Reconstruction of the severely atrophic mandible with iliac crest grafts and endosteal implants: a report of two cases

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Introduction

Edentulism in the mandible can often be a functionally and aesthetically debilitating condition.[1,2] Atrophy or resorption of the alveolus is a continuous process that occurs once the teeth are lost. This process is accelerated by tissue-borne complete dentures, and in particular those that are poorly adapted to the soft tissues and those with an improper occlusal scheme.[3] The sequelae of mandibular atrophy include suboptimal denture retention, impaired mastication and unbalanced diet, loss of vertical dimension, speech difficulties, and facial soft tissue changes. An atrophic mandible is also more vulnerable to fracture because of the decreased bone volume.[4] Reconstruction of the atrophic mandible presents a difficult surgical and prosthetic challenge. Various techniques, involving differing surgical procedures, graft materials, endosseous implant systems, and time periods between augmentation and implant placement have been advocated for reconstruction of the severely atrophic mandible.

Original treatments concentrated on the replacement of resorbed bone and involved autogenous iliac crest or rib onlay grafting to the inferior or superior borders of the mandible.[5,6,7] Reconstruction with iliac crest grafting was first reported in Europe by Clementschitsch[8] and in the USA by Thoma and Holland.[9] Macintosh and Obwegeser,[10] in 1976, reported good initial results following the use of rib grafts. However, long-term follow-up studies of onlay techniques revealed significant graft resorption.[11,12,13] A number of other techniques were developed in an attempt to reduce postoperative resorption. Interpositional (sandwich) grafts were initially described by Schettler[14] and modified by Stoelinga,[15,16] but concerns about sensory nerve deficits secondary to the procedure and continued resorption of the graft meant that this technique is now utilised infrequently.[17,18]

The transmandibular implant (TMI),[19,20] developed by Bosker in the 1970s, was designed to restore the atrophic mandible without placement of a bone graft and consisted of a lower border baseplate secured to the mandible by five cortical screws, with transosteal struts passing through the mandible and into the mouth. Overall success rates of between 56% and 97.8% have been reported.[21,22,23] However, the incidence of "reversible complications" (postoperative infection, post fracture, loss of osseointegration, formation of hyperplastic tissue around the transosseous posts, mandibular fracture) is significant, with rates of between 7.8% and 22.2% reported.[22,24,25]

Following the introduction of endosteal implants, various innovative techniques for the restoration of severely atrophic mandibles became available to clinicians, including the placement of short implants,[26] vertical distraction osteogenesis followed by placement of implants,[27] and autogenous onlay bone grafting prior to implant placement.[28,2,29,30]

The use of endosteal implants in severely atrophic mandibles, without bone grafting, is possible. However, in some patients, the mandibular basal bone can only accommodate short implants. While successful oral rehabilitation can be achieved with short implants,[31,32] the large interarch distance seen in severe atrophy can compromise denture stability and cause unfavourable leverage effects on implants during function.

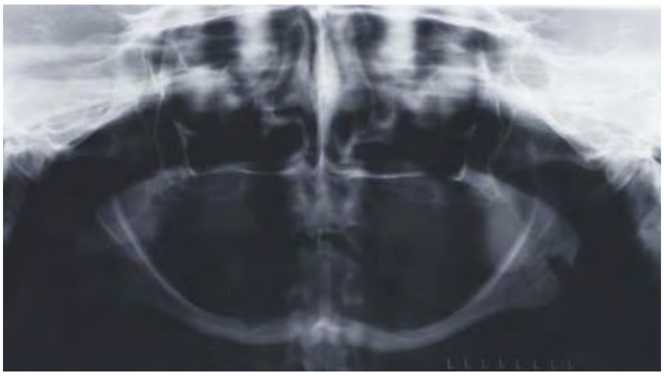

Figure 1: Preoperative panoramic radiograph.

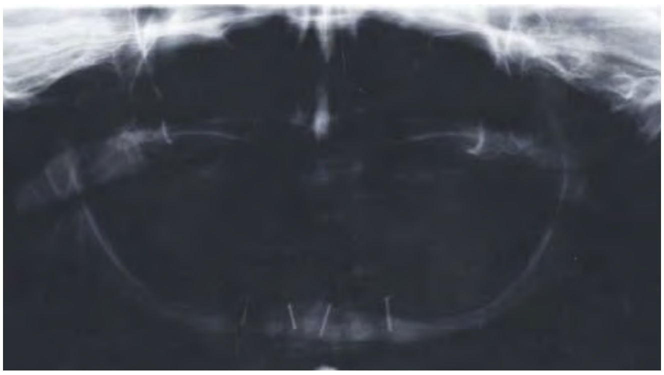

Figure 2: Postoperative panoramic radiograph showing bone graft retained by titanium screws in anterior mandible.

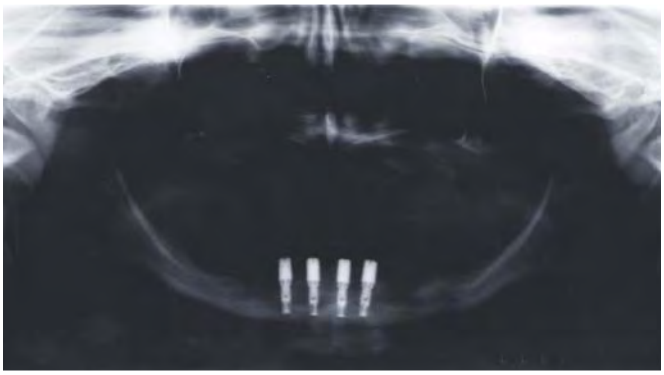

Figure 3: Panoramic radiograph showing four endosteal implants with healing abutments in situ*.*

Figure 4: Panoramic radiograph with prosthetic superstructure in situ.

Keller[32] states that absolute indications for the combined use of implants and bone grafts are a mandibular height of less than 4 or 5mm and a width of less than 6mm. However, others[33] suggest that the minimum height should be 7mm. Implants are placed, via a transoral or transcutaneous incision, simultaneously during the grafting procedure or during a second procedure. Long-term implant survival rates (in combination with autogenous bone grafting) of between 25% and 100% have been reported.[2,29,31,34,35]

This article describes the treatment of two patients suffering from severe mandibular atrophy, with autogenous bone grafting via a transcutaneous submental approach, the subsequent placement of endosseous implants transorally, and prosthetic rehabilitation with implant supported prostheses.

Surgical protocol

Under general anaesthesia, a corticocancellous bone graft is harvested from the medial wall of the anterior iliac crest, and additional cancellous bone is taken in a standard fashion.[36] The mandible is approached via a submental incision. The superior, inferior, anterior and lateral borders are exposed subperiosteally via dissection through skin, subcutaneous tissue, and platysma. The mental nerve is identified and protected bilaterally. Two corticocancellous block grafts are placed in the anterior mandible and rigidly secured with multiple titanium bone screws. Cancellous bone mixed in a 50:50 ratio with hydroxyapatite (HA) is placed along the superior and lateral borders of the mandibular body. The incision is then closed in layers, and the graft is allowed to consolidate for four months. Four months later, endosseous implants are placed in the anterior mandible via a transoral approach under local anaesthesia and conscious sedation. Six months later, after successful osseointergration, the implants are exposed under local anaesthesia via a crestal incision. Prosthetic rehabilitation is completed using an implant-supported prosthesis, which achieves direct internal functional bone loading.

In addition to addressing the lack of denture stability associated with severe mandibular atrophy, concerns about lower facial appearance (sagging/double chin and chin ptosis) are also addressed during the surgery. The extra-oral approach allows a functional and aesthetic reconstruction of the origins of the muscles of the lower third of the face. An elliptical incision of excessive skin and removal of subcutaneous fat is used to correct a sagging chin. When closing the submandibular incision, a muscular sling is formed by connecting the mentalis, depressor labii oris, and depressor anguli oris with the geniohyoid, digastric, and platysma muscles, as described by Bosker.[37]

The submental approach, combined with staged bone grafting and implant placement, addresses a number of important functional and aesthetic issues in this group of patients. The incision and dissection permits access to the mental nerves from an inferior aspect, thus reducing the risk of iatrogenic nerve injury. Identification and protection of the mental nerves in the atrophic mandible can be difficult when approached from an intra-oral route. The incision also provides excellent mandibular exposure and access for excision of excessive submental skin and

Figure 5: Postoperative photograph showing submental incision.

Figure 6: Photograph with prosthetic superstructure in situ.

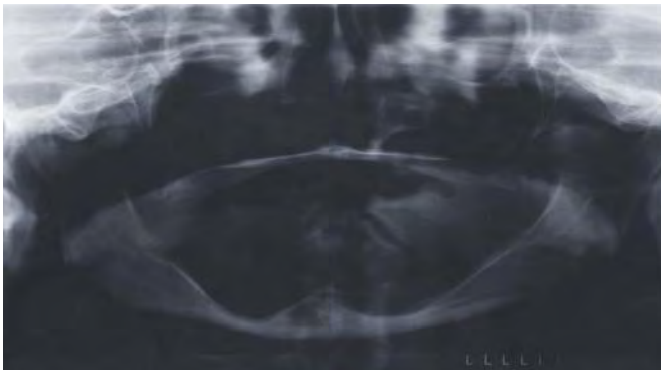

Figure 7: Preoperative panoramic radiograph.

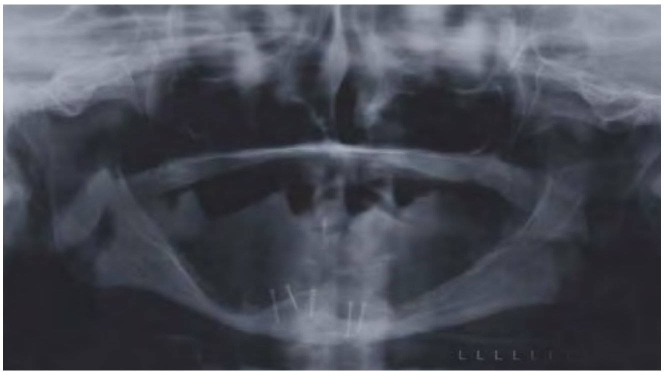

Figure 8: Postoperative radiograph with graft in situ *in anterior mandible.*

subcutaneous fat, as described earlier. The staged approach to bone graft reconstruction and implant placement allows more precise implant placement, with the use of a surgical stent if necessary. However, simultaneous grafting and implant placement in the anterior mandible has the advantage of being a single surgical procedure, but may compromise the accuracy of implant location.

Case reports

Case 1

A 53-year-old woman was referred by her general dental surgeon. She had been edentulous since her late teens. Her primary complaint was an inability to tolerate a mandibular denture. Clinical examination revealed a knife edge mandibular alveolar ridge. A panoramic radiograph showed a mandibular height of approximately 6mm anteriorly and 4mm in the body. The inferior alveolar nerve was lying on the crest of the ridge bilaterally (**Figure 1**). A dual-energy x-ray absorptiometry (DEXA) scan revealed that the patient had early osteoporotic changes. The patient underwent transcutaneous placement of a corticocancellous iliac crest block graft anteriorly and cancellous bone mixed with HA posteriorly (**Figure 2**). Excessive subcutaneous fat and submental skin was excised to improve lower facial aesthetics, as described above. There was no sensory or motor nerve deficit following the surgery. The graft was permitted to consolidate for four months and then four endosseous implants were placed, transorally, in the anterior mandible (**Figure 3**). The patient underwent exposure of these implants six months later, under local anaesthetic and intravenous sedation. The patient's dentition was restored with a fixed implant-supported prosthesis (**Figure 4 and 6**). The patient has been reviewed at six-monthly intervals (**Figure 5**).

Case 2

A 65-year-old woman presented following referral by her general dental surgeon. Her primary complaint was a lack of retention and discomfort associated with a mandibular complete denture. She had been edentulous for more than 15 years. The patient was also concerned about the increased risk of fracture associated with an atrophic mandible.

A DEXA scan showed underlying osteoporosis. Clinical examination revealed a severely resorbed mandibular ridge. A panoramic radiograph demonstrated a mandibular height of 6mm anteriorly and 4mm in the body bilaterally (**Figure 7**). This patient also underwent transcutaneous placement of corticocancellous block grafts harvested from the iliac crest anteriorly, and cancellous bone mixed with HA in the body bilaterally (**Figure 8**). Excessive subcutaneous fat and submental skin was also excised to reduce a sagging chin. The patient suffered no sensory or motor nerve deficit as a result of the surgery. Following graft consolidation for four months, four endosteal implants were placed, transorally, in the anterior mandible (**Figure 9**). Healing abutments were placed six months later. The mandibular dentition was restored with a removable overdenture. The patient has been reviewed at six-monthly intervals (**Figure 10**).

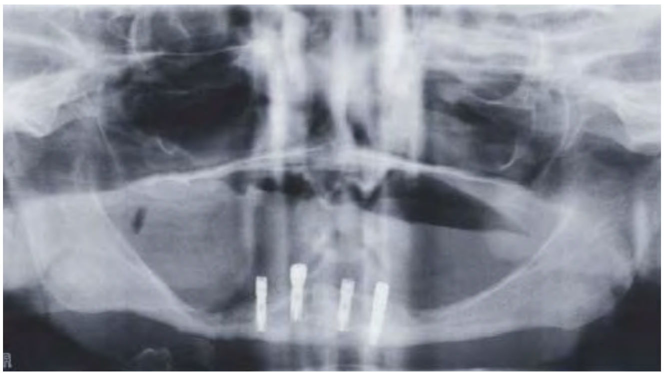

Figure 9: Radiograph with endosteal implants in situ.

Figure 10: Postoperative photograph showing submental incision.

Discussion

Various techniques have been described for oral rehabilitation of patients with severely atrophic mandibles. Keller[32] stated that bone grafting prior to endosteal implant placement is required in mandibles less than 4-5mm in height and 6mm in width. The use of short implants in atrophic mandibles, without bone augmentation, can lead to fracture of the mandible,[38] while peri-implantitis may increase this risk.[39] This article describes the treatment of two patients who underwent reconstruction with autogenous iliac crest bone grafts and subsequent placement of endosteal implants and implant-supported prostheses.

All implants were placed, transorally, four months after grafting. Bell *et al*[2] highlighted the advantages of delaying implant placement, including more precise positioning of the implants compared to those placed via a submental approach immediately after grafting. Also, placement of the iliac crest graft via a transcutaneous, submental approach, avoids communication with the oral cavity, thereby reducing the risk of infection. A number of other studies[40,41,42] have reported improved results following a two-stage procedure. Misch and Dietsh[43] reported an implant survival rate of 90% with implants placed simultaneously with the graft compared with 99% with those placed during a second procedure. Lundgren *et al*[44] showed, in a histological analysis of bone-graft titanium interface, that integration of implants placed six months post grafting was superior to implants placed immediately after grafting.

Multiple titanium bone screws were used to ensure rigid fixation of the corticocancellous block grafts placed in the anterior mandible. Vascular ingrowth is critical for maintaining the grafted bone and movement between the graft and its recipient site prevents successful revascularisation.[45]

As described earlier, a mixture of autogenous bone and HA was placed along the superior and lateral borders of the mandibular body. HA is the major inorganic component of bone and has osteoconductive properties. Similar to bone, it has good compressive strength and research has shown that autogenous bone mixed with HA is more resistant to loading.[46,47] Atrophic mandibles are at an increased risk of fracture, and reconstruction posteriorly with cancellous bone will ultimately reduce this risk.

One of the complications associated with this type of surgery is neurosensory disturbance. Kent *et al*[46] reported a 13% incidence of sensory disturbance with onlay grafting, while Haers *et al*,[47] in an article on interpositional bone grafting, reported a sensory disturbance incidence of 23.4%. McGrath *et al*[29] reported an 11.1% incidence of long-term paraesthesia (involving the lip and chin) following mandibular onlay grafting. Van der Meij *et al*[28] reported a 14.7% incidence of persistent disturbance to the mental nerves when placing onlay grafts via a transoral approach. However, there were no episodes of sensory nerve disturbances in the cases highlighted in this report. While four implants, well positioned between the mental foramina, can adequately support a fixed prosthesis, a removable overdenture may often be a better option to provide lip support in situations of severe resorption. With a fixed prosthesis there is no support in the sulcus area, often creating a lower lip fold below the vermillion border. This may result in a suboptimal aesthetic outcome. The acrylic flange of an overdenture provides good tissue support and prevents this problem. Ongoing evaluation (oral hygiene, peri-implant tissues, radiograph appearance of implants and surrounding tissues, stability of prosthesis, occlusal status and function, and patient comfort) post prosthetic treatment is critical for the long-term success of the implants.

Conclusion

Patients suffering from significant mandibular bone resorption secondary to long-term loading by mucoperiosteally supported removable dentures may be safely and predictably restored to a satisfactory level of function and aesthetics using autogenous corticocancellous iliac crest bone grafting followed by placement of endosseous implants, which support fixed or removable prostheses.

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Antibiotics in odontogenic infection

Antibiotics work by exploiting differences between human and bacterial cells. They are grouped according to their targets of action: cell wall synthesis, protein synthesis, and nucleic acid replication. Generally they should be used as an adjunct to local measures that aim to remove the source of infection and drain pus, usually when infection has spread to adjacent tissue spaces. They should not be used prophylactically after surgical extractions unless significant pre-existing infection is diagnosed.

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Antibiotics in odontogenic infection

Antibiotic therapy works on the principle of selective toxicity, which is to say that antibiotic agents have the property that they can damage micro-organisms without injuring host cells. This is achieved by targeting sites that are present in the pathogen but absent in the host. The basis of this principle is that fundamentally all living cells can be classified as either prokaryotic or eukaryotic; bacteria fall into the first category and all other organisms, from yeast to plants and right up to mammals, fall into the second. Prokaryotic cells are small, simple and have no membrane bound organelles. Eukaryotic cells are larger, more complex, have an obvious membrane bound nucleus and have organelles such as Golgi aparatus and endoplasmic reticulum. Although some of the metabolic pathways, such as oxidative phosphorylation (the Krebs cycle) and macromolecule biosynthesis, are quite similar in both cell types, significant differences exist that can be exploited. One very significant difference between the two is the presence of the peptidoglycan cell wall normally present in prokaryotes but never present in eukaryotes (**Figure 1** and **Figure 2**).

The ideal systemic antibiotic would have the following properties:

1. Selective toxicity against bacterial target.
2. No toxicity to the host.

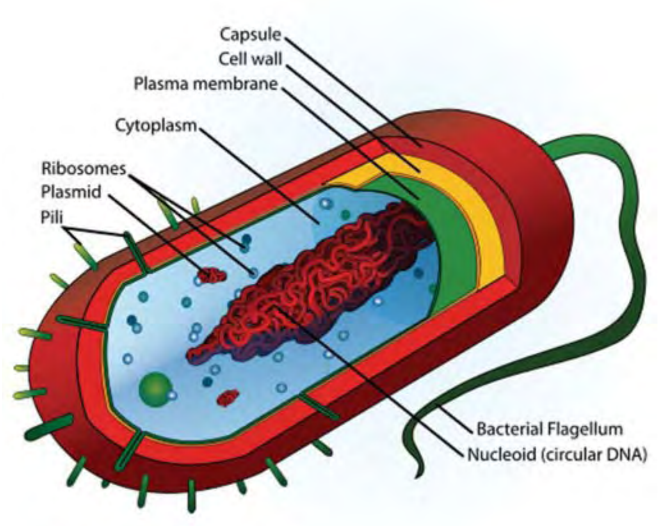

FIGURE 1: Prokaryotic cell.[1]

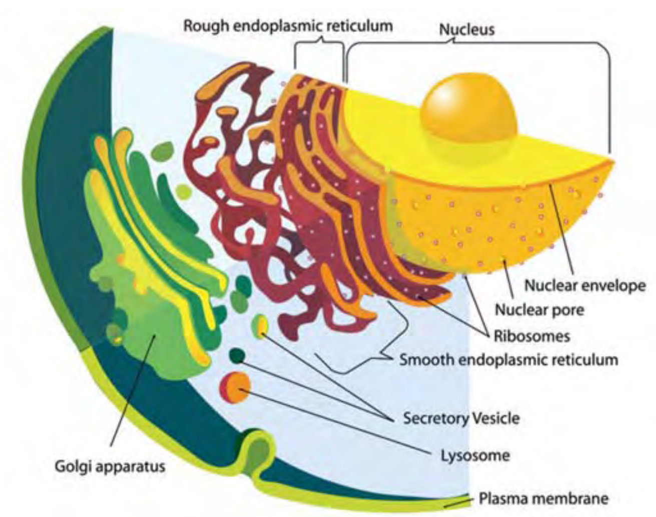

FIGURE 2: Eukaryotic cell.[2]

3. Cidal activity against bacteria.
4. Long plasma half-life.
5. Good tissue distribution.
6. Low binding to plasma proteins, i.e., increased bio-availability with decreased dose.
7. Oral and parenteral preparations.
8. No adverse interactions with other drugs.

Anti-bacterial antimicrobials have three main targets of action: cell wall synthesis; protein synthesis; and, nucleic acid synthesis. Below are some examples of these relevant to the treatment of common infections in dentistry.

Inhibitors of cell wall synthesis

These are the beta-lactams and include the penicillins and cephalosporins. They prevent cell wall synthesis by binding to enzymes known as penicillin-binding proteins. These enzymes are involved in the final stages of the cross linking of the peptidoglycan bacterial cell wall, and their inhibition causes the precursor cell wall units to accumulate within the cell, leading to autolysis. The most important antibiotic in this group for the treatment of odontogenic infections is Phenoxymethylpenicillin (penicillin V), which is effective against oral anaerobes, including streptococci. Approximately 3% of the population is allergic. Extended spectrum beta-lactams such as ampicillin and amoxycillin have limited additional activity against streptococci and other oral anaerobes relative to penicillin V. Their extended spectrum is in the area of aerobic gram-negative rods such as *Haemophilus influenzae, Escherichia coli, Salmonella, Shigella* and *Proteus* organisms; hence, they are not indicated as the antibiotic of choice for odontogenic infections as drug resistance may be promoted.

The addition of clavulanic acid to amoxycillin (co-amoxiclav) inhibits the activity of penicillinase, an enzyme secreted by penicillin-resistant bacteria, which enhances the activity of amoxycillin in the presence of these organisms. Although it is undoubtedly effective, its use is not encouraged in the treatment of most odontogenic infections. It should also be noted that co-amoxyclav was the subject of an Irish Medicines Board bulletin in 2006 in relation to hepatobiliary reactions, ranging from hepatitis and cholestatic jaundice reported rarely to moderately, and asymptomatic increases in liver enzymes occurring occasionally.[3] Its use is contraindicated in patients who have suffered previous co-amoxiclav associated jaundice/hepatic dysfunction, and it must be used with caution in patients with known hepatic impairment.

Cephalosporins are an antibiotic family with a molecular structure similar to penicillin, are bacteriocidal and have a broader spectrum of activity. The two most commonly used in dentistry, cephalexin and cefadroxil, are effective against streptococci and staphylococci, oral anaerobes and aerobic gram-negative rods. 5-15% of patients who are allergic to penicillin are allergic to cephalosporins. In a hospital setting, cefuroxime is used in conjunction with metronidazole intravenously for odontogenic infections that have spread to involve regional tissue spaces. They are generally not considered to be first-line antibiotics.

Inhibitors of protein synthesis

Several groups of antibiotics that are commonly used in dentistry fall into this category. The macrolides work by blocking the first translocation step in protein synthesis, which prevents the release of transfer RNA after peptide bond formation. They are bacteriostatic in low concentrations and bactericidal in high concentrations. The most familiar is erythromycin, which is effective against *Streptococcus*, *Staphylococcus*, bacteroides, *Prevotella* and *Porphyromonas* species, as well as being active against β-lactamase producing bacteria. Its primary indication is for patients who are allergic to penicillin. Nausea, vomiting and epigastric pain are associated with its use, but newer versions such as azithromycin and clarithromycin, which have a similar spectrum, have fewer gastrointestinal side effects due to increased acid stability in the stomach. They also exhibit higher tissue concentrations and longer half-life, so are given once a day and twice a day, respectively, as compared to four times a day for erythromycin. Clarithromycin is a useful alternative to amoxycillin in patients who are allergic to penicillin.

The lincosamides' method of action is not fully understood, but ultimately they inhibit protein synthesis by blocking peptide bond formation. The important member of this group is clindamycin, which is effective against streptococci, staphylococci and essentially all anaerobic bacteria. It is bacteriostatic and has a relatively high toxicity. It is also expensive and not considered a first-line drug for odontogenic infections. It is useful in treating low grade infections that have been resistant to penicillin or erythromycin, but can disrupt the gut flora, allowing proliferation of *Clostridium difficile* leading to pseudomembranous colitis.

The tetracyclines, examples of which are oxytetracycline, doxycycline and minocycline, are bacteriostatic and all have the same mode of action. After active transport into the cell, they bind to 30S ribosomal sub-units, preventing aminoacyl-tRNA from entering the acceptor sites on the ribosome, thereby halting pepide chain elongation. Tetracyclines' original spectrum included streptococci, staphylococci, oral anaerobes and a variety of gram-negative aerobic rods; however, because they are bacteriostatic and have been widely prescribed, there is a high degree of bacterial resistance to them caused by a decrease in cell wall permeability. Their main indication for use in odontogenic infections is in patients with severe allergies to penicillin and cephalosporins who cannot tolerate erythromycin-like drugs. Their use can cause suppression of the gut flora leading to gastrointestinal upset and oral candidiasis. They are also deposited in developing bone and teeth, so should not be used in children, pregnant women or those of childbearing potential without advice.

Inhibitors of nucleic acid synthesis

Since any compound that binds to DNA would be toxic to both prokaryotic and eukaryotic cells, this mechanism would appear to be of no theraputic value. However, there are several compounds that interfere with enzymes that are associated with DNA synthesis, replication and supercoiling, exploiting the fact that bacterial enzymes are structurally different from their mammalian counterparts. The antimicrobials in this group are trimethoprin, the quinolones, rifamycins and 5-nitromidazoles. Of these, only the last group is of significance in odontogenic infections. The most important member of this group is metronidazole, which is very active in anaerobic conditions. It works by entering the bacterial cell where, because of the low reduction-oxidation potential that only exists in strict anaerobes, it is reduced and made active. The intermediate products react with the DNA strands causing breakages. The development of resistance is rare. Clinically, its use is associated with nausea, metallic taste and furred tongue. Flushing and hypotension can arise if the patient drinks alcohol in combination with metronidazole. This is the antabuse effect and patients must be warned.

Table 1: Localised infections and their treatment

Irreversible pulpitis	Endodontic procedure or extraction. Antibiotics not indicated.
Dental abscess	Incision and drainage, endodontic procedure or extraction.
Periodontal abscess	Incision and drainage, debridement of periodontal defect or extraction.
Acute necrotising gingivitis (non-odontogenic but included for completeness)	Gross scaling with copious flush, OHI. Metronidazole 200-400mg tds for four days.
Acute perio-endo lesion	Incision and drainage, debridement of periodontal defect and endodontic procedure or extraction of tooth.
Pericoronitis	Debridement and irrigation of pericoronal tissues, drainage of pus and elimination of occlusal trauma.

Use of antibiotics

The central principle of using antibiotics to treat odontogenic infections is that they are an adjunct rather than a first-line treatment. The inference of this statement is that antibiotics are both overprescribed and inappropriately prescribed in dentistry. This has led to an increased prevalence of bacterial resistance to commonly prescribed antibiotics, as well as exposing patients to the risks of side effects of these drugs with no benefit accruing. In particular, the age old and still prevalent practice of prescribing antibiotics to treat irreversible pulpitis should be condemned. In general, localised infections caused by pericoronitis, periapical abscess, lateral periodontal abscess, perio-endo type infections, or acute necrotising gingivitis (ANG) can be treated by various combinations of local debridement, irrigation, incision and drainage, initiation of endodontic therapy or extraction of the involved tooth, (**Table 1**).

If these measures address the cause of the infection and effect the release of pus, then an antibiotic is not required. If pus is not drained, or if infection has spread to regional tissue spaces (commonly the buccal space, canine fossa or submandibular space), or if the patient is exhibiting regional or systemic symptoms such as trismus or fever and malaise, then antibiotics are indicated as an adjunct to the above measures. These patients sometimes require referral to secondary care for incision and drainage and exploration of the tissue spaces under general anaesthesia.

Antibiotics are usually prescribed 'empirically' rather than 'rationally' in practice, which is to say that clinicians do not routinely perform microscopy, culture and sensitivity testing before deciding which antibiotic to use. Instead clinicians employ a 'best guess' as to the most probable pathogen or range of pathogens involved. Odontogenic infections tend to be anaerobic in character with typically ten or more pathogen types present.[4] These organisms are usually sensitive to penicillin, such as alpha-haemolytic streptococci, penicillinase-negative staphylococci, and gram-negative anaerobes such as *Bacteroides*, *Prevotella*, *Porphyromonas*, *Fusobacterium* and *Veillonella*. On this basis penicillin is the antibiotic of choice for most odontogenic infections. For patients who are allergic to penicillin, erythromycin is indicated. Metronidazole is effective in the treatment of pericoronitis and ANG. It can be used in combination with penicillin for severe infections. In a hospital setting, culture and sensitivity testing is routine. Prescribing is empirical at the outset as microbiology takes up to three days, and becomes rational once a causative organism has been isolated and its sensitivities established. It is important to realise that resolution of infection once the cause has been treated is effected by the body's immune system primarily, and that antibiotics merely tip the balance in the patient's favour. It is often the case that infections resolve before sensitivity is known, even though the results show that a non-optimal antibiotic was used.

The use of postoperative antibiotics prophylactically remains common practice, even though there is little if any scientific evidence to justify it. A study by Poeschl *et al* (2004) involving 288 patients who had 528 asymptomatic lower third molars extracted showed that there was no significant difference in levels of pain, trismus, infection and dry socket between three groups given a post-op five-day course of co-amoxiclav, five days of clindamycin or no antibiotic.[5] Other studies concur with this finding.[6,7,8,9,10,11] These results strongly suggest that the practice of routinely prescribing a course of antibiotics after a surgical extraction involving bone removal in the absence of pre-existing infection is unnecessary. Some experts feel that the concept of 'preventing' infection with antibiotics is flawed and a misuse of these important drugs. Antibiotics can be life saving so it is incumbent on us as healthcare professionals to use them properly, based on evidence with a patient-oriented approach.

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