorly placed to recreate labiomental fold.]

Figures 10 A-B, 10 C, 11 A-C
lying platysma is a thin muscle. No matter which technique is used, the augmented chin should exhibit a smooth transition to the body of the mandible without producing a bulbous appearance.

Revision Genioplasty
As the number of genioplasties has increased, so has the number of revision surgeries. Dissatisfaction with the initial procedure, which may not have satisfied a more severe dentofacial deformity, will often lead patients to seek a revision genioplasty. With moderate dentofacial deformities, edema in the early postoperative period plays a major role in masking the deficiencies. However, over time, many of these patients will seek removal of their implant and request other treatment options. With malpositioned and/or migrated implants, the symptoms and signs include erythema, pain and soft-tissue changes (Figure 12). Submental displacement of the implant can occasionally lead to the implant breaking through the soft tissue because the thin muscle layer in the area provides little soft-tissue coverage and support.

If the chin implant is removed for whatever reason, insertion of another implant or a sliding genioplasty should be performed. This will prevent collapse of the fibrous capsule and maintain the soft-tissue projection. The goal is to recreate the gentle curvature of the soft-tissue drape.

Conclusion
Genioplasty is a relatively simple and short procedure. Although it is a minor procedure, the diagnostic process prior to contemplating surgery can be challenging, especially when the surgeon seeks high-quality results. Successful genioplasty begins with the surgeon’s artistic and scientific understanding of the relationships between the mentum and other facial structures.

During examination, the clinician must consider all the deformities that are related to the chin position and shape, including the posterior airway space. Sliding genioplasty is recommended over other methods because of its versatility and esthetically natural results. Again, although many genioplasties are currently performed, true microgenia remains a rare condition.

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REFERENCES

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The presence of a peg lateral incisor is an example of an autosomal dominant genetic condition that is often associated with several other dental abnormalities, including tooth agenesis. It can occur either unilaterally or bilaterally. Individuals with peg lateral incisors often present with an associated midline diastema, as well as other anterior diastemas. The esthetic restoration of a peg lateral incisor can become a transformative event for an adolescent female patient. This article describes a combined orthodontic and restorative approach to the management of this condition, using a direct composite veneer without tooth reduction. This most conservative and minimally invasive treatment is especially appropriate in the adolescent patient. Final esthetic results are optimized by this combined interdisciplinary approach. By planning for the resultant space mesial and distal to the peg lateral incisor, composite resin can be veneered directly over the tooth to provide excellent esthetics. Other treatment options can be considered in adulthood, if necessary.

The presence of a peg lateral incisor is an example of an autosomal dominant genetic condition that is often associated with several other dental abnormalities, including tooth agenesis. Individuals with peg lateral incisors often present with an associated midline diastema caused by the distal movement of the central incisor. Because of their diminished size, other anterior diastemas may also be associated with a peg lateral incisor. In one study, the incidence of peg lateral incisors was found to be 0.8% in 739 children. This can occur either unilaterally or bilaterally, with one study showing increased occurrence on the left side of the maxilla.

The esthetic management of the peg lateral incisor can vary depending upon a variety of factors, among them, the age of the patient. Treatment options include the following:
1. Extraction of the peg-shaped tooth and orthodontic movement of the canine into the space of the lateral incisor; the canines can then be recontoured to resemble lateral incisors.
2. Extraction and replacement with a single tooth implant restoration or a fixed partial denture (FPD).
3. Direct or indirect restoration of the peg lateral incisors to develop normal tooth morphology.

All of these treatment approaches have been employed to produce acceptable results.

The most conservative and minimally invasive option is placement of a direct composite veneer bonded over the peg lateral
incisor. This technique is especially appropriate in the adolescent patient; and results are optimized by combined orthodontic and restorative treatment. By planning for the resultant space mesial and distal to the peg lateral incisor, composite resin can be veneered directly over the tooth to provide excellent esthetics. At the same time, future growth and development can continue to occur. Other treatment options can be considered in adulthood, if necessary.

This case report describes the orthodontic management and subsequent esthetic treatment of an adolescent female patient utilizing a direct composite veneer technique.

Case Report
Orthodontic Management
A 12-year-old patient presented for orthodontic evaluation and subsequent management of a peg lateral incisor (Tooth #10). Full orthodontic records were taken. The following is a summary of findings:

- The patient has a Class I malocclusion with some Class II tendencies.
- The maxillary arch displayed spacing, and a central incisor diastema exists.
- The mandibular arch exhibited minor crowding.
- The patient is congenitally missing her mandibular third molars.
- A high maxillary mid-labial frenum attachment exists.

Treatment recommendations included full edgewise appliances, as well as a head gear device. Spaces will be preserved mesial and distal to the peg lateral incisor #10 for subsequent restorative treatment. Objectives were to level and align the arches to provide excellent esthetics. At the same time, future growth and development can continue to occur. Other treatment options can be considered in adulthood, if necessary.

Restorative Management
Upon collaboration with the orthodontist, it was decided to leave a 1 mm space mesial and a 2 mm space distal to the peg lateral incisor for the subsequent direct composite veneer to be placed. Approximately 1 mm of space distal to tooth #10 will be preserved for the Class I canine relationship and midline coincidence to be kept intact.

Restorative Technique
Upon removal of the orthodontic brackets, study models were taken (Figures 1,2). A diagnostic wax-up was made to simulate the ideal tooth morphology (Figure 3). A clear stent was fabricated from the diagnostic wax-up (Glidewell Laboratory, Newport Beach, CA)
as a guide for the esthetic composite buildup (Figure 4). A pre-operative assessment of the shade determined the use of Vita A1 composite (Figures 5,6). Adjacent teeth #9 and #11 were coated with Super Bond Sep (Super Bond Sep, Sun Medical Co, Ltd, Moriyama, Shiga, Japan) to prevent adhesion of bonding materials (Figure 7). Tooth #8 was acid-etched for 15 seconds using Etch-Rite 38% Phosphoric Acid Gel (Etch Rite Dental Etching Gel, 38% phosphoric Acid, Pulpdent Corp., Watertown, MA).

After thorough water rinsing of etchant and air drying of tooth, Excite F bonding agent (Excite F Bonding Agent, Ivoclar Vivadent AG, Schaan/Lichtenstein) was applied to the tooth and scrubbed for 10 seconds before light-curing for 10 seconds (Flashlite 1401 Curing Light, Discus Dental, Den Mat, Santa Maria, CA) (Figure 8). Incremental layering buildup of Empress Direct (Empress Direct Composite, Ivoclar Vivadent AG, Schaan/Lichtenstein), a nano-filled hybrid resin composite, shade Vita A1, was used to restore the ideal tooth morphology (Figures 9,10). Each layer was light-cured for 30 seconds and built up in 2 mm increments. Final polishing and finishing were accomplished with Astropol Finishers and Polishers (Astropol Polishers and Finishers, Ivoclar Vivadent AG, Schaan/Lichtenstein) and Soflex XT discs (Soflex Discs, 3M ESPE, St. Paul, MN). Shaping and final contouring were done using fine grit football- and flame-shaped diamond burs (Neo Diamond #1923F, 1510 SF, Microcopy, Kennesaw GA). Occlusion was checked in centric, excursive and protrusive movements (Figure 11).
Results
The treatment for this patient involved the long-term coordination of surgical, orthodontic and restorative modalities. A laser frenectomy allowed closure of the central incisor diastema to be done in the most predictable fashion. Comprehensive orthodontics over a two-year span created a stable Class I occlusion, leveled and aligned the arches, and created the ideal positioning of the peg lateral incisor #10 for the subsequent placement of a direct composite veneer.

The presence of a peg lateral incisor can create significant psycho-social effects on a patient’s behavior. These may manifest as social introversion or a reluctance to smile. The restoration of this patient’s tooth morphology resulted in a profound improvement in her self-esteem and self-confidence.

Conclusions
Direct composite resin veneers can be an economical, conservative and esthetically pleasing restoration for the treatment of a peg lateral incisor in the adolescent patient. Careful treatment planning and coordination of specialty care can improve the final outcome for these patients.

REFERENCES

Eugene H. Bass, D.M.D., has been a full-time clinical instructor at New York University College of Dentistry since 2012. He maintains a private general dental practice in New City, New York. Queries about this article can be sent to Dr. Bass at ehb2041@nyu.edu.
Mandibular Bisphosphonate Osteonecrosis: A Cautionary Tale

Case Report
Ashley Coffey, D.D.S.; Louis Mandel, D.D.S.

ABSTRACT
The authors examined a 55-year-old female who had received eight intravenous infusions of a potent bisphosphonate (BP) for metastatic bone disease. A mandibular extraction was subsequently performed. At presentation, infection with suppuration and sequestrum formation were observed in the area of extraction. Both the oncologist and dental practitioner must be made aware that when BPs are going to be administered, dental care should be performed in a timely fashion. Prophylactic measures must be taken by the dentist if dental surgery is required for a patient who has received BP.

Medication-related osteonecrosis of the jaw (MRONJ) is defined by the American Association of Oral and Maxillofacial Surgeons as meeting the following criteria:
1. Current or previous treatment with antiresorptive or antianangiogenic agents.
2. Exposed bone or bone that can be probed through an intraoral or extraoral fistula in the maxillofacial region and that has persisted for more than eight weeks.
3. No history of radiation therapy to the jaws or obvious metastatic disease to the jaws.

Osteonecrosis of the jaw (ONJ) is initiated by antiresorptive agents such as the bisphosphonates (BP), denosumab and antiangiogenic drugs. BPs are common medications used for treating bone loss due to metastatic breast or prostate cancer, hypercalcemia from malignant bone disease, multiple myeloma and even Paget’s disease and osteoporosis. A third generation BP, zoledronate, administered intravenously and in widespread use, has proven to be very effective in maintaining bone integrity. It has an increased potency over that of the second generation pamidronate.

However, BP use comes with the caveat that it sets the stage for ONJ. The ONJ develops because BPs impede osteoclastic activity, induce apoptosis and have an inhibitory effect on local angiogenesis. Intravenous BP-related ONJ has been reported to occur in 18% to 27% of cancer patients who are treated with the drug. The risk is increased if the patient is a diabetic or is receiving steroids.

Recognition of the presence of ONJ may be difficult because the initial signs are subtle and varied. Diagnosis is facilitated when patients who have received BP present in the dental office with signs and symptoms that may include dental pain, exposed bone, fistulae, paresthesia, tooth mobility, swelling, suppuration, and sclerotic areas involving mandibular and/or maxillary bones.

ONJ after BP use involves the mandible 70% of the time, with 94% of these cases developing after the use of intravenous BPs rather than the oral versions. The jawbones are most often involved for reasons that are not totally clear. It is possible...
that the greater vascularization and bone remodeling that occurs around periapical disease and the periodontal ligament allow for greater local BP accumulations.14,15 It has also been suggested that the jawbones’ increased metabolism, when compared to other skeletal structures, makes them more susceptible.15

Spontaneous symptomatic ONJ onset is rare.3,7,13 Symptoms are usually triggered by an extraction or other surgical procedure associated with intraoral exposure of bone.6,13,16,17 such as periodontal therapy or periapical surgery.6 Patients who have received intravenous BP and undergo an extraction are at significant risk for the onset of ONJ, with 52% to 61% of ONJ cases occurring after an extraction.1 Secondary invasion by oral bacteria can then lead to suppuration and further bone necrosis in a vulnerable jawbone.

After extraction, the second most common cause of ONJ is mucosal breakdown with bone exposure resulting from wearing a prosthesis.18

Ideally, all necessary dental care should be completed four to six weeks prior to intravenous BP infusions. Clinical studies indicate a decreased incidence of ONJ onset when preventive dentistry is initiated before BP therapy.9,19,20 Coronectomy and endodontic procedures have been recommended to avoid any unnecessary extractions in susceptible bone.1,9,13,21 If extraction is necessary following the use of a potent intravenous BP, protocols have been established that include a variety of techniques to inhibit the development of ONJ.2,7,10,11,22,23 Oral hygiene therapy with an antiseptic mouthwash should be instituted prior to extraction. Antibiotics (amoxicillin/clavulanate) should be prescribed pre- and postoperatively. The extraction must be carried out with minimal trauma and followed by careful debridement and smoothing of sharp bone edges. A primary wound closure should be accomplished with the aid of suturing. Autologous plasma, rich in growth factors, can be introduced into the wound.13 Hyperbaric oxygen as an adjunct may have some value.3 The importance of a drug holiday is questionable, because once the agent involves bone, the half-life of the BP extends over many years.3

The authors document a case of suppurative ONJ that resulted from an unavoidable failure to dentally clear a patient with metastatic skeletal bone disease before the initiation of intravenous BP therapy. The problem was compounded by a missed opportunity before a dental extraction to institute some form of preoperative protocol aimed at discouraging the onset of a suppurative ONJ. This case serves to call the dental practitioner’s attention to the destructive events associated with the unimpeded progression of ONJ following an extraction.

Case Report
A 55-year-old female was referred in March 2015 to the Columbia University College of Dental Medicine (CDM) because of severe pain and suppuration that followed the extraction of a non-vital lower left second molar in August 2014. A medical history indicated that the patient had been a diabetic for 29 years. At the time of her referral she was being medicated with insulin, liraglutide and metformin. She has been taking lisinopril and hydrochlorothiazide for hypertension. In April 2013, the patient was diagnosed with a follicular lymphoma following the excision of an enlarged cervical lymph node. Imaging studies revealed the presence of several metastatic skeletal lesions, none of which involved the jaws, and multiple scattered lymphadenopathies. Chemotherapy (cyclophosphamide, doxorubicin, vincristine, prednisone) was initiated in August 2013. Beginning in May 2013, intravenous zoledronate (4 mg) was administered at periodic intervals. By the time the patient was seen in her dentist’s office (July 2014), she had received eight intravenous zoledronate (4 mg) infusions.

The patient’s visit to the dental office was precipitated by a two-month history of severe pain that focused around an end-

Figure 1. Clinical photo. Left facial soft tissues.

Figure 2. Intraoral view. Suppurative flow from gingival fistulous tract (white arrow). Granulation tissue exuding from socket of previously extracted lower left second molar (black arrow).
odontically treated lower left second molar with periapical pathosis. All attempts to alleviate the “horrific” pain failed and an extraction was performed (August 2014) without the use of any preemptive prophylactic protocol. Subsequent to the extraction, the severe pain persisted and a fistula in the left molar area, along with a facial buccal area swelling, developed one month later. Antibiotics, analgesics and chlorhexidine mouthwash were prescribed, and the patient was referred to CDM because of persistent pain, suppuration and swelling.

At the time of our clinical examination, a left facial swelling with moderate pain was noted involving the buccal soft tissues (Figure 1). Cervical lymphadenopathy and trismus were absent. Intraorally, a non-fluctuant swelling and shallowing of the mucobuccal fold in the mandibular left premolar/molar area were evident. A fistulous tract with a free suppurative flow was noted involving the buccal gingival tissue adjacent to the site of the extracted second molar (Figure 2). Probing of the fistula revealed bone at the tract’s base. Granulation tissue also was observed extruding from the incompletely healed socket of the extracted tooth (Figure 2). The remaining areas of the oral cavity were asymptomatic, with the dentition requiring no immediate care. The oral hygiene was good.

A CT scan taken in January 2015 revealed left mandibular soft tissue and bone involvement in the molar area with an associated periosteal reaction (Figure 3) and areas of sclerotic bone. At the same time, a PET study demonstrated increased metabolic activity involving the left mandible and adjoining soft tissues (Figure 4). Regarding the lymphoma, no new or growing lymph node activity were noted on these imaging studies. A panoramic radiograph (March 2015) clearly demonstrated the existence of a large bone sequestrum developing in the left mandibular molar area and an infected lower left first molar (Figure 5).

A diagnosis of ONJ was made based on the intravenous use of a potent BP, the presence of a fistula and the absence of metastatic jaw disease, as evidenced by imaging studies. We then referred the patient for surgical care regarding the developing infected sequestrum and the adjacent infected first molar.

Discussion
Patients with lymphomatous bone metastases are at significant risk for low bone mineral density. Lymphomatous bone involvement leads to increased bone destruction by stimulating osteoclastogenesis, which increases resorption and inhibits osteoblast differentiation. Hypercalcaemia can be anticipated. The mechanism by which the lymphoma affects bone physiology is unclear. Furthermore, the decrease in bone density is intensified when a steroid (prednisone) is incorporated into the chemotherapeutic cocktail. Corticosteroids increase bone resorption, while decreasing bone formation. The use of intravenous zoledronate has become the most effective measure to counter-
We hypothesize that the failure of root canal therapy, as evidenced by the reported periapical pathology, and the sclerotic bone assumed to be present at the time of the extraction were factors in the acute pain symptomatology that prompted the patient’s visit to her dentist. The ensuing extraction served to magnify the problem when alveolar bone was exposed to the oral environment. Oral bacterial bone invasion was facilitated because bone viability had been compromised by zoledronate.

Imaging studies play a key role in the diagnosis of ONJ. Because of the failure of adequate osteoclastic activity, the CT scan’s revelation of osteosclerosis has proven to be an effective adjunct in identifying the extent of BP bone involvement, even in the absence of exposed bone.\textsuperscript{30,31} Localized or diffuse osteosclerosis, or thickening of the lamina dura, may indicate future areas of necrosis.\textsuperscript{32} The presence of osteosclerosis in clinically symptomatic jawbone areas is a known and consistent feature of BP-caused ONJ.\textsuperscript{30-32} Our patient’s CT scan, taken in January 2015, did reveal osteosclerotic areas surrounding necrotic bone. It can be assumed that the sclerotic bone pre-existed and predisposed the jaw to the eventual clinical onset of ONJ subjective symptomatology. In turn, the ONJ set the stage for infection following the dental extraction. Viewing of the involved bone with positron emission tomography (PET) has proven to be of value because it depicts functional activity of tissues.\textsuperscript{32} Sequestrum formation and periosteal activity were authenticated in our patient by PET.

We hypothesize that the failure of root canal therapy, as evidenced by the reported periapical pathology, and the sclerotic bone assumed to be present at the time of the extraction were factors in the acute pain symptomatology that prompted the patient’s visit to her dentist. The ensuing extraction served to magnify the problem when alveolar bone was exposed to the oral environment. Oral bacterial bone invasion was facilitated because bone viability had been compromised by zoledronate.

The obvious breakdown in our patient’s care originated from the failure to appropriately start preventive dental care. Before beginning intravenous BP therapy, dental treatment for infected and potentially infected teeth must be instituted and supplemented with aggressive oral hygiene measures. However, at times, the exigencies of patient neoplastic care take precedence over the time required for dental care.

Once our patient’s diagnosis of lymphoma was made, osseous concerns became paramount and required immediate attention. Consequently, no referral for dental clearance was made by the oncologist prior to the use of zoledronate, and it was overlooked during zoledronate administration. In such situations, necessary extractions can be performed during or after BP therapy, provided the established preoperative protocol is inaugurated.

Our patient’s problem was compounded by the failure to initiate some form of prophylactic care prior to extraction. Admit-
tedly, even if our patient had received such care, the outcome may not have been positive. The risk of infection is reduced but not eliminated.8 Nevertheless, such care is required to decrease the incidence of infection superimposed on a BP-caused diminished bone viability. The need for preventive measures is accentuated by the difficulty in treating infected ONJ and mandates an interdisciplinary approach to patient care.

Queries about this article can be sent to Dr. Mandel at lm7@cumc.columbia.edu.

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This study evaluated the incidence of TMDs and their relationship to psychological factors in children ages 6 to 12 years who sought dental treatment at the Ponta Grossa State University. Following ethics committee approval and informed consent, 75 children were included in the study. Exclusion criteria were craniofacial malformations, history of orthodontic treatment and maxillary fractures. TMD severity was classified, using the Fonseca anamnesis index questionnaire, as “no TMD” (control) and “mild,” “moderate” and “severe.” Parents completed the Child Behavior Checklist, which measures behavior problems and competencies. Data were analyzed using the Chi-square test ($\alpha=0.01$).

Regardless of gender, 40 children had internalizing problems (with TMD, n=32; without TMD, n=8). Children presenting internalizing problems and TMD were classified as having mild (n=23), moderate (n=8) and severe TMD (n=1). Thirty-one children interviewed had externalizing problems (with TMD, n=24; without TMD, n=7). Children presenting externalizing problems and TMD were classified as having mild (n=18), moderate (n=5) and severe TMD (n=1). In addition, 36 children had behavior problems (with TMD, n=26; without TMD, n=10), of whom 19 children had mild, 6 children had moderate and 1 child had severe TMD.

Psychological problems were related to TMD in Brazilian children ages 6 to 12.

Temporomandibular disorder (TMD) is a generic term referring to a large number of clinical conditions involving the structures related to the stomatognathic system. It has been used to define dysfunctions of the temporomandibular joint (TMJ) and the masticatory muscles.¹ TMDs are responsible for most chronic orofacial pain. And the large population affected normally does not receive information about what the disorder is and how to treat it.

The etiology of TMDs continues to be a point of controversy; possible causes include structural, psychological, immunological factors, trauma, degenerative joint disease, parafunctional habits, masticatory hyperactivity and muscular spasms. Today, a majority of authors propose a multifactorial etiology for TMD, considering that the factors involved, as well as their influence, differ depending upon each case.²

Studies have been conducted in several countries in order to verify the prevalence of these diseases in the general population.
The prevalence of TMD is higher in the female gender and in the age group between 21 and 40 years. And it has been described as a condition that affects primarily adults.

The high percentage of children with signs and symptoms associated with temporomandibular disorders suggests the possibility that the TMJ dysfunction originates at the beginning of craniofacial growth. Thus, it is worth highlighting the importance of early diagnosis of TMDs in children, since the occurrence of TMD and deleterious oral habits, especially in childhood, interfere with the function of the stomatognathic system and may result in changes in breathing, chewing, swallowing and speech. According to Sonnesen et al., children may develop oral habits at an early age, affecting the balance between growth and function.

Although TMDs are multifactorial, the importance of the psychological factor should be considered, because the typical signs and symptoms often occur in patients at moments of intense concentration, anxiety and nervousness. Klasser et al. suggest that occlusal and psychological issues are among the main triggers of bruxism, the latter strongly associated with the development of TMDs. However, controversy surrounds the concepts that bruxism in children is related to local factors, mandibular instability resulting from the transition phase between deciduous to permanent dentition, and that there is an association between emotional factors and the habits involved. The psychological factor is noteworthy because of the large number of pediatric patients affected by fears, tension and anxiety.

The Department of Dentistry at the Ponta Grossa State University receives a large number of children who are assisted in the pediatric clinic; however, no study of the incidence of TMD in children has been carried out to date. Because of the possible relationship between TMD and psychological factors and the lack of information on this subject, the aim of this study was to determine the incidence of TMD and its relationship to psychological factors, using the psychological indicators of the Child Behavior Checklist, in children attending the pediatric clinic of the Department of Dentistry at the Ponta Grossa State University.

Material and Methods

Seventy-five children (ages 6 to 12) treated in different pediatric clinics at the Department of Dentistry of the Ponta Grossa State University were selected for this study. Children exhibiting neurological problems, craniofacial malformations, systemic musculoskeletal diseases (which could involve the TMJs), history of mandibular fractures or orthognathic surgery (who were undergoing orthodontic treatment) or whose age did not meet the research were excluded from the study. Children whose parents gave permission, who were able to read and who answered the data collection instrument properly, were included. Children and their respective guardians were interviewed. The study was approved by the Human Research Ethics Committee of the Department of Dentistry of the Ponta Grossa State University (Protocol: 03596/09). Each child’s parents signed the informed-consent form, after they understood the nature and objectives of the research, giving their child permission to participate in the study.

The subjects were subsequently asked to complete a general health questionnaire, which, because the factors mentioned above could affect research results, was used to refine the selection further. The questionnaire also helped us to consider the health condition of the patient at the moment he or she was interviewed.

Children were interviewed using the Fonseca anamnesis index questionnaire to detect the presence and severity of TMD symptoms. The questions were directed to the children; however, if a child did not understand the question, the guardian intervened to facilitate understanding and thereby avoid the influence of the examiner. The instrument allowed the examiners to classify the patients according to the degree of severity of TMD symptoms as mild, moderate, severe and without TMD, according to the score for each answer.

For the psychological evaluation, the guardians answered the questionnaire “Child Behavior Checklist for Ages 6–18 (CBCL),” consisting of 118 questions pertaining to behavior problems. In this survey, the parent or guardian who has daily contact with the child completed the questionnaire. The CBCL describes the social competence profile and internalizing and externalizing problems of children in two formats. The first one investigates parental perceptions, with versions for children from 18 months to 5 years (CBCL/2–3) and for children and adolescents from 6 to 18 years (CBCL/6–18). The second investigates the perceptions of the teacher(s) (Teacher Rating Form-TRF). The CBCL has good internal consistency, which allows an overall evaluation. The application of the questionnaire is easy, which favors its insertion into the clinical routine. The survey contains 138 items that provide an overall behavioral assessment of children. Of these, 20 are intended to evaluate the social competence profile of children and 118 are related to evaluation of behavior problems. This instrument aims only to detect whether or not behavioral, emotional or relationship problems exist and does not provide a specific diagnosis of mental disorder. Therefore, the survey lists a number of behaviors, desirable and disruptive, and presents a gradation of frequency as follows: 0 = Not true; 1 = Sometimes true; and 2 = Often true.

According to Drotar et al., the analysis of the CBCL provides a profile of the children on 11 individual scales: 3 for social competence (Activities, Sociability and Scholarly), which together lead to the Total Social Competence Scale; and 8 for behavior problems (Withdrawal, Anxiety/Depression, Somatic Complaints, Social Contact Issues, Attention, Thought, Behavior of Breaking Rules and Aggressive Behavior), which together lead to the Total Behavior Problems Scale. Analysis of the CBCL allows classification of the in-
dividual clinically, non-clinically or by gender in each of the sums of scales. The raw score from the survey is converted to a T score that has cutoff points for clinical ranges, limitrophe, and non-clinical. The set of obtained T scores, and the classification of these into clinical, limitrophe, or non-clinical, results in the profile of the child/adolescent.

The general health, Fonseca anamnesis index for TMD and CBCL questionnaires were applied by two calibrated examiners. After the clinical diagnosis, patients who had some kind of TMD were sent to the Clinic of Temporomandibular Disorders of the Department of Dentistry at the Ponta Grossa State University for possible treatment.

The data from the CBCL were analyzed using Assessment Data Manager software, which produced the psychological profile of the child/adolescent. The chi-squared test ($\chi^2$) was applied to show differences between the groups, with a significance level of $p < 0.01$.

**Results**

The results showed that, regardless of gender, 40 of the 75 children had some kind of internalizing problem. Of these, 8 were diagnosed as “without TMD” and 32 “with TMD” ($p = 0.0001$). Among the children with TMD, 23 had mild TMD, 8 had moderate TMD and one child had severe TMD ($p = 0.0000$). Thirty-one interviewed children had externalizing problems, 7 of whom were diagnosed as “without TMD” and 24 “with TMD” ($p = 0.0023$). Among the children with TMD, 18 demonstrated mild TMD, 5 had moderate TMD and one had severe TMD ($p = 0.0001$). The results also showed that 36 children demonstrated behavior problems. Of these, 10 had no TMD ($p = 0.0077$). The others demonstrated TMD: 19 of these children were diagnosed as having mild TMD; 6 as having moderate TMD; and 1 as having severe TMD ($p = 0.0000$).

Table 1 shows the percentages of children within each psychological profile according to the diagnosis of TMD. It was obtained by performing the crossover of psychological analysis data from the CBCL questionnaire with data from the anamnestic index questionnaire for TMD. Values were converted to percentages to improve visualization of the results obtained.

The scales of internalizing problems (A), externalizing problems (B) and total behavior problems (C) were compared. Figure 1 illustrates whether and to what degree these problems influence TMD in children.

We observed only four cases of children with TMD who were on the scales of externalizing problems and/or behavioral problems that did not meet the criteria for internalizing problems; however, of 38 children with TMD and internalizing problems, 12 had no externalizing problems, and 10 did not fit total behavior problems.

Because the scale of internalizing problems corresponds to the first three scales of behavior problems (Anxiety/Depression, Withdrawal and Somatic Complaints), we compared the three scales to the rest of the behavior problems (Social, Thought, Attention Problems, Rule-breaking and Aggressive Behavior). Only five cases of children with TMD were negative for the first three scales and positive for any of the remaining. The other results for children with TMD were negative in all scales or positive for at least one of the first three.

**Discussion**

This study demonstrated no significant association of TMDs with psychological factors between genders, which is consistent with

**TABLE 1. Distribution of Children (%) according to TMD and Psychological Diagnoses**

<table>
<thead>
<tr>
<th>Psychological Problems</th>
<th>TMD Diagnosis (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absence</td>
</tr>
<tr>
<td>Anxiety/Depression</td>
<td>10.7</td>
</tr>
<tr>
<td>Withdrawal</td>
<td>17.9</td>
</tr>
<tr>
<td>Somatic complaints</td>
<td>10.7</td>
</tr>
<tr>
<td>Social problems</td>
<td>14.3</td>
</tr>
<tr>
<td>Thought problems</td>
<td>3.6</td>
</tr>
<tr>
<td>Attention problems</td>
<td>10.7</td>
</tr>
<tr>
<td>Behavior of breaking rules</td>
<td>17.9</td>
</tr>
<tr>
<td>Aggressive behavior</td>
<td>7.1</td>
</tr>
<tr>
<td>Internalizing problems</td>
<td>28.6</td>
</tr>
<tr>
<td>Externalizing problems</td>
<td>25.0</td>
</tr>
<tr>
<td>Total behavior problems</td>
<td>35.7</td>
</tr>
</tbody>
</table>

Figure 1. Distribution of children with TMD who fit into one or more of following profiles of psychological problems: A = Internalizing problems; B = Externalizing problems; C = Total behavior problems.
In addition, the results revealed a high prevalence of TMD in children included in this study (62%). Relevant studies in young patients include one by Thilander et al., who analyzed a sample of 4,724 children and adolescents (ages 5 to 17) and found that 25% of subjects demonstrated one or more clinical symptoms of TMD. Santos et al. carried out a study to evaluate the frequency of signs and symptoms of parafunctional habits and occlusal characteristics in 80 children. They found a greater frequency of teeth-grinding, headaches and TMJ sounds, and that onychophagy and bruxism were the more prevalent parafunctional habits. Therefore, the authors from the present study advise evaluation of signs and symptoms of TMJ dysfunction in children routinely during the initial clinical examination.

Currently, psychological factors have been shown increasingly to contribute to the development of TMD and orofacial pain and are of fundamental importance to the correct diagnosis and determination of causal factors so that appropriate treatment can be established. However, we cannot say whether such factors are considered predisposing or just coincidental. A correlation between psychological variables and temporomandibular disorders has been found in children. This study showed a strong association between children with TMD and the scale of internalizing problems (Anxiety/Depression, Withdrawal and Somatic Complaints), which may or may not be associated with externalizing problems (Behavior of Breaking Rules and Aggressiveness) and/or total behavioral problems (Internalizing Problems, Externalizing Problems, Social Problems, Thought Problems and Attention Problems). It is thus suggested that problems related to TMD may be manifestations of issues such as anxiety, depression, withdrawal and somatic complaints, in agreement with studies performed by Rudy et al., Alamoudi, Dworkin et al., Yap et al. and Pereira et al.

Dworkin et al. and Yap et al. stated that non-biological factors such as depression and somatization have been demonstrated to be potentially strong influences on the development and symptoms of TMDs. Likewise, Alamoudi demonstrated high correlation between TMD and emotional states and reported the necessity for dental surgeons to pay attention to emotional factors in children diagnosed with some type of TMD. According to Rudy et al., both depression and somatization may contribute to the development and maintenance of TMD and/or interfere with the acceptance and maintenance of the treatment. Besides, painful sensations, muscle fatigue, noises and cracking from joints, and limited mouth opening, among other manifestations of TMD, can also be a source of frustration and stress. Thus, we might expect a positive feedback between TMD and emotional state.

The symptoms of anxiety are caused by excessive activity of the central nervous system that occurs from the interpretation of a situation as dangerous. Anxious people tend to be apprehensive, believing that something terrible is about to happen, often activating false alarms, and holding onto the belief even after a series of evaluations.
because of failed information processing. They tend to overestimate the danger and underestimate personal resources to deal with it. Anxiety, depression and withdrawal in children may also be associated with traumatic experiences. Traumatic experiences in childhood can manifest as chronic pain, which may lead to the development of some kind of TMD. Melzack postulated the existence of a pain neuromatrix in which the experience of pain is produced by multiple influences and constitutes a wide distribution of the neural network, with entry of stimulus in the stress regulatory system, including the thalamocortical circuit and the limbic and opioid systems. The body is strongly modulated by stress and influence of the brain’s cognitive functions on the traditional sensory functions; thus, psychological factors can be involved in pain perception.

Psychological factors (stress, anxiety) can cause children to develop oral habits, including bruxism, which can cause damage to the TMJ, masticatory muscles, periodontium, and occlusion. In this context, Cheifetz et al. observed that 38% of interviewed parents described the presence of bruxism in their children. According to these authors, some etiologic factors were associated with psychological disorders. However, Restrepo et al. concluded, by means of a systematic review, that there is no proper and effective treatment for bruxism in children and that further study was necessary.

For a child diagnosed with TMD who shows signs of psychological problems, the best approach would be to recommend psychological counseling, since the resolution of psychological problems in children could promote improvement in the symptomatology of TMD by identifying its source and preventing recurrence. In this regard, there is consensus among some researchers about the importance of evaluating and treating both physical and psychological factors in patients with TMD. Moreover, according to Rudy et al., a conservative intervention consisting of occlusal splint, biofeedback and stress management can significantly reduce parafunctional oral habits, pain and incapacity associated with TMD. However, the correct diagnosis, as well as determination of the possible etiologic factors, must precede any intervention so that the treatment can succeed.

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ABSTRACT
Patients typically associate dental care with pain. Pain has both physiological and psychological components. Endodontic post-treatment pain continues to be a significant problem facing the dental profession. For patients presenting with preoperative pain, most will continue to experience pain after root canal treatment, with pain levels ranging from mild to severe. The purpose of this paper was to review the symptoms and classification of irreversible pulpitis, including acute and chronic pulpitis, incidence of postoperative pain following treating teeth with irreversible pulpitis, factors influencing postoperative pain, persistent pain after root canal treatment, preventing postoperative pain and pharmacological management of postoperative pain.

Postoperative Pain following Treatment of Teeth with Irreversible Pulpitis
A Review
Zahed Mohammadi, D.M.D., M.S.D.; Paul V. Abbott, B.D.Sc., M.D.S., FRACDS (Endo); Sousan Shalavi, D.M.D.; Mohammad Yazdizadeh, D.M.D., M.S.D.
a fracture of the tooth or a restoration, or as a result of trauma to the tooth. The involved tooth is usually not tender to percussion unless acute apical periodontitis has also developed. Palpation tests do not produce an untoward reaction.

The characteristics of irreversible pulpitis are a pulp that responds with pain much more quickly than other teeth to cold pulp testing. The pain is usually quite sharp but then becomes a dull throb or ache that lingers for a considerable time. Occasionally, cold may alleviate the pain, which is typically indicative of a pulp with necrobiosis (a later stage of the disease process) where some of the pulp has become necrotic and infected.

Some authors have outlined variations of irreversible pulpitis, including acute, subacute, chronic, partial or total, infected or sterile. However, it is not possible to clearly differentiate between most of these except by histopathological methods—although it is possible to distinguish between chronic and acute irreversible pulpitis, based upon the amount of pain and the time that the pain has been present.

Irreversible Pulpitis

In irreversible pulpitis cases, the pulp is severely inflamed so that healing is unlikely with conservative pulp therapy. Therefore, if conservative pulp therapy is attempted, pulp necrosis and infection are the predicted outcomes and will lead to apical periodontitis. While it can be assumed that all pulps that become necrotic and infected will have irreversible pulpitis at some stage prior to necrosing, not all patients will report having had symptoms of irreversible pulpitis. Some patients might have had the symptoms, but they may not recall having had them, while others may not have had symptoms severe enough or long-lasting enough for them to seek dental treatment.

Barbakow et al. and Bender reported that 20% to 60% of pulps had progressed to being necrotic without pain being reported by the patients. Michaleson and Holland demonstrated that gender and tooth type had no effect on symptoms associated with pulpitis; although age was a factor, as the older the patient was (over 53 vs. under 33 years of age), the less likely there was any pain associated with pulpitis.

Although it is not known how pulp death can occur without symptoms, there are two possible explanations. The more probable hypothesis is that there is effective modification by local, as well as centrally mediated systems. There are several local regulatory factors and systems, including endogenous opioid, adrenergic sympathetic and nitric oxide systems that exist in the pulp. One example is somatostatin, which may inhibit pulp pain activation under certain conditions. Another less probable hypothesis is that, at least in some cases, the progression of inflammation to pulp death is so rapid there is no pain or, conversely, that the inflammation is so slow that the classical inflammatory mediators that participate in the pain process never reach a critical level. Although CNS plasticity can both enhance and reduce pulpal pain, its exact mechanism of action is yet to be clarified. If the pulp is symptomatic, it is most often very sensitive to thermal changes, and the pain sensation has the tendency to linger as a dull ache after the stimulus has been removed. This fact can be used with caution to predict if the pulp is likely to be irreversibly inflamed or not. In a normal pulp, only very intense stimuli will activate the more centrally located C fibers. When a long and intense-enough stimulus is placed on a healthy pulp, there is sharp pain at first, mediated by the A-delta fibers, followed by a poorly localized, dull pain sensation mediated by C fibers.

In teeth with severe inflammation, there are several inflammatory mediators that can cause increased sensitivity in the pulp nociceptors. Initially, these effects will be primarily on the more peripheral A-delta fibers. But when the inflammation reaches deeper structures, the C fibers will be affected. This will cause their firing threshold to be lower and the receptive field larger. Therefore, it is important when the patient is being questioned about lingering pain after the stimulus has been removed to not only ask about the time it took for the pain to go away, but also the nature of the lingering sensation. The more C-fiber-mediated pain complaint (dull, throbbing and poorly localized), the more severe the inflammation might be and, thus, the more likely it is that the pulpitis is irreversible in nature.

Although there is no relationship between the histological condition of the pulp and the clinical symptoms, the more severe the pain and the longer it has been symptomatic, the more likely it is that the pulp is irreversibly inflamed. The most obvious sign of irreversible pulpitis is the history of spontaneous pain, which may wake the patient from sleep.

Acute Irreversible Pulpitis

Acute irreversible pulpitis is usually determined by a recent or even a sudden onset of pain that may wake the patient at night. The pain is spontaneous, with moderate to severe intensity, and it lingers in response to temperature changes. The pain may be intensified by posture changes, such as when lying down or bending over. Common analgesics are rarely effective in controlling the pain. Radiographs are not useful in diagnosis in most cases; however, they can be helpful in identifying the possible cause of the disease (e.g., deep caries, an extensive or fractured restoration, pins, etc.). The tooth may be tender to biting pressure and/or percussion and, if present, this usually indicates spread of the inflammatory process to the periapical tissues (that is, primary acute apical periodontitis). In some cases, the biting or percussion pain may indicate a crack in the tooth; this is particularly noticeable when the crack is undermining a cusp.
**Chronic Irreversible Pulpitis**

Chronic irreversible pulpitis has signs and symptoms similar to those of acute irreversible pulpitis, but they will be much less severe than those in acute cases. In addition, the pain has been present for some time—typically several weeks but possibly months. Patients may complain of moderate pain, which is more intermittent rather than continuous, and it may be controlled by common analgesics. In the early stages of the disease process, the diagnosis can be difficult because the tooth may not show any demonstrable periapical change on the radiographs or a definitive sign of tenderness to percussion. However, information from the patient and pulp sensibility tests should be useful. As the disease progresses to involve the periapical tissues, periapical changes are more likely to be evident radiographically and/or clinically.\textsuperscript{11,25}

**Postoperative Pain following Root Canal Treatment**

Although current endodontic treatment can be virtually pain free during the procedure itself, patients still may experience pain after the appointment.

**Incidence of Postoperative Pain**

Most studies that have investigated the prevalence of postoperative pain following root canal treatment refer to the so-called “flare-up.” There have been many different definitions for a flare-up but most include severe pain and/or swelling after endodontic treatment that requires an unscheduled appointment and active treatment. However, patients may also experience pain or discomfort that does not meet this definition and, therefore, it is quite limited in its applicability. A more comprehensive term to use is “postoperative pain following root canal treatment.” The reported frequencies of postoperative pain range from 1.5% to 53%.\textsuperscript{26} The large range is due, in large part, to differences in the definitions used. In a prospective clinical study, Georgopoulou et al.\textsuperscript{1} showed that 57% of the patients reported no pain after debridement of the root canal system, 21% had slight pain, 15% had moderate pain, and 7% had severe pain.

Genet et al.\textsuperscript{3} found that the incidence of severe and moderate postoperative pain was 7% and 23%, respectively. By far, the greatest number of cases of postoperative pain (65%) was related to patients who reported at the first appointment with preoperative pain. In contrast, only 23% of those who developed postoperative pain were free of pain prior to treatment. Most postoperative pain occurred on the first day after treatment.

Clem,\textsuperscript{27} Calhoun and Landers,\textsuperscript{28} Marshal and Liesinger,\textsuperscript{29} Fox et al.,\textsuperscript{30} and Udoye and Jafarzadeh\textsuperscript{31} found that postoperative pain was more common following treatment of teeth with inflamed pulps. In contrast, Albashaireh and Alnegrish,\textsuperscript{32} Mor et al.\textsuperscript{33} and Mattscheck et al.\textsuperscript{34} reported greater incidence of postoperative pain following treatment of teeth with infected root canal systems. The discrepancy may be due to different criteria used to evaluate postoperative pain or to different endodontic materials and techniques.

Gotler et al.\textsuperscript{35} showed that the incidence of postoperative pain was high, ranging from 34.6% to 63.8%, depending upon the pulp condition. Furthermore, they found that root canal treatment of teeth with pulpitis was associated with a higher incidence and intensity of postoperative pain (six hours after treatment) compared to teeth with infected root canal systems or retreatment cases (which were probably also infected). This is in accordance with Levin et al.,\textsuperscript{36} who showed that 53% of patients receiving root canal treatment reported postoperative pain. In contrast, in a systematic review, Tsesis et al.\textsuperscript{37} showed that the incidence of postoperative pain was only 8.4%.

Kusner et al.\textsuperscript{38} reported that 72% of their patients experienced moderate-to-severe postoperative pain. According to a systematic review, the frequency of “all-cause” tooth pain at six months or longer after root canal treatment of permanent teeth was approximately 5%.\textsuperscript{39}

Wang and Xu\textsuperscript{40} revealed that the incidence and intensity of postoperative pain after the root canal filling was placed following one- or two-visit root canal treatment on teeth with pulpitis and a single canal were not significantly different.

**Factors Predicting Postoperative Pain**

Torabinejad et al.\textsuperscript{2} revealed that the presence of preoperative pain, tooth type, sex, age, history of allergy and retreatment were significantly predictive for the incidence of postoperative pain. They further showed that intra-canal medicaments, systemic disease and establishment of the patency of the apical foramen had no relationship to the incidence of postoperative pain. Specifically, the highest incidences of postoperative pain were associated with mandibular teeth, retreatment procedures, females over the age of 40 and patients with a history of allergies. Furthermore, the number of treatment sessions may influence postoperative endodontic pain.\textsuperscript{41}

**Persistent Pain after Root Canal Treatment**

Pain at six months after root canal therapy (i.e., persistent pain) is known to occur and has many possible explanations, including an untreated or incompletely filled root canal, unsatisfactory coronal restoration, tooth fracture, pain associated with an adjacent tooth, referred pain from a non-odontogenic structure or differentiation pain. Thus, such pain might best be characterized as all-cause pain. Whatever the underlying etiology, it is important for dentists to keep in mind that the subjective feeling of pain is the contributing negative factor for their patients. Although persistent pain is an important outcome in dentistry, its frequency, severity and extent of interference with daily life has not been well characterized in dental care populations. Adequate treatments for some of these pains are emerging, and early identi-
fication and treatment may improve prognosis. But the first step is to determine how widespread the problem is.

Preventing Postoperative Pain

Although pulpotomy and pulpectomy reduce endodontic pain, postoperative pain has been reported in 25% to 40% of patients. The pain is thought to be associated, in part, with a periapical inflammatory response produced by the endodontic instrumentation. A significant relationship also exists between preoperative and postoperative pain. Patients with severe preoperative pain tend to have more severe postoperative pain than patients with mild or no preoperative pain.

Prostaglandins (PGs) are important mediators of inflammation, the synthesis of which is initiated by release of arachidonic acid from damaged cell membranes. PGs probably are the most important hyperalgesic and inflammatory mediators. By sensitizing nerve endings to bradykinins and histamines, PGs increase vascular permeability, raise chemotactic activity, induce fever and increase sensitivity of pain receptors to other active inflammatory mediators. If the periapical inflammatory reaction is a major contributor to postoperative pain, then it is possible that a nonsteroidal anti-inflammatory drug (NSAID) will be useful in its management. NSAIDs inhibit inflammation and induce analgesia by inhibiting the activity of cyclooxygenase (COX) enzymes.

Two forms of COX enzymes have been identified: COX-1 and COX-2. The COX-1 enzymes are present in tissue at all times and are responsible for synthesizing prostanoids that have cytoprotective functions. The COX-1 enzymes regulate normal cell activities in the stomach, kidneys and platelets. COX-2 enzymes normally are not present in the tissues (other than in the kidneys), but they come into play when tissue injury and inflammation occur. Therefore, the COX-2-mediated inflammatory response is generally delayed because of activation and release of COX-2 enzymes by macrophages, monocytes, synovial cells, leukocytes and fibroblasts, which require one to three hours to occur. Ibuprofen, ketoprofen, aspirin and naproxen are nonselective NSAIDs that inhibit both cytoprotective COX-1 enzymes and inflammatory COX-2 enzymes. Consequently, the prolonged use of these agents is associated with possible damage of the gastrointestinal tract causing gastric erosions, ulcers and bleeding. Drugs that specifically inhibit COX-2 enzymes and leave the cytoprotective COX-1 enzymes intact may provide analgesia, anti-inflammatory and antipyretic activities while avoiding adverse effects on the gastrointestinal tract and other tissues, as well as on platelets.
Managing Postoperative Pain

Endodontic treatment, either in the form of pulpotomy or pulpectomy, is very efficacious in reducing pain. However, it is rarely immediate and complete. Therefore, postoperative analgesic intervention is often required in a variable percentage of patients.

There are three pharmacologic approaches to the management of postoperative pain following root canal treatment: 1. drugs that block inflammatory mediators that sensitize or activate nociceptors (e.g., NSAIDs and glucocorticoids); 2. drugs that block the propagation of impulses along the peripheral nerves; and 3. drugs that block central mechanisms of pain perception and hyperalgesia.

Non-steroidal Anti-inflammatory Drugs

NSAIDs have been the traditional treatment for moderate pain. Numerous NSAIDs are available for managing pain and inflammation. Nevertheless, moderate-to-severe pain of dental origin is best managed through the use of ibuprofen or other NSAIDs; and its maximum analgesic effect is at least equal to that of standard doses of acetaminophen-opioid combinations. It is important to understand that NSAIDs generally require a higher dose to achieve maximum anti-inflammatory action than that to achieve analgesic action. For example, 200 mg to 600 mg ibuprofen four times a day (i.e., 800 mg to 2,400 mg in one day) or 800 mg three times a day (i.e., 3,200 mg) may be needed for analgesic effect, but 2,400 mg to 3,400 mg a day may be needed for an anti-inflammatory effect.

In a meta-analysis of randomized clinical trials, Mehlisch found that ibuprofen given in doses of 50 mg to 400 mg was superior to a placebo at all dose levels. In addition, he showed that monotherapy with ibuprofen managed dental pain better than acetaminophen. Another study revealed that preoperative administration of ibuprofen one hour before local anesthesia injection was an effective method for achieving a deep anesthesia during treatment of teeth with pulpitis.

According to Torabinejad et al., the effectiveness of ibuprofen (400 mg) on postoperative pain was similar to ketoprofen (50 mg) and was superior to placebo treatment. A study demonstrated that ketorolac was a potent NSAID that significantly reduced pain after apicoectomy. Ketorolac (60 mg) was superior to placebo treatment. A study demonstrated that ketorolac was a potent NSAID that significantly reduced pain after apicoectomy. Ketorolac (60 mg) was superior to placebo treatment. A study demonstrated that ketorolac was a potent NSAID that significantly reduced pain after apicoectomy. Ketorolac (60 mg) was superior to placebo treatment. A study demonstrated that ketorolac was a potent NSAID that significantly reduced pain after apicoectomy. Ketorolac (60 mg) was superior to placebo treatment. A study demonstrated that ketorolac was a potent NSAID that significantly reduced pain after apicoectomy. Ketorolac (60 mg) was superior to placebo treatment. A study demonstrated that ketorolac was a potent NSAID that significantly reduced pain after apicoectomy. Ketorolac (60 mg) was superior to placebo treatment. A study demonstrated that ketorolac was a potent NSAID that significantly reduced pain after apicoectomy. Ketorolac (60 mg) was superior to placebo treatment.

Another study compared oral administration of ketorolac and acetaminophen codeine in the management of acute apical periodontitis. Findings showed that patients in the ketorolac group had significantly less pain than those who received acetaminophen codeine.

COX-2 NSAIDs

Although NSAIDs are remarkably effective in managing pain and inflammation, their use is limited by several adverse effects, including gastrointestinal bleeding and ulceration, impaired renal function and inhibition of platelet aggregation. Discovery of a second cyclooxygenase-2 led to the hypothesis that NSAIDs’ side effects could be decreased, as the inhibition of COX-2 is more directly implicated in ameliorating inflammation, while the inhibition of COX-1 is related to adverse effects in the gastrointestinal tract. This stimulated the development of selective COX-2 inhibitors that are better tolerated than nonselective NSAIDs but comparable in analgesic efficacy. However, recently identified adverse cardiovascular reactions associated with these drugs mandate a reappraisal of their use in dental practice.

Khan et al. demonstrated that administration of Celecoxib, 200 mg prior to extraction of impacted third molars, had no effect on thromboxane B2 (a product of COX-1) and inhibited PGF2 only at time points, which are consistent with the induction of COX-2. However, another study, using an oral surgery model, showed that Celecoxib was superior to a placebo, comparable to 650 mg of aspirin, but generally less effective than a standard dose of naproxen.

Brown et al. compared 50 mg of rofecoxib (withdrawn from the market in 2004 because of safety concerns) to ibuprofen 400 mg and a placebo in a single dose study in the oral surgery model of acute pain using traditional analgesic end points as well as the two-stop watch method for estimating analgesic onset. Results indicated that the total pain relief and sum of the pain intensity difference scores over eight hours following a single 50 mg dose of rofecoxib was superior to a placebo, but not distinguishable from ibuprofen (400 mg). The median time to the onset of pain relief was indistinguishable for rofecoxib (0.7 hour) and ibuprofen (0.8 hour). But significantly fewer subjects in the rofecoxib group required additional analgesic within 24 hours of the study drug than in the placebo or ibuprofen groups. Chen et al. reported that the analgesic efficacy and tolerability of single-dose COX-2 inhibitors were more effective than opioid-containing analgesics and similar to non-selective NSAIDs in postoperative pain management.

Valdecoxib, a second-generation coxib, is a potent and highly selective COX-2 inhibitor. According to Daniels et al., valdecoxib could be an efficacious oral safe alternative to other analgesics used to treat pain after oral surgery.

Gopikrishna and Parameswaran showed that the efficacy of prophylactic rofecoxib was similar to ibuprofen at four and eight
hours after pulpectomy. However, at the 12- and 24-hour periods, rofecoxib demonstrated significantly better pain relief than both ibuprofen and a placebo. In a randomized, double-blind, placebo-controlled, parallel-group trial, Nekoofar et al.\textsuperscript{65} compared the pain-reducing effect of oral preparations of meloxicam, piroxicam, and placebo in endodontic emergency patients. According to their findings, there was no significant difference between the tested groups.

\textbf{Acetaminophen}

Acetaminophen (N-acetyl-p-aminophenol), alone or in combination with an NSAID or a narcotic, is also used for pain relief. Menhinick et al.\textsuperscript{66} showed that, following pulpectomy, the combination of acetaminophen (1000 mg) and ibuprofen (600 mg) provided greater pain relief than ibuprofen (600 mg) alone.

\textbf{Corticosteroids}

Glucocorticoids have been used in endodontics for their potent anti-inflammatory effects.\textsuperscript{50} They have been employed as an intracanal medication either alone or in combination with antibiotics or antihistamines, and systemically as a means to decrease pain and inflammation in endodontic patients.\textsuperscript{50} It has been indicated that using hydrocortisone as an intracanal medication resulted in reduction and elimination of inflammatory reactions in periapical tissues.\textsuperscript{67} Ledermix paste (containing a corticosteroid, triamcinolone and a tetracycline antibiotic, demeclocycline, in a water soluble cream) placed as an intracanal medicament has been reported to be very effective at reducing the pain associated with apical periodontitis.\textsuperscript{68} It has been demonstrated that Ledermix eliminated postoperative pain within minutes to a few hours after placement.\textsuperscript{69}

A double-blind study assessed the effect of intracanal prednisolone acetate 2.5% compared with saline on postoperative pain and revealed that prednisolone acetate 2.5% was effective and significantly better in reducing the incidence of pain in teeth with irreversible pulpitis when compared to saline. In a randomized double-blind study on teeth with irreversible pulpitis, Negm\textsuperscript{70} showed that the intracanal application of a corticosteroid-antibiotic medication significantly reduced the mean pain when compared to placebo.

Another randomized, prospective, double-blind, placebo-controlled study assessed the effect of intramuscular injection of dexamethasone on postoperative endodontic pain. The findings indicated that at 4 and 24 hours after endodontic instrumenta-
tion and/or obturation, IM injection (1 ml) of dexamethasone significantly reduced pain incidence and severity.71 Krasner and Jackson72 evaluated the effect of oral dexamethasone (0.75 mg/tablet) on post-treatment endodontic pain. Results showed that patients receiving oral dexamethasone had significantly less pain at 8 and 24 hours compared to a placebo. This result was confirmed by Glassman et al.73 Lin et al.74 demonstrated that both etodolac and dexamethasone had significant effects on reducing postoperative pain in patients who had surgical endodontic procedures compared with a placebo. Marshall and Liesinger6 showed that taking 0.07-0.09 mg/kg of dexamethasone IM reduced pain 79 immediately before the patient’s discharge from the office. It may be administered at the start of the procedure; for postoperative pain control following a short procedure, the bupivacaine solution with 1:200,000 epinephrine. The patient’s requirement for postoperative opioid analgesics can be considerably lessened when bupivacaine is administered for pain control. For postoperative pain control following a lengthy procedure, it might be reasonable to administer bupivacaine prior to an oral surgical procedure reported to commence more promptly.79 Gordon et al.80 showed that patients given an inferior alveolar nerve block injection with bupivacaine prior to an oral surgical procedure reported significantly less pain at 24 and 48 hours after the procedure, compared to placebo-injected patients.

Opioids—Opioids block central mechanisms of pain perception and hyperalgesia. They are often used in dentistry in combination with acetaminophen, aspirin or ibuprofen. This analgesic blocks pain perception in the cerebral cortex by binding to specific receptor molecules (opiate receptors) within neuronal membranes of synapses. These bindings result in a decreased synaptic chemical transmission throughout the central nervous system, thereby inhibiting the flow of pain sensation into the higher centers. Mu and kappa receptors are the two subtypes of opiate receptors that narcotics bind to and cause analgesia. The narcotics are not anti-inflammatory in nature and do not inhibit cyclooxygenase or block the production of inflammatory factors such as prostaglandins.81

Codeine, hydroquinone, oxycodone and meperidine are the most commonly used narcotic analgesics. Codeine is an opioid analgesic that occurs naturally as a component of the poppy plant, along with morphine, and can be recovered as such from the opium extract of the plant.81 Codeine is often considered the prototype opioid for orally available combination drugs. Most studies have found that a 60 mg dose of codeine produces significantly more analgesia than a placebo, although it often produces less analgesia than either 650 mg of aspirin or 600 mg of acetaminophen.70

Tramadol is a synthetic, centrally acting analgesic that is thought to relieve pain through synergistic monoaminergic and µ-opioid mechanisms of action.82 It is widely used for the treatment of acute and chronic pain, but has low abuse potential, and unlike pure opioids, clinically relevant effects on respiratory or cardiovascular parameters are rare at recommended doses for postoperative pain.83 A meta-analysis of data from 3,453 patients in 18 placebo-controlled trials established the safety and dose-dependent efficacy of tramadol in the treatment of moderate-to-severe dental or postsurgical pain.84 In patients with dental pain, 100 mg of tramadol provided at least equivalent analgesia compared with an opioid combination (e.g., codeine/aspirin 60/650 mg or propoxyphene/acetaminophen [APAP] 100/650 mg). A single dose of 100 mg of tramadol was clearly more effective than 50 mg or 75 mg of tramadol in this patient population, but increasing the dose to 150 mg provided no additional analgesia. Dose-related adverse events with tramadol treatment included vomiting, nausea, dizziness and somnolence.85

Combination Analgesia Therapy for Postoperative Pain
Analgesic monotherapy has shown equivocal success in treating dental pain. The goal of combining analgesics with different mechanisms of action is to use lower doses of the component drugs, thereby improving analgesia without increasing adverse effects.52
NSAIDs Combinations

There are two general methods of combining an NSAID with an opioid in treating cases of moderate-to-severe pain. The first method achieves the analgesic advantages of both an NSAID and an opioid by prescribing an alternating regimen consisting of an NSAID followed by an acetaminophen and opioid combination. For example, the emergency pain patient could take 400 mg of ibuprofen (or an NSAID of choice) at the office. Then, the patient could take an acetaminophen and opioid combination two hours later. The patient would then receive each treatment every four hours, taking each drug on an alternating two-hour schedule. In most cases, these treatments do not need to be continued beyond 24 hours.87

The second method for combining an NSAID with an opioid in treating rare cases of moderate-to-severe pain achieves the analgesic advantages of both an NSAID and an opioid by administering a single combination drug consisting of an NSAID and opioid combination.88 For example, oxycodone/ibuprofen 5/400 mg (Combunox) is an oral fixed-dose combination tablet with analgesic, anti-inflammatory and antipyretic properties. It is approved in the U.S. for the short-term (up to seven days) management of acute, moderate-to-severe pain and is the first and only fixed-dose combination containing ibuprofen and oxycodone.87 Ziccardi et al.88 found that the combination of 400 mg ibuprofen and 15 mg hydrocodone was superior to the combination of 600 mg acetaminophen and 60 mg codeine in providing analgesia after third-molar extraction, as demonstrated by superior total analgesic effect, duration of analgesia and global evaluation. Traumatol has been shown to be effective in managing dental pain when combined with a peripherally acting NSAID. Doroschak et al.89 demonstrated that combining 100 mg traumatol with 100 mg flurbiprofen significantly reduced pain compared to a placebo at 6 hours and 24 hours following pulpectomy. They also reported that compared to a placebo, neither traumatol nor flurbiprofen significantly relieved pain in 6 and 24 hours when they were used alone.

Pre-emptive Analgesia

The concept of preventing the development of central sensitization was first explored as a clinical strategy through a retrospective review of medical records. McQuay90 reported the amount of time to the first request for postoperative analgesics in patients immediately following a variety of surgical procedures performed under general anesthesia. The preoperative administration of a local anesthetic and an opioid delayed the postoperative request...
for medication by approximately six and three hours, respectively. The combination of a local anesthetic and an opioid resulted in an even greater delay, suggestive of an additive effect.

Tverskoy et al.91 provided evidence that administration of a local anesthetic before the surgical incision resulted in substantially less pain for up to 72 hours postsurgically, particularly when pain intensity was elicited after a standardized movement. Gordon et al.72 demonstrated that preoperative administration of bupivacaine (a long-acting local anesthetic) in patients undergoing removal of impacted third molars under general anesthesia resulted in less pain and analgesic consumption at 48 hours than a parallel group of subjects administered saline placebo injections. Although less pain was experienced in the bupivacaine group long after the local anesthetic had dissipated, it was not clear whether this was a result of less nociceptive input during surgery, less postoperative pain or the additive effects of both.

Preventive Analgesia

Most studies in which an NSAID is administered orally after the onset of pain demonstrated an onset of activity within 30 minutes and peak analgesic activity in two to three hours after drug administration. The administration of an NSAID before pain onset (preventive) will suppress the release of inflammatory mediators, particularly prostaglandins, which contribute to the sensitization of peripheral nociceptors.92 According to Dionne,93 the combination of NSAID preoperative before pain onset and a long-acting local anesthetic markedly prevents pain during the initial six to seven hours after oral surgery.

Preventive Analgesia or Pre-emptive Analgesia

It appears that optimal clinical benefits can be achieved by administering drugs such as local anesthetics and NSAIDs before the onset of postoperative pain. Administering these drugs before a surgical or an endodontic procedure may be of benefit for longer procedures or for minimizing peripheral sensitization, which is a result of the cascade of inflammatory mediators that are released by tissue injury and fuel the subsequent inflammatory process.93

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