A Patient’s Comprehensive Guide to

Endodontic Disease Prevention and Treatment

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Welcome

This booklet explains about endodontic disease, its cause, prevention and treatment. The most common form of endodontic disease is an infection of the inside of the tooth’s root and then of the surrounding jaw bone. Most dental disease is preventable with good diet control and mouth cleaning. So why then is dental disease, including endodontic disease so common? Well, prevention is often poorly implemented because patients may not understand exactly what to do, or may not be convinced it will work. This is unfortunate, because decades of scientific evidence show strongly that when implemented correctly, dental disease can be just about entirely prevented. It has to be accepted that a certain amount of detail must be understood for a person to grasp exactly how to prevent dental disease, and to be convinced it really will work. This booklet contains that detail in a frank format, and you are recommended to work hard to understand it because the improved quality of life with painless teeth and financial savings by avoiding dental treatment are enormous. You will need about two hours to read the booklet. Please read it all. Great effort has been made to ensure that the information given is established mainstream scientific opinion, so do believe it. If you already have endodontic disease, then how it progresses, how it can be treated and what choices you might have are given here. Technical terms are fully explained. However, it is only a summary, does not contain all facts, and is not intended to replace advice from your endodontist. He or she will be happy to answer further questions you might have.
What’s wrong with my tooth?

Here’s the basic information promised about how endodontic disease happens. This is called pathology, which is just ancient Greek for the study (“-ology”) of suffering (“pathos”), and is the key to understanding your diagnosis and why certain treatment may be needed. Know this lot and all the mystery disappears, and with it your anxiety. It will all become very matter of fact and obvious. So come on, let’s get stuck in to it.

The Basics

What Is Endodontics?

In Greek, *endo* means “inside” and *odont* means “tooth”, so *endodontics* is all about the space inside teeth, part of which is the **root canal**. This root canal is a tiny tube down the middle of each root of your tooth, so endodontic treatment is also called **root canal treatment**. The finished job is a **root canal filling**. All dentists are trained to do basic endodontics but some do several more years of university training to become specialist endodontists. They are referred cases from general dentists. Today, specialist endodontics is an exciting and rewarding field with many new advances not available a decade ago. We now have surgical microscopes (shown below) as good as any microvascular surgeon’s to see deep into the root canal. Diamond coated ultrasonic cleaning tools clear out obstructions in the root canal with relative ease. And special tiny torches make the whole tooth glow to display hidden root canals or cracks. Miniature electrically heated tools precisely mold filling materials into the canal. Such new devices have greatly improved the predictability of endodontic treatment, particularly when retreatting previous root fillings.
Will It Be Painful?
Your two biggest concerns are probably: will it be painful, and will it work? Despite the usual expectation, your endodontic treatment visits should be painless. Often the nerves inside the tooth are long dead so sometimes local anaesthetic may not even be required. If some living nerves are expected then local anaesthetics will be given, and these days they are very effective. Of course there will be a little pin prick, but this can be reduced with anaesthetic cream beforehand and good slow technique. Your endodontist will stop working if there is any discomfort at all, as and when you request or raise a hand. So you’re in control all the time. For most people their anxiety is more of a problem than actually feeling any pain. What might happen next, rather than what is happening now. The secret is to remove the anxiety. While this can be done with sedatives, it is far more powerful and long lasting to do it with education. Hence this booklet. Once you understand the problem and its solution then it ceases to be scary. Like knowing that thunder and lightning are just static electricity, and you should stay indoors. This booklet will also show you that the benefits usually outweigh the risks and frankly, you will see it would be foolish to refuse the good chance of the great benefit of keeping your tooth.

Will It Work?
And will it work? Most cases have an excellent prognosis with over 90% successful for many years. Other cases are more difficult and some cases have a hopeless prognosis. Your endodontist will assess the chance of success and advise you whether to proceed with endodontic treatment. This decision is all part of diagnosis and treatment planning.

But notice that we can only give you a success rate prediction not an individual promise. The reason is that even endodontists are only human and don’t exactly know the future of their own teeth, let alone yours. No one can know what definitely will happen to your individual tooth.
There’s too much natural variation. So don’t ask “Will it work?” because we don’t ever know for sure. However, from scientific studies and clinical experience one can say what will happen to a certain proportion of a large group. Then we can make a rational decision and overall be right most of the time. *Table 1* shows that endodontic treatment is generally successful. These studies and our experience guide us in assessing your tooth. For example, if a type of case has a 95% success rate, five people in every 100 will experience a failure. This could be you. But there will be 95 people who’s treatment goes well. This is much more likely to be you – 20 times more likely. So it would be foolish to decline treatment with these good odds. Realise though that you are not buying a favourable outcome. You’re buying a very good chance for a favourable outcome, and your endodontist will make sure that the odds are stacked very heavily in your favour.

*Table 1.* Some overall root filling success rates from scientific studies from 1956 to 2002

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>% Success</th>
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<tbody>
<tr>
<td>Strindberg</td>
<td>1956</td>
<td>87</td>
</tr>
<tr>
<td>Grahen &amp; Hansson</td>
<td>1961</td>
<td>81</td>
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<tr>
<td>Seltzer <em>et al.</em></td>
<td>1963</td>
<td>80</td>
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<td>Ingle</td>
<td>1965</td>
<td>92</td>
</tr>
<tr>
<td>Harty <em>et al.</em></td>
<td>1970</td>
<td>90</td>
</tr>
<tr>
<td>Adenubi &amp; Rule</td>
<td>1976</td>
<td>88</td>
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<tr>
<td>Morse <em>et al.</em></td>
<td>1983</td>
<td>95</td>
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<tr>
<td>Molven and Halse</td>
<td>1988</td>
<td>80</td>
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<tr>
<td>Sjogren <em>et al.</em></td>
<td>1990</td>
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<td>Cvek</td>
<td>1992</td>
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<td>Friedman <em>et al.</em></td>
<td>1995</td>
<td>78</td>
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<td>Caliskan &amp; Sen</td>
<td>1996</td>
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<td>Sjogren <em>et al.</em></td>
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<td>Sundqvist <em>et al.</em></td>
<td>1998</td>
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<td>Weiger R <em>et al.</em></td>
<td>2000</td>
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<td>Chugal <em>et al.</em></td>
<td>2001</td>
<td>78</td>
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<tr>
<td>Peters &amp; Wesselink</td>
<td>2002</td>
<td>76</td>
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</table>
So What’s Really Going on in my Tooth?

In short, the problem is that bacteria get into the root canal. These bugs often painfully kill off the original flesh inside the root canal and leak toxins out the end of your root. The surrounding bone then dissolves away leaving a hole in your jaw bone. More pain, swelling and a non-healing lump on your gum leaking pus are then likely. The principle of treatment is to remove or kill the bacteria in the root canal and then to permanently seal it off to prevent reinfection. Practically, the cleaning is done with fine metal instruments which look like needles. But they have rough cutting edges in a spiral down their length to scrape out the dead flesh and bacteria and to widen the root canals. Strong antiseptics are used to swill out and medicate the cleaned space until all the infection is gone. Then the root canal is filled up with compacted rubber and glue to try to deny bacteria a space to live. Despite the glue, the tube is still not well sealed and a good filling in the top of the tooth is essential to prevent re-entry of new bacteria from the mouth. The tooth also requires mechanical strengthening, usually with an artificial crown. This is like a metal thimble which holds the tooth together. It can be coated with porcelain on the outside to look exactly like a tooth.

The following sections are a more detailed look at the pathology of tooth decay, endodontic infections and treatment. You will need to
appreciate the structure of teeth (anatomy) and how bacteria (microbiology) can destroy (pathology) them. Importantly, this empowers you to prevent new tooth decay and therefore most endodontic problems. Then the principles and typical methods of treatment are explained so you know what to expect. Remember that understanding this detail is the key to allaying your fears and making sensible choices. Read on.

The Anatomy of Teeth

The part of the tooth seen in the mouth is called the crown. The rest is inside the gum and jaw bone and is called the root. This root anchors the crown in position. The crown is covered with an outer layer of hard wearing white enamel surrounding the yellowier dentine which makes up the bulk of the tooth. Unlike enamel, dentine is a living tissue with millions of microscopic tubes (dentine tubules) which run outward through dentine up to the enamel. Each tubule is about one thousandth of a millimetre across, about the size of a bacterium. Bit of a design fault, as you will see later.

Inside the dentine layer is the pulp (the ‘nerve’), a soft tissue with blood vessels, nerves. It is this pulp tissue which originally created the tooth. The space inside the tooth for the pulp is called the root canal in the root, and the pulp chamber in the crown. Nerve cells in the pulp can sense fluid movements in the dentine tubules which allow pain to be felt in the dentine. The pulp’s blood and nerve supply come into the root canal from the jaw bone through tiny holes.
at the end of each root. Apex (plural is apices). Each root end is pointy and so is called the apex. The tooth is held into the surrounding jaw bone by a thin layer of fibrous connective tissue. Despite being a thin sheet, this really is a ligament like found in a knee or ankle joint. In Greek, peri- means “near to” and odont means “tooth” and so this ligament near to the tooth is called the periodontal ligament. Similarly, the ligament and bone near to the root apex is called the periapical region. Unfortunately the medical sciences are full of Greek and Latin terms, but you can see that behind the foreign language there is nothing complicated. An ancient Greek or Roman would think these terms were very simplistic indeed requiring no great intelligence. Don’t be put off by a few strange terms. It’s just plain language, albeit from 2000 years ago.
It's an Infection! Bacteria and How to Stop Them

Everyone's mouth contains approximately 350 species of bacteria. Millions of these bacteria form colonies of sticky white stuff which can be seen with the naked eye. This is called plaque and your mouth is a perfect incubator for it: moist, 37ºC and with a regular food supply. The bacteria make acids and toxins from sweet tasting sugars in your diet. This is not just refined sugar, but anything with more than a few percent of any type of sugar in them, including many fresh fruits and their juices. Orange juice and soft drinks are particularly bad because they are also acid, giving the bacteria a head start. Your teeth are easily dissolved in these acids making cavities with tooth decay, or caries (means “rotten” in Latin).

Dental decay is disgusting. It is soft, brown and smelly, and it causes so much pain and suffering. Unless you're a dentist removing it every day close up, it's difficult to fully appreciate what bacteria and sweet foods can do to strong white teeth. Some photos are included here so that you know too. Also many patients don't really seem to appreciate that the hole in their tooth is irreversible, and that the new filling will probably not last their remaining lifetime. If only they truly knew the later problems and expense in store for them. Look at the photographs and X-ray pictures (radiographs) here of tooth decay, and re-evaluate whether
frequent sugar is really worth it. The only really effective solution is prevention.

Prevention of Dental Decay

So if prevention is better than cure, then what do you need to do to prevent tooth decay? Well, the method is surprisingly simple and has been so well established by many scientists and clinicians for decades. So why then do most people still have dental decay? The problem is that the general message to eat less sugar isn’t detailed enough and so doesn’t always work. You need to understand a little more complexity to get a result. Hence the greater detail in this booklet. Considering the suffering dental decay causes and the cost of its repair, you should be very motivated to read on.
Here’s the critical technical background. Thinking caps on. Read it twice to really understand it. If you understand these six points then how to prevent tooth decay will become obvious.

1. Teeth are made mostly of mineral, calcium phosphate to be specific. Calcium phosphate is soluble in acids. Just like us, oral bacteria use sugars to make energy, but they turn them into acids as a waste product. Research has shown that even a 5% sugar solution is strong enough to cause plaque acid (Gao et al. J Dental Research 2001;80:1834-1839). Look on the packaging of foods for the percentage sugars content to see if it could cause decay.

2. Research in 1940 by a guy called Dr Stephan (J American Dental Assoc 1940; 27: 718) has shown that bacteria in plaque can make significant acid (low pH) for only about 20 minutes after being fed some sugary food or drink. Also they can only metabolise a small quantity compared with what we would normally eat; any more sugar is in excess and doesn’t increase acid output.

3. The acids diffuse out of the bacteria and dissolve any nearby tooth surface. The mineral is packed into crystals like bricks in a wall. But the plaque acid doesn’t dissolve the surface of the tooth and then work on the next layer in. It attacks weak spots making the tooth material porous. It’s almost like taking some microscopic bricks out of the wall. A cavity is formed only when enough bricks (crystals) are missing and the whole structure then collapses.

4. Saliva is important too. Saliva is supersaturated with mineral. Amazingly, this means that when there is no acid about, mineral can
come out of your saliva and into the damaged tooth. Mineral crystals can be put back in place if the tooth structure hasn’t yet collapsed. (This ability of saliva to mineralise should be no surprise to you. How do you think dental calculus [tartar] forms? – it’s mineralized bacterial plaque).

5. You can see there is a competition between plaque acids removing mineral, and saliva replacing mineral into the tiny spaces. Which one wins depends on the time proportion with demineralisation by acids or remineralisation by saliva without acids. This depends on the number of sugar attacks per day. Remineralisation is slower than demineralization, so be warned that you will get tooth decay if you have sugar attacks every 30 minutes over half of each 24 hour day.

6. So the all important question is – How many sugar attacks can I have without causing tooth decay? The general answer is that if you have more than about four acid attacks per day including your three meals, then you are at risk of getting dental decay (World Health Organization, Feb 2002 Annex 6). Another study (Duggal et al. J Dental Research 2001; 80: 1721 - 1724) showed demineralization with two or more sugar attacks per day if no fluoride was present. Six sugar attacks could be tolerated when a fluoride was around. So you can see that the range is perhaps two to six sugar attacks, with four being typical. Certainly if you have just one sugar attack per day including your three meals, then it is unlikely that you will ever get any new tooth
decay, and we advise this goal. Check out your own diet – honestly and accurately. Many people are horrified to find that they already have 10 to 20 sugar attacks per day, so there’s no surprise why their dentists are so busy. That’s commonly the case. Don’t forget that brushing and flossing well helps too.

**Conclusion:** have one or less sugar attack per day and you are unlikely to get tooth decay. The amount of sugar you eat at that one time is probably not that important. So gorge yourself if you want. Enjoy it when you have it. You don’t have to give up sugar – just change how often you eat it. Brush and floss afterwards but this is not as effective as having no sugar attack in the first place. Basically, all dental decay is preventable, despite what you might think.

**Some Common Myths Exploded**

letics can metabolize anything that chemically is a simple sugar. Anyway most ‘refined’ sugar comes from sugar cane, which _is_ a natural sugar. Sugar in, say, a ripe mango is as bad as sugar in a chocolate bar or can of soft drink. It counts as one sugar attack.

I thought it was only white sugar itself that was a problem. Not so – all sorts of food contain hidden dissolved sugar. Manufacturers use many different names to disguise it but all the following are sugars: sucrose, maltose, lactose, galactose, fructose, dextrose. You can see that if the name ends in “–ose” then it’s probably a type of sugar. Look on the packaging under the carbohydrate heading to see how much sugar is present. If it’s greater than 10% watch out. Even 5% could be a problem. Fruit often contains enough sugar to rot your teeth, so eat it at mealtimes to minimize your sugar attacks.

Reducing sugar in my tea or coffee to half is better for my teeth. Not so! There is probably little difference in decay because even half a teaspoon is enough for maximum bacterial acid production. Any more sugar is in excess of what the bacteria can turn into acid. Instead, halve your sugar attacks not the amount of sugar. Try every other cup without sugar. Or just go cold turkey and get off the sugar all together in one go. It takes about three weeks to get used to it, and you’ll be glad you did.
Eating sweet foods doesn't hurt my teeth so long as I brush afterwards. Not entirely true. You can not brush out the tiny gaps and crevices which are most likely to decay. So while brushing and flossing might reduce the duration of the sugar attack, and the fluoride in the toothpaste will reduce the amount of tooth dissolved, it is no way near as good as not having the sugar attack at all. Reducing the frequency of sugar attacks is far more effective than good cleaning. But cleaning, especially flossing does help to some extent and is to be encouraged.

I've got weak teeth from my parents. Genetics probably has little influence on tooth decay. Rather it is far more likely to be an environmental thing. Your parents taught you their diet as a child and you probably continued on a similar diet as an adult. Nurture not nature. Even were your family’s teeth more acid soluble, good diet control and cleaning are the dominant factors and you can still avoid decay.

My teeth were fine until I had children. Again probably no direct cause. Bleeding gums can be a problem in pregnancy but this has nothing to do with tooth decay. Probably, because babies and young children feed frequently, then mothers tend also to feed frequently too. You now know that this frequent feeding is hazardous to our teeth, causing more sugar / acid attacks. Try not to nibble throughout the day. Three square meals per day, and all that.

Some people use artificial sweeteners such as aspartame, although often as a weight loss measure rather than for dental reasons. These substitutes do not decay teeth significantly so should be encouraged as an alternative to sugar. But in a sense it might be better to get off the frequent sugar taste anyway.

The main problem for someone trying to control their sugar attacks is the general acceptance of sugar in the Western community. For example, can you believe that one dental materials supplier in Melbourne actually sends out promotional...
chocolate bars with its dental materials to dental practices? That surely is proof that even the dental industry doesn't take decay prevention seriously. It is up to the dental profession to show leadership over this issue, and help the community avoid this preventable disease.

A final point to motivate you further to prevent decay. Add up all the money you have ever spent on dental work to repair tooth decay or its effects. You may be horrified. Then multiply it by the amount of inflation over all those years to put it into today's value. You'll be mortified. Tens of thousands of dollars over a lifetime at least in many cases, more in some cases. For no other reason than the financial one, avoiding tooth decay is a good idea. And if it's easily achieved, then why not? Remember, it has been shown many times over that dental decay is entirely preventable. We can never be without bacteria in our mouths but there is an effective way to prevent them from damaging our teeth and gums.
How Did Bacteria Get into my Tooth?

So we learned above that bacteria can get into a tooth by dissolving it with acids to make cavities. Once bacteria are into porous dentine, their toxins and then later the bacteria can get through the dentine tubules to damage the pulp. That bad design flaw.

Bacteria can also get into dentine through gaps around and under previous fillings. You may be surprised to be told that fillings, even new ones, usually don’t properly seal their cavities. But it’s true. There is nearly always a microscopic gap around even modern adhesive fillings. Only small white fillings bonded to thick enamel have been shown to reliably seal (Mertz-Fairhurst Amer. J. Dentistry 1992; 5: 5-10). All other filling types leak, particularly large white fillings in back teeth (DeMunck et al. J. Dental Res. 2003; 82: 136-140). So you can see that a filling is a poor replacement for the missing bit of tooth and this should strongly motivate you to avoid new decay.

The third way bacteria can get into your teeth is through cracks. Cracks can occur because the teeth suffer a blow against other teeth or an object. Typically accidents in contact sports or elsewhere are to blame and are difficult to avoid. However, wearing a professionally made mouthguard can reduce the damage done. Cracks can also occur from chewing forces. Sometimes the chewing forces are excessive because of abnormal tooth clenching or grinding habits, perhaps when you’re asleep. This is usually due to stress and is terribly destructive. A night guard (like a thin mouthguard) can be cheaply made by your general dentist to save you much suffering and expense.
But the majority of cracks occur in teeth with normal chewing forces and without accidental trauma. These teeth have been weakened by previous decay, and fillings often do not return the tooth to its original strength. So you see yet again that having fillings already puts you at higher risk of new decay or root filling problems. About two thirds of a dentists work is replacing old fillings. About one quarter of an endodontist’s work is dealing with cracked teeth. If you are not convinced already then seriously consider decreasing the number of times in the day you have sweet foods and drinks, and get flossing. Preventing dental disease is the only way to long term dental health, no matter how good your dentist or endodontist are.

The Stages of Tooth Infection: Pathology
Pathology is the study (“-ology”) of suffering (“pathos”) or disease, and is our key to understanding what’s wrong and how to fix it. Below is a description of the different stages and typical symptoms as the bacteria invade deeper into your tooth and jaw bone. If you recognise any symptoms that you have or had, even months ago, then tell your endodontist. It could be important for your diagnosis. The diagnosis can often be found just from properly talking with you, although clinical examination and radiographs are essential too. Diagnosis is critical because if wrong, then planned treatment may be ineffective or even harmful. It’s in everybody’s best interest to find the correct diagnosis.
a) Reversible Pulp Inflammation
Once into dentine through decay, leaking fillings or cracks, bacteria continue to produce acids and toxins which pass down the dentine tubules damaging the pulp. The pulp is not yet infected but gets inflamed. It can then hurt with a sharp, short pain on cold drinks or sweet foods, but not without a stimulus and not usually on biting. The condition is called *reversible pulpitis* (-itis in Greek means inflammation). As the name implies, if caught early then this disease stage may only require a simple filling with an excellent prognosis. Unfortunately, in some cases there may be no pain to warn you before endodontic treatment is necessary. Hence the need for regular dental checkups and radiographs (X-rays). If the symptoms are as described above, except that biting also gives a sharp temporary pain then you may have a cracked live tooth, or *cracked tooth syndrome*. The bacteria are entering the dentine through a crack.

b) Irreversible Pulp Inflammation – Infection
When bacteria reach the pulp then irreversible damage is usually done to it. The pain episodes on cold or sweet get stronger, last for more than a few seconds or even occur spontaneously. The pain can become very severe, throbs and spreads throughout the side of your face, so that it is difficult to tell where it is coming from. This excruciating type of
toothache is the pulp dying and is called an **irreversible pulpitis**. Mercifully, when the pulp finally dies in a few days the pain reduces or disappears. Sometimes a dead pulp can stain the tooth darker because the blood inside degenerates into brown substances (just like a bruise in skin). However, surprisingly, this whole process can sometimes be entirely painless and you might not know that you have a dead pulp. The prognosis is usually good with about 90% of cases successful.

c) Pulp Death and Putrefaction

After bacteria have killed the pulp off with toxins they digest the dead (necrotic) tissue. Sometimes the root canal can look empty, but of course there are many bacteria inside which can’t be seen. The body can’t fight this continued infection because there’s no blood flow into the dead pulp space. The blood contains infection-fighting white blood cells. Antibiotics in the blood stream are also of little use for the same reason, so shouldn’t be prescribed. The condition is called a *necrotic pulp* or a *pulpless pulp space*, depending on whether any pulp is left inside. At this stage, there may be no pain, but your tooth will not feel temperature changes anymore. The endodontist will demonstrate this by applying ice to the tooth without sensation. Prognosis with treatment at this stage is very good with about 95% of cases successful.
d) Jaw Bone Disease

Bacteria and their toxins leaking out of the holes in the root’s end (apex) into the living jaw bone probably don’t survive long unless the condition is acute. But their dead bodies and toxins still cause severe inflammation. This inflammation (-itis in Greek) of the tissues near (peri- in Greek) the tooth (odont in Greek) occurs near (again peri- in Greek) the root end (apex, apical) and so is called periapical periodontitis: i.e. inflammation of the tissues near the end of the root, in plain English. All very obvious if you happen to know some ancient Greek.

As you might expect, biting on the tooth presses it into this inflamed jaw bone causing bone pain. You might also feel some soreness on the outside surface of the gum at the level of the end of the infected root. So if your tooth gives a dull soreness on biting but is not sensitive to cold and the gum nearby is sore then chronic periapical periodontitis may be your root end diagnosis. If acute, the dull poorly localized pain can occur without stimulus, may throb and the tooth may feel raised in its socket. You might also get a sore lump under the angle of your jaw on that side. This is a swollen lymph node caused by infection draining from the tooth down lymphatic channels.
Your body's response to toxins exiting the root end is partly self destructive. White blood cells home in on the root's end and fuse together to form massive giant cells. Over weeks to months, these huge cells actually dissolve periapical jaw bone, perhaps in an attempt to get better access to the root end. This missing jaw bone shows up as a shadow on a radiograph (X-ray film). Can you believe that part of your jaw bone has dissolved away! If you have this, then your endodontic problem has been there for some time and is more severe. The longer it is left, the more bone can dissolve away and the poorer the chance of saving your tooth. However, the condition is still worth treating and in about 70% to 90% of cases the bone returns over up to one year when the infection in the root canal is removed. The bone itself does not require direct treatment in most cases. Remember that even the dissolving of jaw bone in some cases can occur without pain, so have regular dental checkups with radiographs of suspect teeth.

Patients often worry that infection might spread from one root end to another. This rarely happens unless the disease is very extensive and longstanding. Endodontic disease in adjacent teeth is more likely to be from separate decay, leaking fillings or cracks in these teeth.

e) Jaw Bone Infection - Dental Abscess
While some white blood cells join up to dissolve bone, others work alone to release their own antibacterial toxins or even wrap themselves around whole bacteria and debris particles. It's a war zone on a microscopic scale between the bacteria and your defence cells and biochemicals. In the battle, many white blood cells and other cells die. The fragments along with dead and living bacteria constitute pus. Anyone who has had an acne zit will be familiar with this creamy liquid. The definition of an abscess is when pus collects in a pathological space. So a zit is a skin abscess. If pus collects around your root end then you have a dental or periapical abscess.
If acute, an abscess can be very painful with throbbing pain on touching the tooth or spontaneously. The pain is not well localized and may feel as if it is in other teeth, or even the opposite jaw. But the tooth does not feel cold stimuli because the pulp is already dead, although it can feel heat sometimes perhaps because of liquid and gas expansion in the pulp chamber. Eventually enough bone dissolves away to let the pus out of the side of the jaw bone. Often the pain then reduces, but swelling of your cheek can occur as infection.
exits the jaw bone. If the swelling is just local to the one tooth then a lump forms, which is known as a *pointing abscess* or colloquially a *gum boil*. After more time, this swelling ruptures releasing pus and symptoms reduce. However, the hole in the gum, called a *fistula*, and surrounding swelling will not heal properly until the source of infection, the tooth, has been treated. Prognosis is poorer when established pus drainage is present but treatment is still worthwhile with over 60% success.

In some cases the swelling can be much greater. This condition is called *cellulitis* (inflammation of cells, in Greek) and is caused by types of bacteria (*e.g.* Streptococci) which make enzymes (*e.g.* hyaluronidase) that soften your tissues. The enzymes allow these bacteria to penetrate further and so cause more extensive and diffuse swelling. If very severe and under the lower jaw, this can raise the tongue and prevent breathing. In extreme circumstances, the infection might also spread into your blood stream (*septicaemia*) with similarly fatal results. These days in the First World, death from dental infection is rare because antibiotics or dental treatment control the spread of infection. So don’t be alarmed, but antibiotics should be prescribed for any diffuse infective facial swelling. However, antibiotics should not be given for cases without extensive swelling or swollen lymph nodes, where normal endodontic treatment or extraction is all that is required. Unnecessary antibiotics are a wasted resource as there is no benefit to the patient, but the bacteria may learn to be resistant to the antibiotic so may not be killed by it in the future. This could have fatal consequences.
f) Dissolving Roots, Bags of Skin and Foreign Bodies

If periapical infection persists for months or years, then two changes in addition to bone dissolving can happen. The root end may begin to dissolve too, lowering your success rate by about 20% (Strindberg 1956). You can also get a radicular cyst. This is a bag of skin inside the jaw bone which swells up making surrounding bone dissolve. This is bad news too because even if a decent root filling is done, then the cyst won’t go away by itself. The cyst has to be removed surgically at the specialist endodontist’s practice before the bone can heal. Luckily most regions of bone loss around a root end are not cysts and heal with normal root canal therapy. It isn’t possible to tell beforehand if a shadow on the X-ray film is a cyst or not, and so a cyst is assumed likely if a good root filling fails to make the bone return by one year.
ENDODONTIC INFORMATION

Cyst lining

Cyst Cavity
**g) Reinfection of Previous Root Fillings**

Teeth which have already been root filled can get reinfeected again if the seal is broken. While there is no pulp anymore, infection can get under the fillings or crown and back into the root canal. Unfortunately, even good root fillings do not seal their canals well and bacteria can get between the root filling materials and the root canal wall, and finally out of the end of the root again. This means that periapical periodontitis, abscess and cellulitis are all possible again. So get to a dentist if you notice a rough or stained edge develop around a filling, or if the filling is lost.

**h) Root Fractures**

Cracks above the gum can often be mended with filling materials. However, if cracks in the roots of teeth below the gum can not be mended with current materials because the environment under the gum is too wet and the forces too great. The gum edge is supposed to make an infection tight seal around the tooth to keep the jaw bone bacteria free. A crack passing under the gum allows bacteria to infect the jaw bone, damaging the tooth’s attachment to the
gum and bone (periodontal ligament). The gum becomes loose away from the side of the tooth and is called a gum pocket. If there is no gum disease generally, then this pocket is narrow and deep as it just follows the crack line, and strongly indicates a vertical root fracture. A second problem arises if the crack goes right through the dentine into the pulp space. Then cleaning the root canal becomes pointless because new bacteria will always reinfect it through the crack line. In both cases the tooth’s prognosis is hopeless and should be extracted.

So in a few cases of trauma sometimes the root can break within the bone. If the fracture line is not connected to the gum and so remains uninfected, then this may not require treatment, other than splinting temporarily to hold it steady to adjacent teeth. If the root canal gets infected or the tooth gets loose though, endodontic treatment or extraction will be required.
Now you have learned the terrible damage that frequently fed bacteria can do to your teeth and jaw bone, you will be highly motivated to stop the infection and prevent it happening again. Welcome aboard. You appreciate a part of reality which us endodontists see every day. Your next step is to arrange a consultation appointment.
Your Consultation Visit

Provided you are not in serious pain, it is usually better to not plan any treatment at your first visit. This allows you the time to properly consider your options and sort out any scheduling or financial issues. It also allows the endodontist to set an appropriate amount of time for the treatment planned so your work can be done properly. The consultation visit is all about your endodontist picking up enough information from you to make a diagnosis. This then largely dictates the treatment plan. The diagnosis is made by trying to match the pattern of signs and symptoms you have with the pathology descriptions above. Now you can see why the pathology is so important. If you understand it then you may be able to spot a problem earlier and avoid a root filling. This is the power of education. The consultation is also an opportunity for you to learn more about your specific condition and decide whether to proceed. This is your choice because it’s your body, not your endodontist’s.

Your Dental History

Your endodontist will gather the information in a systematic way to make sure nothing is missed. The first part is just talking about what you felt and when, who did what, when and why. This is called the history and very often is all that’s needed to make the diagnosis. The importance of this stage can not be overestimated, so don’t rush it. Let your endodontist ask you a series of structured questions so you best describe your symptoms, recent dental treatment and timings in an ordered manner for recording. If you feel that there is more to say, then make sure you say it.
Dental History: Some Questions for your History

Your name: ________________________________

► Have you had any pain or discomfort with your teeth? 
  Yes □  No □

► Can you identify which teeth were painful? 
  Which teeth: __________

► When did this symptom first occur? 
  Date: ________________

► How often does the symptom happen, 
  and how long is each episode?  

► Are the episodes getting more, the same 
  or less common? 
  More □  Same □  Less □

► Are the episodes getting the more, the same 
  or less severe? 
  More □  Same □  Less □

► Is there anything which makes the symptom come, or go?  

► Do cold or hot food and drink bring on the 
  symptom? Just cold or just hot or both? 
  Hot □  Cold □

► How long does the pain last for after the stimulus? 
  Few secs, minutes or hours? 
  Secs □  Mins □  Hours □

► Is the pain sharp and short, just in one tooth .. or ? 
  Yes □  …is it a duller, longer lasting, more generalized 
  pain in the region? 
  Yes □  or something else □

► Does the pain ever occur spontaneously 
  without stimulus? 
  Yes □  No □

► Does the pain ever throb? 
  Yes □  No □

► Do any of your teeth hurt on biting?  Which? 
  Yes □  __________  No □

► If biting causes pain, does the pain stop when 
  you stop biting? 
  Yes □  No □

► Does shaking your head cause any pain? 

► Have you had any recent dental treatment, 
  particularly to teeth which are symptomatic? 
  What: __________  No □

► Are you aware that you grind or clench your 
  teeth, perhaps at night? 
  Yes □  Maybe □  No □

► Have you had any trauma to your teeth, 
  say in sports accidents? (Even years ago) 
  Yes □  No □

With your new understanding of the pathology, try to identify the answers for these questions to help the endodontist work out which stage of endodontic disease you might have.
# Your Medical History

Next comes your medical history. You would be surprised how medical conditions can affect dental treatment and vice versa. You will be given a sheet (see below) or something similar to fill out beforehand.

<table>
<thead>
<tr>
<th>Name</th>
<th>Date of Birth (dd/mm/yy)</th>
<th>Address</th>
<th>Post code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tel: (H)</td>
<td>(B)</td>
<td>(M)</td>
<td></td>
</tr>
<tr>
<td>Medical Doctor</td>
<td>Address</td>
<td>Tel:</td>
<td></td>
</tr>
<tr>
<td>General Dentist</td>
<td>Address</td>
<td>Tel:</td>
<td></td>
</tr>
</tbody>
</table>

Are you generally fit and well?  
Yes □  No □

Have you seen your general medical doctor or medical specialist 
in the last 2 years?  
Yes □  No □

If yes, why: ________________________________

Do you take any medication at present?  
Yes □  No □

If yes, what: ________________________________  Dose /mg

(Remember any antibiotics your dentist or doctor may have given you)

Ladies, are you pregnant?  
Yes □  No □

Do you have or have had any of the following?  

<table>
<thead>
<tr>
<th>Condition</th>
<th>Yes □  No □</th>
</tr>
</thead>
<tbody>
<tr>
<td>High blood pressure</td>
<td>Yes □  No □</td>
</tr>
<tr>
<td>Anaemia or any bleeding problem</td>
<td>Yes □  No □</td>
</tr>
<tr>
<td>Rheumatic fever (this is not rheumatoid arthritis)</td>
<td>Yes □  No □</td>
</tr>
<tr>
<td>Asthma</td>
<td>Yes □  No □</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Yes □  No □</td>
</tr>
<tr>
<td>Epilepsy</td>
<td>Yes □  No □</td>
</tr>
<tr>
<td>Hepatitis or Jaundice</td>
<td>Yes □  No □</td>
</tr>
<tr>
<td>HIV or AIDS</td>
<td>Yes □  No □</td>
</tr>
<tr>
<td>Allergies to any drug (e.g. Penicillin)</td>
<td>Yes □  No □</td>
</tr>
</tbody>
</table>

Do you have any conditions of the following?  

<table>
<thead>
<tr>
<th>Condition</th>
<th>Yes □  No □</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td>Yes □  No □</td>
</tr>
<tr>
<td>Heart</td>
<td>Yes □  No □</td>
</tr>
<tr>
<td>Lungs</td>
<td>Yes □  No □</td>
</tr>
<tr>
<td>Stomach or bowels</td>
<td>Yes □  No □</td>
</tr>
<tr>
<td>Bladder or genitals</td>
<td>Yes □  No □</td>
</tr>
<tr>
<td>Arthritis/Spine</td>
<td>Yes □  No □</td>
</tr>
</tbody>
</table>

Do you have any other medical condition not given above?  
Yes □  No □

If yes, what: ________________________________
Clinical Examination and Tests

Some information can only be found by looking and touching. But before you open wide, your neck, face and jaw joints will be checked for soreness, swelling or other abnormalities. Then it’s into the mouth to check out your teeth, bite, gums, tongue, cheeks, palate and throat. Your endodontist will be looking for anything abnormal, particularly those signs and symptoms featuring in the pathology descriptions above. Let him or her know if anything is or was sore, or feels different. If a symptom can be recreated then its presence can be confirmed and its character observed. Such information is often highly diagnostic.

Checking of the gums can be a little uncomfortable because a blunt measuring tool is placed under the gum edge. This finds whether the gum has come away from the tooth to form a gum pocket.

You will also have your teeth tapped. This tests whether the bone around the root ends is inflamed, and will not be uncomfortable unless there is some inflammation. There is also a biting test for teeth suspected of being cracked. Just bite on the plastic handle as instructed and indicate any soreness, particularly as you release the force.

Finally, the pulps in any teeth under suspicion will be tested with a stick of dry ice. If your tooth is alive then this cold stimulus may give a momentary sharp pain, just like you might have felt with ice or ice cream. As soon as you feel it, the ice will be removed and your job is
to count the number of seconds it takes for the pain to go. A few seconds is normal. If greater than about five seconds and you might have an irreversible pulpitis (See p 19). If not at all, then the pulp space may be necrotic or pulpless (see above), or else the pulp could still be alive in the root but the part in the crown has become mineralised. Further pulp testing with electricity or heat may be helpful in some cases.

**Radiographs (X-rays)**

Reliable diagnosis for endodontics requires at least one radiograph (X-ray film) before treatment, and more during treatment. This film shows whether any bone has dissolved from around your root tips, and many other features. It also will be a record of your tooth and jaw bone before any treatment was provided. If you have a hole in the gum (fistula) leaking pus then your endodontist may want to temporarily place a rubber stick into this. This stick shows up on the radiograph and indicates where the pus is coming from. Give your endodontist time to view the radiographs with a magnifying glass and note down all the information. Every last bit of useful information should be got out of them and recorded to make your radiation dose as worthwhile as possible.

While we're on the subject, we should talk more about the risks of X-
ENDODONTIC INFORMATION

rays. Some patients and all dentists are concerned about the harmful effects of X-rays. This is a real worry because X-rays can cause damage and should only be taken when the expected benefit is greater than the expected harm. You will need perhaps five to eight films for each root filling done.

The Risks of X-Rays
The expected risk is small. Each dental X-ray exposure gives about 5 microSeiverts (µSv) of radiation (RCSEngUK 1998). This value means little to most people so the dose has been compared with other risks you might take, to allow you to put it into perspective. You have the same risk of death from just over one day of background radiation from your surroundings, from driving about 5 km, and from smoking less than one cigarette (Danforth 1990). In comparison, larger medical X-rays are generally more risky with a chest X-ray (20 µSv) dose four times a dental radiograph and a head medical CT scan (480 to 3300 µSv) about 100 to 650 times the dose (RCSEngUK 1998). This is a large dose, up to one year’s background radiation. So think seriously about having a medical CT scan, but probably a dental X-ray exposure is less risky than your drive to the appointment. Remember that just existing with background radiation yesterday gave you the same dose of radiation as from having a dental film taken. Nevertheless we still try to minimize X-ray exposure and maximize the information obtained. Younger people are more at risk than the elderly because they have more time left for genetic damage to have an effect. If you’re over 80 years old then diagnostic X-rays are very
unlikely to cause you any illness at all. Patients sometimes query why everyone else in the room dashes out when the exposure is made. This is because we take tens of thousands of films over a working lifetime which would be a significant risk to us. In comparison, you might have a couple of hundred dental films over your life at most, which is a negligible dose.

The Benefits of X-Rays
The benefits of radiographs are absolute in endodontic treatment. We can’t do the job without them, so if you want a root filling, then you have to accept some radiographs. Even your alternative (an extraction) requires a radiograph. We use them for diagnosis and for quality control as the root canal is cleaned and filled. The final film is a baseline reference for assessment of your healing in years to come. Without decent radiographs the work would be substandard and you would need more radiographs later to get the work redone. Let’s get it done properly at the first time.
Diagnosis and Treatment Planning

Your Diagnosis

A diagnosis is the definition of the problem. It is found by assembling all the information found in the history, examination and tests, and looking for patterns which match known disease states. We need to make separate diagnoses for the enamel, dentine, pulp space, gum and periapical region of each suspected tooth. Without clear diagnoses treatment can not be reliable, and may be harmful. Sometimes a diagnosis is not found and further tests or waiting is required. Sometimes a filling can be removed to get a diagnosis without causing you any irreversible harm. But do NOT have destructive or irreversible treatment begun without a diagnosis, even if you are in pain. Better to think harder and wait for clearer signs and symptoms than to end up with an unnecessary root filling for which you will have to pay. Waiting a few days is free and is unlikely to change the outcome. Painkillers (analgesics) such as Nurofen® can be used to control the pain and bring down swelling, and anyway you now know from the pathology that this usually happens naturally in a few days even without treatment. Even were treatment given the pain may not subside immediately anyway.
If diagnosing is defining problems then treatment planning is designing solutions to fix those problems. Not only do you need the right solution, but the order and timing must be correct. However, some things have to be, or else can not be done. But for others there may be some choice available. Most people need professional advice. After all, that’s an important part of what you’re paying for. So your endodontist will try to estimate roughly your expected success rate, time commitments and costings for treatment including different available options. It’s important that the worst case scenarios and any contingency plans are explained so you know the risks as well as the benefits. As we said on page 5 above, we can not predict your personal future – just advise you how to get the best odds for a good outcome. After you understand the situation, the risks and benefits, and any options, it’s your tooth and your choice, so with the professional advice (and this booklet), make the right decision for you.

Now you understand the pathology, you can have a guess at what treatments might be necessary. Bear in mind that a little knowledge can be a very dangerous thing, so do be guided by your endodontist. The following might be appropriate in many cases. If the enamel or dentine is decayed, then the decayed bits need removing and restoring with filling materials. If the dentine is cracked, then the crack line needs to be cut out and the tooth strengthened to prevent further cracking and entry of bacteria. A stainless steel band with filling materials and then, if everything’s fine, crowns are used to strengthen back teeth. Filling materials and sometimes a crown will be needed for front teeth. A crack or decay might not be repairable if it goes down into the root and you might loose the tooth. If the pulp is infected then the pulp space needs cleaning out, disinfecting, and filling up with dental materials. This is what a root filling does.
Endodontic Management Chart

Does tooth have an endodontic infection?

- Yes
  - Is the tooth: 1. Needed, 2. Restorable, 3. Without serious gum disease?
    - Yes: Recheck (2) at first Rx visit
    - No: No for any question

- No
  - Is root filling needed to allow retention of the filling by locking into the pulp chamber?
    - Yes: Yes
    - No: No

  - No endodontic treatment required

  - Can root canals be disinfected and filled properly?
    - Yes: Routine endodontic treatment or retreatment
    - No: Surgical endodontic treatment

  - Was treatment successful?
    - Yes: Restore tooth, with crown if needed and monitor
    - No: Extract tooth
If the periapical region is inflamed or abscessed from an infected pulp space, then removing the pulp space infection is usually enough for the periapical region to heal by itself. However, if infected dental materials or an infected cyst is present outside the root end then the infection will continue even if a root filling is done. Therefore periapical surgery is required to remove the infection.

See how the treatment follows on from the diagnosis for each tissue of the tooth and jaw bone. That’s why we must have the correct diagnosis for each tissue to get the correct treatment.

Not all teeth can be saved. Some teeth are too badly damaged to be repaired. Some have too complex a pulp space shape inside to be disinfected properly. Others are blocked up with unremovable old root filling materials. These technical problems might be good reasons to decide not to try to do a root filling. Occasionally a tooth may not chew against anything and not contribute to your appearance, so extraction may be sensible. Extraction solves the endodontic infection by removing it within the whole tooth and the gum heals to then seal off the defect.

Wider issues must also be considered in treatment planning. Often other less advanced disease elsewhere in the mouth is the priority before endodontic treatment. The obvious example is other decayed teeth at the reversible pulpitis stage (see page 19). If left then these teeth might also require endodontic treatment at vast expense. Better to spend limited resources on simple fillings for these other teeth than to save one tooth with endodontic treatment. Sort out the wounded before the dead. Obviously though, if finances and time allow it’s best to save them all.
Some Questions to Be Answered by You and your Endodontist during Treatment Planning

- Is the tooth or a replacement at that site required or not (aesthetics and function)?
- Is the pulp space infected or not?
- Is the tooth restorable or not?
- Do you find a root filling procedure acceptable or not?
- Will you have the tooth restored properly (e.g. a crown) or not?
- Does the tooth need root canal treatment to allow a filling to be better held in place?
- Is a root filling feasible or not?
- Do you find an extraction procedure acceptable or not?
- Would an extraction be routine or complicated?
- If the tooth is extracted, do you want a replacement tooth, and what types (denture, bridge, implant) are possible?
- Do any of the options for replacing the tooth with an artificial tooth carry a higher success rate than the proposed root filling?
- Is a root filling or a replacement tooth affordable?
- Which is cheaper: total costs of endodontic and restoration or extraction with or without replacement?

This is the end of the consultation visit and you’ll need to schedule some appointments if your tooth needs a root filling, has a good prognosis and you want to proceed. Use the time before your first treatment appointment to reconsider the information and your choices. If you do go ahead, your endodontist will do his or her best to get you a successful result. If you are not sure, then ring up to chat it through again. If you still have serious doubts when fully informed, then a root filling may not be for you, and an extraction with your general dentist or an oral surgeon is your only other alternative. Please be courteous and give at least a week’s notice if you wish to cancel your appointments.
Your Treatment Visits

The general aims of endodontic treatment are simple: Firstly to remove or kill the bacteria in the pulp space. Secondly to prevent reinfection by blocking up the pulp space and sealing off the entrance hole. No great intellect required there. But let’s learn practically how that is done, so you can see there’s no reason to be unduly concerned.

The First Treatment Visit

This visit is the most worrying for patients as they know they will have something done but don’t really know what it will be like. The scary unknown again. Well, let’s see if we can make it seem a little less daunting. Everything done is done for your benefit by trying to maximize your comfort and success rate.

Getting your Tooth Numb

Everyone is worried about pain, and so pain prevention is essential. Believe it or not, endodontists also find it stressful too if you’re not comfortable and can not do their best work. So it’s in everyone’s interest to make the procedure painless. In many cases this is automatic because the pulp has already died, and so can not feel pain. Sometimes even with a dead pulp, a dash of anaesthetic is needed around the tooth to numb the gum which may be nipped by a spring clip. If there is live pulp in your tooth then you will be given local anaesthetic. This can be done painlessly by first applying an anaesthetic cream to numb the skin, and then injecting slowly. Slow is the key word. If you’ve ever had a painful injection before, it’s because it was done too fast. The injection should be done over at least a minute and probably two. At any time if it’s sore, indicate to your endodontist and he or she will stop injecting and then restart slowly and painlessly. You’re in control.
There is only one situation where anaesthesia is notoriously difficult, and this probably doesn’t apply to you. This is with lower molars which have acutely inflamed pulps, typically after cracked tooth syndrome (Page 17). A large artery, vein and nerve pass within half a centimetre of the root ends, giving excellent nerve and blood supply. While pulps in other teeth tend to die within days to a week after infection, pulps in lower molars can live when inflamed for months giving extreme sensitivity to cold and biting. A normal anaesthetic injection is unlikely to render an inflamed lower molar pulp to be pain free. So what’s the solution? The secret is to bring the patient in half an hour before the main appointment time and give a normal injection for that big nerve (inferior dental nerve block), as well as more injections either side of the tooth. Then, to repeat this dose half an hour later at the beginning of the appointment. So a double dose has been given and the extra time makes for excellent anaesthesia. Finally if need be, further local anaesthetic is given down the side of the tooth with a special type of anaesthetic syringe. This has a very fine tip and high pressure mechanism which forces anaesthetic solution down between the root and the bone. Don’t worry, earlier injections will have made this region painless. This injection through the periodontal ligament (intraligamentary injection) is very effective in a short space of time to gain the additional anaesthesia. Then these problem teeth can be managed well. If the tooth still remains sensitive then endodontic treatment will be delayed and some anti-inflammatory medicine under a temporary filling will calm the pulp down. Next time the acute inflammation will be gone, anaesthesia will be easy and the tooth can be worked on, but you will need an extra visit.
Isolating the Tooth from your Infected Saliva

Once you’re numb then your tooth is passed through a small hole in a rubber sheet, and the sheet held in place with a spring clip called a clamp. This equipment is called rubber dam and makes life so much easier for you and your endodontist. You can cease to worry about any water, antiseptics or bits of filling going down your throat. They can’t, and will be sucked away by the dental assistant. Also, and probably more importantly, your infected saliva can’t get into the tooth we’re trying to disinfect. It would be impossible to get the root canals clean otherwise and so rubber dam is mandatory. Note that it’s not good enough to just have the rubber sheet on. It must actually make a watertight seal around the tooth, at least later on during the root canal cleaning and filling processes. You may initially feel a little claustrophobic but the sheet will be arranged to be clear of your nose, and to leave a breathing space on the opposite side of your mouth. Rubber dam is a great thing for everyone. Many patients ask why they have not had this wonderful device before for normal fillings. There is no reason other than the two minutes it takes to put on. Just ask your dentist to use it.
Removing All Old Fillings

The first stage of cleaning is to remove all your tooth’s old fillings, any decay or cracks, and then to judge whether the remainder can be rebuilt. This full deconstruction maximizes your chances of success by ensuring that we only proceed with teeth which have a reasonable chance of being resealed and are strong enough later on. If not, then you’re better off to save your time and money and abort treatment at the beginning. Leaking fillings, decay, cracks and insufficient remaining tooth material are common problems to be identified. But most teeth are fine and go forward to the next stage.

Finding and Cleaning the Root Canals

The next job is to remove dentine to get access to the root canals. The canals are often blocked up with mineral deposits laid down by the sick pulp in an attempt to seal out the invading bacteria. Some deposits are lumps and so are called pulp stones (a bit like kidney stones). Unfortunately, the mineral is porous and soluble by acids from the bugs anyway, so the barrier rarely works. That’s why you now need the root filling and you can realise that the only real solution is prevention: less frequent sugar and scrupulous cleaning. Special rotating and vibrating (ultrasonic) tools coated in diamonds and used with an operating microscope are the most reliable way to shift any mineral deposits or old filling materials. The clinical
microscope allows us to see very clearly without shadowing. This piece of equipment have done more to increase our capability than any others in the last 20 years. Once found, the root canal orifices are funnelled open to allow easy access by later instruments and to remove the bulk of infected material.

Once the root canals are found, fine metal instruments typically 0.15 mm across at their tips are passed down to the root ends. These are designed as cleaning tools but are also used now as measuring sticks of known length. A radiograph is taken with these instruments in place and the distance between each root end and its instrument end is measured on the film. From this and the instrument’s known length, the true length of each root canal is calculated. An electrical device can also be used to confirm the same measurement, if need be. A range of sizes of instruments are used until all the debris is out and the root canal is widened into a gradual taper to its end. These instruments look like flexible needles but have spiral grooves down them. The edge of the groove is sharp and so cuts at the root canal wall, widening and cleaning the canal. Some people move the instruments just by hand, others use a motor. Whichever is used, the ideal point to clean up to is about half to one millimetre
from the root end. There are many equipment types and techniques available for this cleaning and shaping of the root canals, and your endodontist will choose the one most suitable for your tooth.

Killing the Bugs
Much flushing of the root canal is also done with a strong antiseptic called sodium hypochlorite. This is squirted in with a syringe. You will be amazed to be told that this chemical is actually the main constituent in household bleach, although a medical grade will be used in your tooth. It is incredibly effective at dissolving out old dead pulp and killing bacteria, and has been used for decades by most endodontists and dentists worldwide. You will be able to smell the chlorine smell. It is not harmful to you because there is no living tissue inside your tooth anymore. You can also see why the rubber dam is important to prevent you swallowing the antiseptic. Those who do not use rubber dam, probably don’t use sodium hypochlorite enough or at all, and so it is likely infection would remain in your tooth.
Once the root canal is cleaned and shaped, it is then dried out with tiny absorbent white paper sticks and filled with another antiseptic called calcium hydroxide. This viscous white paste is also powerful in killing bacteria and can diffuse into the many microscopic nooks and crannies in the pulp space and dentine tubules which we can’t access with even our finest instruments. This dressing is left in your tooth for several weeks or even months to ensure that all the remaining bacteria we can’t clean out are killed.

Sealing the Tooth
Finally, the tooth must be sealed off to prevent new oral bacteria from reinfecting the root canals. This is done with temporary filling materials. This is incredibly important as all the cleaning and disinfection done up until now are for nothing if new bacteria get inside again. Several filling material types can be used, and generally the deeper the temporary filling the better it seals. Many endodontists use a layer of a plaster based material followed by a layer called glass ionomer on top. The plaster expands when it gets wet and so seals well but is weak so needs to be protected with the harder glass ionomer on the biting surface. This is called a double seal. The glass ionomer is designed as a permanent filling material but is used on a temporary basis here.
Another problem with teeth during and after root canal treatment is the development of cracks. Some teeth, particularly back teeth, can even break apart. If this happens then the tooth often needs to be extracted, so it’s a good idea to strengthen all back teeth with a metal band. Stainless steel bands are available for use by orthodontists and are often used by endodontists too. The band also holds the filling tightly in place, reducing its chance of leaking too. However, bands can irritate your gum and often prevent flossing, so there are some minor problems, but nothing compared with a split tooth.

Once the tooth is cleaned, dressed, sealed and strengthened, the rubber dam is removed and the height of the tooth (the ‘bite’) is checked with marking paper. A high filling will cause soreness on biting, so do say if the filling feels even slightly high before the instruments are cleared away.
Your Post-Operative Care

As you might expect, there can be some soreness after root canal treatment. This is mainly because, no matter what technique was used, by whom, there will be some infected debris pushed through the root end into the bone by the cleaning process. As you read above in the pathology section (page 21) bacterial rubbish exiting the root end is the cause of periapical periodontitis, the inflammation around the root end. In some cases, the post-operative inflammation does not cause any symptom. In most cases the tooth will be a bit sore for a few days. Sometimes this will be great enough that you might need to take over the counter analgesics (pain killers), as you might use for a headache. Ibuprofen (e.g. Nurofen®) is recommended as it directly reduces the inflammation as well as the pain, and is kinder on the stomach than aspirin. However for those with asthma or stomach ulcers, then paracetamol (e.g. Panadol®) would have less side effects, but doesn’t directly reduce inflammation, the process causing of your pain. Analgesics stronger than this are rarely any more effective for dental pain.

Some patients take analgesics with a small amount of codeine added such as Nurofen Plus® (Ibuprofen and codeine) or Panadeine® (paracetamol and codeine). The codeine is an opiate like morphine but has been shown not to help much with dental pain. Its main effect is to make you drowsy, which can help you get a good night’s sleep. However, some patients find it makes them feel unwell or even develop allergies. Constipation is common too. You also shouldn’t drive or operate machinery when drowsy with codeine. Dentists generally are not allowed to prescribe stronger opiates, because they are seldom necessary or that much more effective.
Research has shown that about 2% of endodontic patients will suffer severe pain and perhaps some swelling (Trope, Endodont. and Dental Traumatol. 1990; 6: 226-229). This uncommon situation is called a ‘flare up’ in professional slang. It is usually only short lived because the probable cause, infected rubbish pushed out of the root end, is a one off event. It is more common in patients who beforehand already had bone missing from around their root ends, but exactly who is unlucky enough to get serious pain and swelling is not really predictable. Also the research showed that the pain experience was not related to long term success. So don’t worry the treatment is failing because of initial soreness.

A flare up should be treated with antibiotics from your endodontist, especially if there is any swelling of the face or neck. Generally penicillins such as amoxicillin (500 mg, three times per day, for seven days) is effective. If you are allergic to penicillins then be sure to tell your endodontist to give you an alternative antibiotic instead. Penicillin allergy can kill. Suitable alternatives might be metronidazole (200 mg, three times per day, no alcohol) or erythromycin (250 mg, four times per day) instead. Antibiotics have good access by the blood stream to those bacteria around root ends, so work well to remove the cause of the pain – the bacteria. However, remember that there is no blood supply inside the root now and so antibiotics can not be used alone instead of root canal treatment. You need your endodontist to clean these internal bacteria out and kill the remainder with antiseptics directly. Also understand that surviving bacteria exposed to antibiotics may develop resistance to the antibiotic so that its use another time, perhaps in another person, is less effective. Minimise antibiotic resistance by
only taking antibiotics when absolutely necessary, take them as prescribed and finish the whole course to ensure that no resistant bugs are left alive.

This is the end of your first visit. Remember, whether there is postoperative pain or not does not affect the end result, and 49 out of 50 people manage with no medication at all or simple over the counter anti-inflammatory analgesics (e.g. Nurofen®). If you’re in the unlucky two percent you may get serious pain and swelling and need antibiotics. Give us a ring if that’s the case.

Subsequent Treatment Visits

Later visits are similar to the first visit from your point of view, but with less workload and much less chance of postoperative soreness. Some patients prefer not to have local anaesthetic for later visits when they understand that there is no pulp (nerve) in the tooth. Instead anaesthetic cream is applied only to the gum. Occasionally, the rubber dam clip can nip the gum and so a small injection around the tooth may be needed. Also occasionally, there may be some pressure effect within the root canals which cause nerves outside the tooth to be sore. This too may require local anaesthetic. Other than for those situations, many people prefer to try without anaesthetic at first and avoid the injection and irritating sensations as it wears off.
Others want an injection straight away, no matter what and that’s also fine. Your endodontist will give you the choice. Again, you’re in control.

At the second visit some teeth need more cleaning work, or just redressing again to fight a difficult infection. Others can be finished off. It is comforting to know that little of your actual tooth structure needs to be changed after the first cleaning visit. The remainder of the work is simply remedicating the pulp space or filling it up with root filling materials. You can regard these later stages as little to do with your tissues and divorce yourself mentally from the process.

**Redressing your Tooth**

Redressing is a quick process taking about 15 minutes for a front tooth and about 30 minutes for a back tooth. With rubber dam on, the central part of the temporary filling is drilled out to leave the outer material and any band in place. The antiseptic dressing is washed out of the root canal and replaced with fresh dressing. The central temporary filling material is replaced and you’re on your feet again.

**Filling up your Root Canals**

To finish off a root filling is a bit more complex and takes about an hour or so. After cleaning and dressing has removed or killed the root canal bacteria, the next job is to pack the disinfected space tightly with an orange rubber based material called gutta percha. The rubber comes in fragile tapered needle shapes, requiring much skill to place into the narrow root canals. These gutta percha “points”, which show up on radiographs, are intended to deprive any remaining bacteria of any space in which to exist and to prevent entry of new bacteria. To help, a glue called sealer is used to try to make a bacteria-tight seal between the rubber and the root canal wall. Typically, a gutta percha point matching the size of the last cleaning
tool is inserted up to the root end. The endodontist may take a radiograph to show that this main point is in the right place. If so, then sealer is added and the remaining space around the point is packed with many more finer ‘accessory’ gutta percha points, until the canal is crammed full. A metal tool called a spreader is pushed into the canal hard to squash the gutta percha already inside and make room for the next accessory point. You will feel this pushing and then a tug as the spreader is removed. It is important then that you keep still while the next fragile accessory point is inserted into the space. If it’s not exactly lined up right it will miss the canal orifice and crumple up uselessly. Once the endodontist is sure the canal feels full, then another radiograph will be taken to confirm this. Finally the excess ends of the rubber points sticking out of your tooth will be melted off with some heat and the cavity sealed with a filling. There can be a bad smell from heating the sealer, but the heat rarely escapes the tooth which is a good thermal insulator.

The filling up process is called obturation, and the traditional technique described above is called lateral condensation, meaning that the gutta percha is squashed (condensed) tightly with a sideways (lateral) pressure generated when the
tapered spreader tool is wedged in vertically. Another technique is to melt the gutta percha with heat and flow it in vertically before it cools and sets firm. This not surprisingly is called vertical condensation. Most endodontists will use a combination of lateral and vertical condensation. While these newer molten rubber methods of obturation are popular, they still require considerable skill to do well and have not been shown to lead to higher success rates than the original method described above. Remember, it’s the absence of bacteria which leads to success.

Talking of bacteria, the next bit may surprise you. Can you believe that despite gutta percha and sealer being used regularly by just about all dentists and endodontists, many scientific reports have shown that it does not actually seal the root canals well against bacteria. If bacteria contact even well compacted root fillings then they can get to the root end in a matter of days to months (Gale, Annals Royal Austral. Col. Dent. Surg. 2000). This is a remarkable failure of a widely used set of dental materials.

So why don’t we use better materials? Simply put, there is none better suited, and gutta percha is currently the best compromise. The main problem is that any root filling material must be removable to allow retreatment if necessary. This prevents the use in root canals of the harder and more adhesive routine filling materials used in cavities in the crowns of teeth. In the natural crown, these materials can be easily drilled out, if need be.
But root filling materials need to go in to the root end to perhaps 25 mm, often out of sight around a curve. Should treatment fail, then retreatment is impossible because the materials can’t be safely drilled out to this depth. Gutta percha is easily removed with solvents and endodontic files to allow retreatment of the canals. Secondly, if normal filling materials are used well to seal the access cavity in the crown of the tooth, then root fillings placed with good technique work very well indeed with an 80 to 90% success rate (Table 1, Page 6). So now you might see that there is not much motivation from dental materials manufacturers and researchers to develop better materials, although some have tried. Gutta percha is still the predominant root filling material. But its success is absolutely dependant on ensuring firstly that the root canals are properly disinfected before the root filling is placed, and secondly that new bacteria from outside the tooth are not allowed in later.

So the importance of the seal of the outside filling can not be overemphasized. The endodontist will always place a seal (filling) of some sort, and it may be convenient to make this a permanent filling. There is no doubt that the sooner a tooth is permanently sealed off then the less chance of leakage of bacteria inside, and reinfection of the root filling. The endodontist already has rubber dam in place to exclude infected saliva, and also has the skills and the tools to get the filling well compacted into the canal orifices. This seals the canals well and holds the filling in well, but is removable with drills. However, the restorative dentist must take responsibility for the strength of the tooth and its exterior shape. So sometimes an endodontist will only place a temporary filling, to be replaced by a permanent filling later by the restorative dentist. In this case, it is so important for you to see the restorative dentist within a few weeks for the permanent filling. He or she will know to ensure infected saliva does not recontaminate the root filling and so should use the rubber dam. You should insist on it.

Rebuilding your tooth

A separate requirement to sealing the canals is to ensure that the tooth is strong enough to chew on for many years, and it would be nice to make it look good too. These goals are also achieved by the permanent restoration. As you might imagine, most teeth requiring a root filling are already substantially damaged by past decay or trauma.
Then the tooth has to be weakened further to get access to the pulp space inside. So most root filled teeth are quite fragile and need strengthening. In a few cases this can be done just with routine filling materials. However, the forces expected on chewing can be 50 to 100 kg and often a prosthetic crown is the only type of restoration strong enough to hold the tooth together. The crown can also be made to look just like a tooth from the outside. Certainly most back teeth will give longer service if restored with a crown after root canal treatment.

**What Is a Prosthetic Crown?**

The crown of the tooth is the bit which sticks out of the gum. A prosthetic crown is an added cup-shaped piece of dental material which is glued on over the damaged remains of the natural crown. This binds everything together and reduces the risk of further tooth breakage. The outside of the prosthetic crown is made to be similar in size and shape as the original exterior of the natural crown. It can be made to have porcelain on the outside to look the same colour as a tooth, or may be silver or gold in colour. Often people simply call a prosthetic crown a ‘crown’ without indicating that it is not the natural crown. Some people also colloquially call it a ‘cap’.

If the final prosthetic crown is to be the same size as the original natural crown, then clearly the remains of the tooth on which the prosthetic crown is glued must be much smaller. Typically the sides of the crown need to be at least 0.5 to 1.5 mm thick depending on the materials used, so at least this amount must be drilled away from your tooth, if not already missing. As the root filling process made a hole in the centre and now the outside is skimmed away, you can see that there may be little strength left in your tooth. It is important to put filling materials into the middle of the tooth which are glued or else mechanically lock into the space. This is called a core and is partly what the prosthetic crown glues on to. The core must be well fixed in the tooth.
to prevent the prosthetic crown from coming off the tooth. Sometimes there is insufficient tooth left to hold even the core in place and therefore a post is required. This is a rod, usually metal, which is glued into the root canal and holds the core in place, and so consequently holds the prosthetic crown in place. It’s best to avoid posts if possible as they can encourage root fractures or other damage to the roots.

There are some disadvantages to crowns. Clearly the necessary trimming of the tooth can remove much healthy tooth structure. Secondly, like all fillings too, the edges are never a perfect fit and can allow sugars and bacteria under the crown, decaying the adjacent tooth material. Of course the crown can not decay, but the crown can still fail because of new decay, and many do. No pain will be felt in a pulpless tooth and X-rays are blocked by the metal crown, so the damage inside may be so advanced to be unrepairable when discovered. Reinfection of the root filling is likely. Thousands of dollars of specialist quality root fillings and prosthetic crowns can still be easily destroyed by humble bacteria and frequent sugar. As you see time and again, the only long term solution is prevention of dental disease by diet and cleaning.

**Recall and monitoring**

Even if your tooth is now entirely asymptomatic and all has gone well, you are still requested to reattend for a further check at one year, and at five years. This allows us to monitor the healing of your jaw bone and check that the all important seal of the tooth remains intact. If there were any problems, early detection could prevent reinfection and save you thousands of dollars for retreatment or loss of the tooth. It also allows us to check that you have got a long term result, and for us to audit the effectiveness of our own work.
Alternatives to Saving the Tooth with Endodontic Treatment

Extraction of the tooth

If a decision has been made that a tooth can not or should not be saved, then the next decision is whether to replace it with a false tooth. This depends on the balance of the benefits, the costs and disadvantages of the false tooth. You will need information on the expected effect of leaving a gap or a replacement tooth in your specific circumstances. There are only three common ways of replacing a tooth: with a denture, a bridge or an implant, in ascending order of workload and cost. While extraction is often cheap, the cost of replacement with an artificial tooth is often more expensive than saving the tooth with a root filling and a crown. That’s why your endodontist is so busy.

What about having no tooth?

This next point may surprise you. But think about it. There is little evidence that losing a tooth, or indeed all your teeth will lead to malnutrition with our excessive, highly refined and digestible Western diet. Many people regularly overdose themselves with vitamin pills. Obesity afflicts one third of us and so if anything a less functional digestion might not be such a bad thing. So let’s forget the idea of saving your teeth on the basis of general health and nutrition. This is just not realistic for all but a small minority of us in Western society.

So why would you want to save your teeth and what are the negatives of losing a tooth? Well, if it is not about general health, then it’s about quality of life and lifestyle. It’s about your self esteem, internal comfort and enjoyment of your food. Not being able to chew certain foods that others normally can has to be considered a disability. It’s also about the external social acceptability. Rightly or wrongly, people may judge you negatively if you have a gappy smile, or know that you have false teeth. Just like if you had messy hair or dress in shabby clothes at a posh dinner. I’m afraid that society really is that shallow. These issues, and the fear of future suffering and
pain are what motivates people to spend large amounts of money at the dentist to ‘save their teeth’. Hopefully from the prevention information above you have realised that the more effective and very cheap way to really save your teeth is to have one or less sugar attacks per day, and floss and brush impeccably. Do still go for regular dental checkups, but remember that spending large amounts of money on dental treatment can only remove previous disease and repair the damage. Dental treatment generally can not prevent remaining tooth structure from dissolving. New decay and gum disease will return if the causes (sugar and plaque) are not controlled, no matter how fantastic the dentistry. Disease prevention in your daily life and regular dental check-ups is the only long term solution.

What can happen when you lose a tooth

Losing a tooth has many effects. Often people feel saddened and slightly decrepit. It’s older people have missing teeth, don’t they? People hate change, especially in the intimate space of their mouth. The gap feels enormous when the local anaesthetic wears off. Your self esteem will suffer. You will also immediately notice that the food slips into the gap when you chew, and you have to learn how to rechannel the food between remaining opposing teeth with your tongue and cheeks. Over time your brain will register these changes and learn the required skills to begin to cope with or at least accept your new disability.

There are also biomechanical changes which you may not be aware of. Clearly, the remaining teeth will need to share the mechanical load previously borne by the extracted tooth. While this may not be significant for one lost tooth, a few lost teeth must increase the wear and tear on the others. The damage takes time, with small cracks appearing and then slowly spreading until the tooth breaks apart. Another effect is movement of adjacent teeth. Typically the tooth behind the gap tips forwards, trying to close the space. Of course the gap is rarely closed, but the tilting
misaligns the biting surface and puts an unnatural sideways stress on the root. This makes chewing less efficient, and can encourage root cracks and gum disease. The opposing tooth can also grow (erupt) into the gap. Your jaw naturally moves sideways and forwards as you chew, and over eruption can interfere with these movements. This can cause high stresses on the teeth, soreness of the jaw muscles and damage to the jaw joint. Drifting of teeth may also prevent the later fitting of a false tooth, so you will have lost the choice.

Finally, loss of appearance is important to most. Even premolars and first molars are often seen on broad smiling, and so only loss of your very back molars will not change your appearance. If you want to maintain that smile, you’ll need to keep your own tooth or arrange an expensive replacement.

**What is a denture?**
Dentures are artificial (prosthetic) teeth which you can remove.

**Full Dentures**

The word denture comes from the French (les dents) for teeth and in English means specifically false or prosthetic removable teeth. The teeth are usually made of a type of hardened plastic called cross linked acrylic. They are held in place on a base of softer pink acrylic plastic which replaces any missing gum. The denture sits on the remaining gum where the natural teeth once were. If there are no teeth in that jaw, then the denture is called a full or complete denture and is held in rather badly by your mouth muscles and air pressure, a bit like a rubber suction cup. It’s very difficult to eat like you did with your own teeth before. Most full denture wearers have to accept that they are dental invalids. Just like you can’t expect to run well with a prosthetic leg, you will find difficulty in eating hard or sticky foods with full dentures. The denture will rub the gum and cause painful ulcers. The upper denture’s thick plastic plate covers taste buds on your palate reducing your taste enjoyment.
Food can get under your dentures making them uncomfortable. In particular, lower full dentures are very difficult to wear because there is less area of jaw bone to support them. If you really understood the plight of full denture wearers then you would be certain to control the frequency of sugar attacks and clean scrupulously. Prevention of dental disease is the best and cheapest way to avoid this awful disabled state.

**Partial Dentures**
If some teeth remain, the denture is called a partial denture, and thankfully remaining teeth can help hold it in place. Partial dentures can be quite successful in returning function and appearance when designed and made well. Two or three small metal spring clips called clasps catch onto bulges on your natural teeth to hold the denture in. These clasps can usually be hidden from view in most cases by good design if you have enough remaining back teeth. Sometimes small alterations to teeth must be done to improve the denture’s fit and retention. However, be aware that partial dentures come in two types. The cheap and less effective, and the expensive and more effective.

**All Plastic Partial Dentures**
The cheap type is made all of plastic except for the embedded metal clasps used to hold the denture in place. When you bite on this type of denture the forces are all transmitted onto the gums. This works, but the gums can be sore after much chewing, and the pressure can make the jaw bones and gums shrink back more, although poor cleaning can also be responsible for this gum disease around teeth. These partial dentures resting just on the gums are known in professional slang as “gum strippers” and for good reason. Eventually remaining teeth may get loose and need to be extracted. They should really only be used as temporary dentures, but for reasons of cost are often used for years. Temporary use is acceptable and is common in endodontic practice where a front tooth root is being treated. It keeps you looking good and allows the endodontist to better seal off the root canal without having to put a metal post inside.
Cobalt Chromium Partial Dentures

The more expensive type of partial denture is like a well made piece of custom jewelry. It has the same plastic teeth but the plastic pink gum part can be made much smaller, just around the plastic teeth. This is because the main strength of the denture is provided by a special thin metal alloy framework. This strong alloy is made of a mixture of two metals called cobalt and chromium. You will know of chromium as the shiny metal on old fashioned car bumper bars. This silvery cobalt chromium alloy doesn’t corrode and is very strong so can be made into a very thin frame of one or more flat bars. These are so much more comfortable than thick lumps of plastic in your mouth, and allows you a full taste sensation over your palate. The metal clasps are part of the framework so can be made very accurately to hold the denture in. Importantly, the framework can be made to have small projections of metal which rest onto the biting surfaces of remaining teeth. This means that the biting forces are borne by the teeth to some extent and so the gum stripping problem is solved. Teeth are designed for biting forces; gums are not. The design of the shape is crucial to how well the denture looks and functions so it is a skilled job to make a decent cobalt chrome partial denture. In most cases no metal shows even when you smile unless you really have no back teeth left to clip on to. Some patients worry that the clasps might damage their teeth. If this happens it is very slight and no worse than normal tooth wear.

However, what does cause a lot of damage is plaque collecting around parts of the denture. This may lead to decay and perhaps gum disease. But remember it is not the denture causing the disease. It is the plaque and frequent sugar. With good diet control and cleaning of the teeth and the denture, new disease will not be a problem. Yet again you see that prevention is the only way to get a long term solution whatever the treatment method.
What is a Bridge?
A bridge is a series of connected prosthetic crowns which span gaps in a row of teeth. This structure is usually made in one piece to span the gap, just like a bridge spans a river. Hence the name bridge. There is no false root under the prosthetic crown in the gap. The adjacent teeth are called abutments because they abut the gap, and their prosthetic crowns are called retainers because they fix the bridge in. The prosthetic crown between the two is called the pontic, from the Latin (and French) for bridge. Bridges can be longer than just three teeth if there are longer or multiple gaps. The advantage of a bridge is that it provides a tooth which is fastened in and so seems like your own tooth. However, bridges suffer the same problems as crowns regarding new decay and pulp death or root filling reinfection. Decay prevention is the key. The stakes are higher because if one abutment tooth decays, then the whole bridge may have to go. The more abutments you have, the greater the risk of failure. Keep bridges short for best reliability and easier maintenance. Like crowns, bridges are too destructive of tooth material if adjacent teeth are not already mostly filling material.

What is an Implant?
A dental implant is a prosthetic tooth fixed to a titanium bolt typically about 4 mm across by 10 mm long. This bolt is screwed into your jaw bone with some out patient surgery at an oral surgeon’s or a gum specialist’s (periodontist’s) practice. Titanium is a cheap and abundant metal, but very special because the bone can grow and stick right up to its surface, rigidly fastening it into the jaw bone. The procedure is technically about as complex as removing a troublesome lower wisdom tooth, but easier from your point of view because there should be much less soreness and swelling afterwards. This is because the site is not infected beforehand. Implants can be very effective with about 80% to 95% success rates over 10 years. This may equal the success
rate of good root fillings. However, for both root fillings and implants the high success rates are obtained only if strict rules are applied in selecting suitable patients and if the work is done to a high standard. For implants, the critical factor is whether there is enough bone left in which to bury the implant. This can be a problem, particularly for back teeth. There are methods of adding bone (grafting) but this is less reliable and the bone may dissolve later. Several specialists are required to place an implant. The prosthodontist coordinates the process and will refer you to either a gum specialist (periodontist) or oral surgeon for the surgery. It’s best to consult these specialists ideally before the extraction is done so that the extraction can be carried out with minimal bone loss. Generally the implant bolt will be placed about three to six months after the extraction, although some can be placed immediately. There is then a delay of three to six months to allow the bone to attach. They can also be placed years later if sufficient bone remains. Be aware that after a tooth is lost the bone continues to dissolve away slowly, so don’t delay if you want an implant.

The other issue with implants is the workload for patients of multiple appointments and the discomfort of surgery. Previously, two surgical visits were required and the new tooth could not be placed for many months. Recently, new designs of implant with better surfaces work better and can require only one surgical visit. Some prosthodontists are also currently experimenting whether a tooth can be attached straight after this surgery, rather than waiting for the bone to attach. This immediate loading technique needs more confirmation so you may not wish to try this yet.
The final problem is cost. Implants currently are the most expensive option compared with a root filling and a crown, or an extraction and either a partial denture, a bridge or an implant. This cost is not likely to decrease much as the majority of the costs are labour fees of the laboratories who manufacture the parts and the clinicians who fit them. These parts and fittings are each customized to a specific patient and so can not be mass made to reduce costs.

Typical Costs of Various Options

You can not make an informed choice of whether to save or replace your tooth unless you are aware of the costs as well as the technical benefits and problems. Prices of dental treatment vary from dentist to dentist, from place to place and with time. Cases may have varying degrees of difficulty and therefore can also vary widely in cost. However, the following might be an approximate guide for Melbourne general dentists and specialists in 2012. This is just a general guide so don’t take it too seriously as wide variations occur.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Root canal therapy</td>
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<td>General dentist</td>
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<tr>
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<td>2400</td>
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<td>Incisor</td>
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<td>1800</td>
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<tr>
<td>Prosthetic crown</td>
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<td>Routine extraction</td>
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<tr>
<td>Surgical extraction</td>
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<tr>
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<td>400</td>
</tr>
<tr>
<td>Specialist oral surgeon or periodontist (implantologist)</td>
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<td>Denture</td>
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### Reasons Why Root Canal Treatment Can Fail

There is very little more distressing for patients motivated enough to spend large amounts of money trying to save a tooth than to be told that their endodontic treatment is a failure. This situation is slightly less distressing if by good diagnostic and treatment planning skills, the bad news is delivered before treatment has begun. At least then only the loss of the tooth rather than loss of both the tooth and the money needs to be reconciled. However, even the best endodontists will have failures during and after treatment, typically about 10% of cases. Most of these patients then will have a keen interest in understanding why their tooth still can’t be saved.

There are many reasons causing a case to fail, but they can be grouped under three headings. Firstly and most commonly the failure is because of continued or new infection. Secondly, mechanical failure can be to blame. The tooth was simply breaks in function and can not be repaired. Thirdly, and less commonly, dental materials may cause some irritation to the surrounding bone. This is a very mild effect compared to that from bacteria.
1. Infection causing failure

a) Original bacteria not all removed or killed
   - Original bacteria still remaining in complicated shaped pulp spaces
     ● Whole root canal(s) not found, which contain bacteria
     ● Canals blocked or inaccessible because of severe curvature, mineral deposits, ledges or dental materials. Remaining unaccessed canal contains bacteria.
     ● Canals found but complex spaces off the main canal still contain bacteria (e.g. fins, lateral canals, apical deltas, dentine tubules)
     ● Pulp space all accessed and medicated well but bacteria very resistant to the antiseptics (e.g. the Enterococcus faecalis bacterium)

b) New bacteria enter the tooth
   ● Rubber dam not sealed, or even used so infected saliva enters tooth during cleaning procedures.
   ● Instruments contaminated with bacteria from saliva when used during cleaning procedures.
   ● Temporary filling leaks allowing new bacteria inside.
   ● Bacteria allowed inside when permanent filling placed.
   ● Permanent filling leaks allowing new bacteria inside.
   ● Tooth cracks allowing new bacteria inside.
   ● Tooth decays allowing new bacteria inside.
   ● Serious gum disease pocket reaches apex or lateral canal letting bacteria into the pulp space (perio-endo lesion).

c) Extraradicular bacteria present
   ● Virulent bacteria colonize outside of root end or bits of dental material outside the root end (e.g. Actinomyces species).
   ● Epithelial cyst present and infected
2. Mechanical Failure

The pathology section above (Page 17) described the entry of bacteria into teeth through gaps around fillings or cracks through fillings and tooth structure. Clearly, making a large hole into the middle of the tooth to get sufficient access to the root canals is going to weaken the tooth substantially more. Most root filled teeth can be rebuilt to have sufficient strength to function, and work well. However, any engineer will tell you that predicting whether the strength of a complex shape like a tooth made up of many different materials, some of them natural and therefore variable, is quite difficult even with computer predictions. Then add in the wide variation of forces and behaviour expected in different locations in the mouth in different people with different diets and the prediction becomes even more difficult. Remember that the dentist can only judge the required strength of your tooth and the expected strength of dental materials by guesswork with no measurements or mathematics, and it is quite surprising that we get it right so often. However, some mechanical failures occur in the dental materials or in the tooth material despite your endodontist’s efforts to identify unrestorable cases from going ahead to treatment.

3. Dental Materials Reaction

Dental materials have little effect on the health of the root end if confined to within the root canal. However, sometimes small amounts of dental materials can exit the root end into the surrounding bone. This will always cause a slight inflammatory reaction on a microscopic level but this is very minor and short lived compared with the effects of bacteria. Most endodontic materials in common use of Australia have little long term toxicity. If small amounts of dental materials do cause a clinical failure, it is probably because they are also contaminated with bacteria.
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About the author

Dr Martin S Gale qualified in 1989 from the University of Newcastle-upon-Tyne, England. He worked as a general dentist until 1991 when he undertook a PhD at The University of Hong Kong. The work studied how well fillings seal their cavities. A new method was developed to map where fillings leaked in three dimensions to identify where new decay was more likely to occur. As a postdoctorate in 1997, Dr Gale then investigated fluoride release from fillings as a method for reducing new decay. He then obtained fellowship of the Royal Australasian College of Dental Surgeons and joined The Specialist Endodontics Program at The University of Melbourne. He is now registered as a specialist endodontist in both Australia and The United Kingdom. He has lectured in Hong Kong, Chicago, Nice, Singapore, Melbourne, Auckland and Tokyo. Dr Gale is currently working in specialist endodontic practice in Ivanhoe, Melbourne.

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