

Systemic complications due to endodontic manipulations

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As with all surgical procedures, there is a risk of operative and post-operative complications associated with endodontics, but these should be unusual provided appropriate precautions are taken (1–3).

This paper reviews the evidence on complications that are cardiac, infections, neurological, accidental, or immunological.

Cardiac

Trigemino-cardiac reflex

The trigemino-cardiac reflex (TCR) is a well-recognized phenomenon that consists of bradycardia, arterial hypotension, apnea, and gastric hypermotility. It occurs particularly during ocular surgery and during other manipulations in and around the orbit. The parasympathetic supply to the face is carried in the trigeminal nerve. Alternative afferent pathways must exist via the maxillary and/or mandibular divisions, in addition to the commonly reported pathway via the ophthalmic division of the trigeminal nerve in the classic oculocardiac reflex. The efferent arc involves the vagus, regardless of which branch of the trigeminal nerve transmits the afferent impulses.

Central stimulation of the trigeminal nerve can also cause these reflex bradycardic responses. Most cases reported have followed neurosurgery (4–6), but some have followed oral or perioral procedures (7). None has been reported following endodontic manipulation.

In different experimental studies, authors have analyzed the autonomic responses elicited by the electrical, mechanical, or chemical stimulation of the trigeminal nerve system.

The TCR has been reported in three healthy young adults undergoing operations that did not include any

manipulation of orbital structures (8). After the patients had been anesthetized and were hemodynamically stable, profound bradycardia or ventricular asystole occurred suddenly in response to manipulations of the bony structures of the maxilla or mandible, or dissection of, or traction on, the attached soft tissue structures. The authors suggested therefore that all patients undergoing maxillofacial procedures should be monitored carefully for reflex bradycardia and ventricular asystole (8).

Catecholamines, including dopamine, epinephrine, and norepinephrine, are present in the dental pulp in higher levels during inflammation than in uninflamed pulp tissue (9) and it is conceivable, therefore, that catecholamine release during endodontic manipulation could also trigger dysrhythmias.

Interference with cardiac pacemaker function

Electrical dental devices such as vitality pulp testers, electronic apex locators, and ultrasonic instruments may interfere with the function of cardiac pacemakers (10) and may produce deleterious effects in medically fragile patients with cardiac pacemakers (11). In contrast, a recent report (12) suggested that electronic apex locators can be used safely in these patients. Given the effect of individual patient's condition and a variety of pacemakers, it may be wise to consult with the cardiologist before treatment.

Bacterial endocarditis

There is abundant evidence for the infective basis of pulpal and periradicular disease (13, 14). The flora is complex and summarized in Table 1.

Surgery (15) or non-surgical endodontics (16) in at-risk patients clearly predisposes to bacterial endo-

Table 1. Endodontic microorganisms (Modified from Siqueira (14))

	Chronic periradicular lesions	Acute periradicular lesions	Secondary infections	Extra-radicular infections
<i>Actinomyces</i>	+		+	+
<i>Campylobacter</i>	+			
<i>Candida</i>			+	
<i>Enterococcus</i>	+		+	
<i>Eubacterium</i>	+	+		
<i>Fusobacterium</i>	+	+		
<i>Lactobacillus</i>	+	+	+	
<i>Peptostreptococcus</i>	+	+		
<i>Porphyromonas</i>	+	+		
<i>Prevotella</i>	+	+		
<i>Propionibacterium</i>	+		+	+
<i>Pseudomonads</i>			+	
<i>Staphylococcus</i>	+		+	
<i>Streptococcus</i>	+	+	+	
Treponemes	+	+		

carditis. Dental procedures implicated in infective endocarditis cases were reviewed over a 13-year period in the UK, and while most cases involved exodontia (17) or scaling (18), root canal treatment with extra-canal instrumentation accounted for seven cases due to bacteremia. For many years, it has also been believed that bacteremias could arise from treatment of infected root canals (19–22), less so in non-surgical than surgical procedures (18, 23). During non-surgical root canal treatment, it has been estimated that the greatest risk of bacteremia occurs during the early phase when the canal is still infected and instruments are placed to the apical termini for length determination and/or canal preparation (17). It is important to debride the canals to their full length without causing apical blockage with infected debris, in order to increase the chances of periapical healing (24). This is facilitated by ‘recapitulation’ or ‘patency filing’ to ensure that dentine debris and pulp tissue do not clog up the apical canal anatomy. It must be noted that definitive evidence for bacteremia caused by root canal instru-

mentation is lacking because previous studies have not sufficiently accounted for confounding factors.

In the survey by Carmona et al. (15), the dentists involved with the reported cases failed to give prophylactic antibiotics (48 cases), prescribed incorrect antibiotics (two), or gave antibiotics at inappropriate times (two). There was one episode of prophylaxis with amoxicillin failing despite it being given correctly (25).

Antibiotic prophylaxis is said to be indicated for surgery, or when there is instrumentation beyond the root apex (15). If litigation is to be avoided, dental practitioners must keep accurate dental records, take an appropriate medical history that is kept up to date, and adhere to national guidelines on antibiotic prophylaxis (25).

Other infections

Although endodontic manipulations may result in bacteremias (20–22), septicemia is remarkably rare (26), presumably testament to highly effective host defences. Murray & Saunders (13) reviewed the

bacteremia, or the associated bacterial endotoxins, subsequent to endodontic treatment, that may cause potential systemic complications and concluded that further research is required using current sampling and laboratory methods from scientifically controlled population groups to determine if a significant relationship between general health and periradicular infection exists.

Serious consideration of antibiotic prophylaxis for all bacteremia-producing procedures, and prompt diagnosis and early treatment of all bacterial infections is essential. Surgical procedures should be covered by antibiotic prophylaxis (summarized by Carmona et al. (15)).

Localized bone infections

Localized bone infection may follow endodontic procedures, although the entire purpose is to prevent bone infection (27). Inoculation of bacteria by instruments into a previously uninfected site, followed by an acute exacerbation may result in localized bone infection. Proliferative periostitis of Garre, a productive and proliferative inflammatory response of periosteum to infection or other irritation may result from periapical inflammation of endodontic origin (28). Elimination of pulpal/periapical infection through root canal treatment was shown to be sufficient management in such a case (29). In contrast to these responses, it is also possible for extra-radicular establishment of bacteria in the periapical tissues (30). The chief culprits implicated include *Actinomyces* and *Propionibacterium* species that form matted colonies and prevent access of host defences to the deeper lying cells. These are reputedly one of the causes of root canal treatment failure and need to be managed surgically. In rare instances, spread of infection of endodontic origin may cause inflammation of bone, i.e. osteomyelitis (31).

Antral infections

Asymptomatic maxillary sinus aspergillosis may develop around a foreign body such as gutta-percha (32) or zinc oxide-based root canal cements (33–38) used for root canal filling. In particular, *Aspergillus fumigatus* has been found to be associated with the maxillary sinus infection. Radiographically, the unique appearance of a dense opaque foreign body reaction in the maxillary sinus is considered a characteristic finding in maxillary sinus aspergillosis. Chronic sinusitis caused by silver

cone overfilling in a maxillary first molar has also been reported (39). Overextension into the maxillary sinus with root canal cements should be avoided and any material removed from the sinus because otherwise an aspergillus infection may ensue.

Infections of prostheses and implants

Occasional reports suggest that the infection of various prostheses by microorganisms that may gain entry from the root canal is possible (Table 2).

The area of prophylaxis for patients who have had knee prostheses is controversial with contradictory advice from different quarters. There are case reports of the infection of arthroplasties following endodontic manipulation. For example, a 78-year-old woman with a cemented total knee replacement developed a *Haemophilus parainfluenzae* infection following routine endodontics (40). Another 44-year-old male with total knee replacement for hemophilic arthropathy developed knee symptoms following routine root canal treatment. However, the patient was a severe hemophilic, known to be HIV-positive and also suffering from hepatitis C and non-insulin-dependent diabetes (41). A retrospective review (42) of 3490 records of patients treated with total knee arthroplasty between 1982 and 1993 showed 62 total knee arthroplasties with late infections (greater than 6 months after their procedure), of which seven were associated strongly with a dental procedure temporally and bacteriologically. These seven cases represented 11% of the identified infections or 0.2% of the total knee arthroplasty procedures performed during this period; however, only one case was associated with root canal treatment. In addition, among 12 patients referred for infected total knee arthroplasties from outside institutions, two infections were associated with a dental procedure. Five of the nine (56%) patients had systemic risk factors that predisposed them to infection, including diabetes and rheumatoid arthritis. All dental procedures were extensive in nature (average, 115 min; range, 75–205 min). Eight of the patients received no antibiotic prophylaxis: one patient had only one preoperative dose. Infections associated with dental procedures may be more common than previously suspected. Eight of these patients had no prophylactic antibiotics, and one had inadequate coverage. Breast implants have also been infected (43).

Table 2. Microorganisms associated with infection of knee prostheses or breast implants.

Prosthesis	Microorganisms implicated	References
Total knee arthroplasty	<i>Haemophilus parainfluenzae</i>	Pravda & Habermann (40)
Total knee arthroplasty	<i>Staphylococcus aureus</i>	Waldman et al. (42)
	<i>Streptococcus aureus</i>	
	<i>Streptococcus viridans</i>	
	<i>Serratia marcescens</i>	
	<i>Peptostreptococcus</i>	
Breast implant	<i>Clostridium perfringens</i>	Hunter et al. (43)

To define the risk of infection of total knee arthroplasties associated with dental surgery, Curry et al. (44) reviewed the relevant literature and concluded that less than 0.01% of knee arthroplasties infected were strongly associated with a dental procedure. They recommended that according to current evidence, routine antibiotic prophylaxis should not be offered to all patients with artificial joints undergoing dental treatment. It is advised only in patients who have a systemic immunosuppressive illness, in those who require prolonged endodontic treatment (>45 min), or in those who have obvious oral sepsis. A first-generation cephalosporin, given 1 h pre-operatively and 8 h post-operatively, would provide the best prophylaxis against the organisms identified (41).

Systemic infections

Systemic infections following endodontics are rare, but even tetanus has been recorded (45).

Neurological

Surgical damage to the peripheral nerves is a rare complication. There may be some pain and swelling and, with lower premolar and molar teeth, there may be altered sensation in the lower lip. However, cases of nerve damage from root canal therapy are remarkably rarely reported.

Lower lip numbness often is a sinister symptom caused by pathological lesions, metastatic tumors in the mandible, or certain systemic disorders. Occasional cases of lower lip numbness resulting from the

compression of the mental nerve by a periradicular abscess have been recorded (46, 47).

Inadvertent extrusion of endodontic instruments or root canal filling materials such as thermoplasticized gutta-percha (48), epoxy resin-based sealer (49), paraformaldehyde (50), and N2 (51) have been reported as causes of nerve injury. If the extruded material is non-neurotoxic, the chances of spontaneous recovery are high and a wait-and-see approach is indicated. If neurotoxic filling material has been introduced into the direct vicinity of the nerves, prompt surgical intervention is required to prevent irreversible nerve damage.

Even where there has been no instrument or material extrusion, patients may sometimes complain of chronic residual pain following pulpectomy and root canal treatment. This may be explained by local retrograde neural changes (52) or deafferentation (53) due to pulpectomy: perhaps these account for a proportion (2.5–3%) of the patients who report persistent chronic pain in the absence of periapical disease or damage (54, 55).

Accidents

Even in the best hands, accidents may occur.

Foreign body aspiration or swallowing

Swallowing or aspiration of a foreign body is a complication that may arise from any procedure in the oral cavity performed without the use of a rubber dam (56). Endodontic instruments may be swallowed or more seriously, inhaled (57).

Foreign body reactions

Nair et al. (30) suggested that some brands of marketed gutta-percha may contain elements (magnesium, silicon) that evoke foreign body reaction and compromise root canal treatment outcome. A follow-up animal study showed the response to be related to the gutta-percha particle size: small sizes eliciting a more severe reaction (58).

Surgical emphysema

Surgical emphysema may follow the use of compressed air from the air-rotor or syringe (59–62). Significant air pressures can be generated beyond the apex, especially with root apical diameters in excess of file sizes 20 (63). Tissue-space emphysema, tissue necrosis, and infection followed the use of compressed air during pulp therapy, complicated by tissue destruction due to the movement of canal irrigants/medicaments into the periapical tissues and by secondary infection (64). Treatment recommendations vary from symptomatic care with follow-up in cases of facial emphysema to immediate medical attention in cases of pharyngeal or mediastinal emphysema. The use of air-turbine handpieces that exhaust the driving air backwards and away from the surgical site may help prevent surgical emphysema (65).

Tissue damage

Endodontic rotary instruments (66) or medicaments (67) used in endodontic treatment may cause tissue damage. Serious complications may follow inadvertent extrusion of sodium hypochlorite through apical foramina or root perforations. Patients may report sudden sharp, excruciating pain, even under local anesthesia accompanied by immediate tissue swelling. Management requires reassurance, relief of pain with local anesthetic, and prescription of oral analgesics. Initial swelling should be treated with cold compression and followed by warm compression and mouth rinse to stimulate local circulation. Antibiotics should be considered in serious cases if there is a risk of infection (68). Necrosis of the gingivae caused by calcium hydroxide (69) and localized alveolar bone necrosis following the use of arsenical pastes as pulp-devitalizing agents (70) have also been reported.

Temporomandibular joint dislocation

Non-surgical root canal treatment often requires relatively long appointments and, in some patients, may lead to dislocation of the temporomandibular joint (TMJ) or may even trigger TMJ disorders (71).

Immunological

Materials used during endodontic therapy may cause allergic responses in the patient or health-care staff handling the materials (Table 3) and in extreme and rare instances, anaphylaxis has even occurred after endodontic treatment (72, 73). However, by far the most significant problem is of latex allergy.

Latex allergy

While many people come in contact with latex-containing products every day with absolutely no problems, some susceptible individuals have developed hypersensitivity to proteins derived from natural rubber latex, which can cause allergic reactions. Individuals with an increased risk are those who are prone to allergies, those who have undergone numerous surgeries (such as those who have spina bifida), health-care workers, rubber industry workers, and others who have regular, continuous contact with latex ((76); <http://latexallergylinks.tripod.com/dental.html>).

Natural rubber latex is a common ingredient in many consumer products, such as appliance cords, balloons, balls, condoms, hoses, hot water bottles, rubber bands, shoes, swimwear, toys, and tyres. Latex also can be found in many medical supplies and devices, such as masks, gloves, syringes, catheters, dressings, tape, and bandages. Latex can be encountered in several materials used in endodontics (Table 4).

Irritant contact dermatitis is not uncommon in health-care workers and may be associated with frequent hand-washing and inefficient drying of the skin. This may increase the passage of latex allergens across the compromised skin barrier.

Type I immediate hypersensitivity reactions are immediate in their onset and can take the form of itching, a generalized rash, rhinitis, conjunctivitis, wheezing, palpitations, dizziness, laryngeal edema, and anaphylactic shock leading to death if not treated urgently.

Table 3. Allergic reactions to materials used in endodontic therapy.

	Responsible agent	References
Local anaesthesia	Lidocaine	Ravindranathan (74) Ball (75)
Gloves	Latex	Knowles et al. (76)
Rubber dam	Latex	Blinkhorn & Leggate (77)
Root canal cleansers	Enzymes	Sfondrini & Ossido (78)
	Eugenol	Grade & Martens (79)
	Hypochlorite	Kaufman & Keila (80) Dandakis et al. (81)
	Chlorhexidine	Yusof & Khoo (82)
Root canal fixative	Povidone-iodine	Ijima & Kuramochi (83)
	Formalin	Bielawska & Kowal (84) Candura (73) Fehr et al. (85) El Sayed et al. (86)
	Unknown composition	Bava & Brunamonti (87)
Root canal devitalising paste	Lead/paraformaldehyde	Block et al. (88) Sporcic & Paranos (89)
	Caustiner-fragipide containing (Phenol, menthol, ephedrine, lidocain)	Tabacov & Popova (90)
Root canal filling material	Gutta-percha	Gazelius et al. (91, 92) Boxer et al. (93, 94)
	Silver	Nawachinda (95)
Root canal sealer	Epoxy resin	Torabinejad et al. (96)
Corticosteroid	Endomethasone	Forman & Ord (97)
Antimicrobial	Penicillin	Rumberger (98)

Type IV delayed-type hypersensitivity reactions tend to appear 2–4 days after exposure to rubber products, producing erythema of tissues having been in direct contact with the material.

Dental treatment of patients with proven or possible latex allergy

All patients claiming to be sensitized to latex should have their claims treated seriously. Non-latex (vinyl, neoprene, neolon, nitrile-based, or polymer) gloves should be used and an alternative dam can be fashioned

from vinyl sheet or a vinyl glove (99). It is, however, worth keeping in mind that vinyl rubber dam is dissolved rapidly by chloroform if this material is used to remove gutta-percha during retreatment: great care should be taken to avoid chloroform overflow from the access cavity. There is only a single report of a supposed allergic reaction to gutta-percha, but no definitive proof that the patient had a true allergic reaction to it (91). Gutta-percha does not cross-react with latex, but some gutta-percha products including gutta-balata *can* cross-react. Occasionally, health-care workers have reacted to gutta-percha (92). In patients with a true

Table 4. Materials containing natural rubber latex.

Rubber gloves
Rubber dam
Rubber polishing points
Rubber prophylaxis cups
Gutta-percha and gutta-balata
Local anesthetic cartridges and disposable syringes
Rubber mouth props
Some items of protective eyewear
Some surgical face masks and other protective items of clothing e.g. gowns, overshoes

immediate hypersensitivity to natural rubber latex, the patient's physician should be consulted prior to initiating the obturation phase of treatment.

It has been suggested that patients with a history of allergies are more prone to acute flare-up reactions during root canal treatment (98, 99). Such reactions are said to have an allergic element and so do not respond well to antibiotics, but better to prophylactic antihistamines (100).

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