BONES, CALCIUM, PHOSPHATE AND PTH in Kidney Failure
**Introduction**

The problems discussed in this section usually only develop in people who have had kidney function down to less than 40% of normal. More rarely, calcium and phosphate problems can occur in people with other kidney diseases. If you are not someone with kidney failure, on dialysis, or with a kidney transplant and you are aware of some calcium or phosphate problems, you should discuss these with your doctor on an individual basis.

Bone disease is very important for people with kidney failure. Once serious problems have developed, they cannot be fully reversed. Therefore ‘prevention is better than cure’. Blood tests can identify problems at an early stage, and treatment can be altered to reduce the chances of serious problems developing.

Unfortunately, this is a complicated area. Although the authors have tried to explain everything as simply as possible, it is still not easy. The good news is that it is not necessary for people with kidney disease to understand all the details, so don’t worry! Look at the key points immediately below and then any particular issues that affect yourself, and the rest is only there for your information.

**Key action points**

- Understand that some problems with calcium and phosphate can make you feel ill right away, but other problems with your bones or your heart can develop slowly over years, so that preventative treatment will help keep you well.

- Discuss targets for treatment with your Renal Unit – the simplest target is to keep the blood phosphate level below a certain level (ideally 1.8 mmol/l, though 2.0 mmol/l is a more realistic target in some people).

- Understand your diet, so that you have the correct daily intake of phosphate.

- Take medication to reduce the phosphate levels regularly as prescribed, and discuss honestly with your Renal Unit if you are unable to take the medication as prescribed.

**This is a complicated topic. Is it important?**

Problems with calcium, phosphate and a chemical messenger in the blood called parathyroid hormone (PTH for short) can occur in anyone with kidney failure. The
level of kidney function at which problems start to become apparent is about 40% of normal, or an eGFR of 40 ml/min.

Sometimes there are symptoms – in other words someone feels unwell. In many cases, however, problems can start without any symptoms, and slowly cause irreversible damage to the bones, the heart or blood vessels over a period of years.

Preventative treatment can reduce the chances of this irreversible damage occurring, but requires a lot of care and energy from the patient (yourself) and the renal team in hospital.

What is calcium?

Calcium is a mineral that is found throughout the body. It makes up, together with phosphate, the main strength in the bones. Calcium is also used to help ‘power’ muscles, and is carried around the body in the blood. The blood calcium level must be kept very tightly controlled for the body to work normally, and PTH is important in this. Calcium gets into the body from food, and is found particularly in dairy products, green vegetables and eggs.

The normal calcium level in the blood is between 2.2 and 2.6 mmol/l (millimoles per litre).

What is phosphate?

Phosphate is a mineral in the body, and together with calcium makes up most of our bones. Phosphate, like calcium, is also used in other parts of the body to ‘power’ muscle and is used in many other chemical reactions. Phosphate gets into the body in food. Dairy products, nuts and meat are three types of food that can contain a lot of phosphate.

The normal level of phosphate in the blood is 0.8 to 1.4 mmol/l.

What is PTH and why is it important?

Parathyroid hormone (PTH for short) is a hormone (chemical messenger) which is very important in controlling the level of calcium in the blood. PTH is produced in the parathyroid glands. There are usually four parathyroid glands, each the size of a pinhead (0.1cm). They are found in the neck, behind the thyroid gland. The thyroid gland has completely different functions from the parathyroids, they just happen to be next to each other.
If the level of calcium in the blood falls, the parathyroid glands normally produce more PTH, which pulls some calcium from the bones into the blood, normalising the level. If the calcium level in the blood rises above normal, PTH secretion falls, and the level of calcium in the blood falls back to normal.

The normal range for PTH depends on the technique used by an individual laboratory, please check with your Renal Unit if you want to know your local normal range.

**What is Vitamin D and why is it Important?**

Vitamin D is a chemical needed so that calcium can get from food into the body. A little Vitamin D is absorbed from food, but most is made in the skin, in a process that only occurs if the skin is stimulated by sunlight. Even then, vitamin D has to be converted to an active form in the kidneys.

Vitamin D blood levels are not routinely measured by most Renal Units, as it is not necessary to measure Vitamin D except in very rare cases.

**What can go wrong with Calcium, Phosphate, PTH and Vitamin D in Kidney Failure?**

If someone developed kidney failure and went onto dialysis, the following sequence of events might occur. However, preventative treatment can stop many of these problems.

A fall in the blood level of calcium is the first major change. As the kidneys do not convert vitamin D into its active form, calcium does not get into the body from food, and the blood level of calcium can fall. The treatment is to replace active vitamin D.

Levels of phosphate in the blood rise, because the kidneys are not excreting excess phosphate into the urine. High levels of phosphate can cause itching. The treatment is to reduce phosphate levels by diet, dialysis, and medication.

PTH may be produced in large quantities, stimulated by low levels of calcium in the blood. The PTH tries to keep the calcium level in the blood normal by increasing calcium absorption from food, but also takes calcium out of the bones. Eventually the parathyroid glands work so hard they go out of control, and cause persistently high calcium levels. This may require an operation to remove the glands (the operation is called a parathyroidectomy.)
Abnormal Calcium, Phosphate and PTH levels - Causes, Effects and Treatment

High and Low Calcium – Causes, Effects and Treatment
Low calcium levels in the blood can occur in kidney failure when there is insufficient Vitamin D available, or in people who have already had surgery to remove their parathyroid glands. Low calcium levels may cause no symptoms. Very low levels can cause muscle twitching and spasms, especially in the face and arms. The treatment is to give Vitamin D and calcium supplements in tablet form. An injection of calcium may be used if there is muscle spasm.

High calcium levels in the blood can be caused by high levels of PTH, or by too much calcium getting into the body because of treatment with calcium and vitamin D tablets. This may cause no symptoms, but high levels of calcium can also cause agitation, gritty eyes, and abdominal pain. The treatment is to stop calcium and vitamin D tablets and, in some cases, to perform surgery to remove the parathyroid glands.

High and Low Phosphate – Causes, Effects and Treatment
Low phosphate levels in the blood are not commonly seen in people with kidney failure, but may occur between 2 and 8 weeks after a successful kidney transplant, because the kidney is too leaky and phosphate is passing out through the urine. Usually there are no symptoms, and the treatment is to relax any phosphate restriction in the diet, and to take phosphate tablets.

High phosphate levels occur in most people on dialysis, and also those with advanced kidney failure. Often there are no symptoms, but high phosphate levels can cause generalised itching, which can be severe. Calcium and phosphate can be deposited in tissues, this is known as cactiphylaxis. The treatment is to optimise dialysis, reduce phosphate in the diet, and to take medication to reduce phosphate absorption. Despite these measures, phosphate is very difficult to control in many people.

High and Low PTH – Causes, Effects and Treatment
Low PTH may occur after surgery to remove the parathyroid glands, and causes a low calcium level (see low calcium for symptoms and treatment).

High PTH levels can occur when the parathyroid glands are stimulated. Sometimes PTH can be controlled by using Vitamin D. In some people the parathyroid glands keep producing more and more PTH. This can cause high calcium levels and muscular weakness with aches and pains around the shoulders and hip joints. Eventually, bone disease with shortening of the ends of the fingers and collarbones may occur. The high levels of calcium and phosphate caused by excess PTH can cause chalk to build up in blood vessels and heart valves, known as cactiphylaxis.
The treatment in severe cases is surgery to remove the parathyroid glands. Renal Units check PTH regularly in people on dialysis, and try to plan any necessary surgery before serious complications occur.

**What Treatment can be given for Calcium, Phosphate and PTH Problems?**

There are several types of treatment used. No single treatment is effective for all these problems, largely because dialysis cannot replace 100% of kidney function, and there is almost always a tendency to high phosphate levels.

**Diet**

A reduced phosphate diet will help you control the level in your blood. On a low phosphate diet the following foods should be limited but not avoided:

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<th>FOOD</th>
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<tr>
<td>Milk</td>
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<tr>
<td></td>
<td>1 yoghurt) Can be swapped for 1 small bowl rice pudding/custard</td>
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<td>¼ pint of milk</td>
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Cheese No more than 1oz per day

(Cream Cheese and Philadelphia are lower)

Eggs No more than 1 per day. A maximum of 3-4 per week

Offal e.g. Heart, Liver, Kidney, Sweetbreads.

No more than once per fortnight.

**You should also try to avoid the following foods:**

- Pilchards, Sardines, Kippers, Herrings, Whitebait, Sprats, Fish Roe, Prawns or Crab.
- All Bran.
- Bournvita, Cocoa powder, Horlicks and Ovaltine.
- Evaporated milk, Condensed milk.
- Chocolate (especially milk) and Fudge.
- Chocolate spread, Peanut butter.
- Marmite, Bovril.
- Nuts.
- Plain popcorn.
Meat and fish do contain phosphate, but it is important not to limit these too much as they contain protein. If in doubt discuss this with your Dietitian. It is important that you continue to eat well.

If you are prescribed phosphate binders (e.g. Calcichew, Phosex, Renagel Lanthanum) it is important that these are taken only with meals containing protein (e.g. meat, fish, milk, cheese and eggs). These will help to bring your phosphate level down.

(Written by Caroline Dean, Dietitian, University Hospitals Coventry and Warwickshire, UK)

Good quality dialysis
Good quality dialysis means more effective removal of waste products from the blood. This is very important because phosphate is not removed from the body very efficiently by dialysis. Therefore if the dialysis is not working well, there will be high levels of phosphate with all the problems that can arise from this.

High phosphate levels occur in most people on dialysis, and also those with advanced kidney failure. Often there are no symptoms, but high phosphate levels can cause generalised itching, which can be severe. Calcium and phosphate can be deposited in tissues, known as cailiphylaxis. The treatment is to optimise dialysis, reduce phosphate in the diet, and to take medication to reduce phosphate absorption. Despite these measures, phosphate is very difficult to control in many people.

Therefore, whether treatment is being given with peritoneal dialysis or haemodialysis, there should be checks on the quality of dialysis every so often. If dialysis is not properly effective, it may be necessary to change the dialysis in some way, for example making haemodialysis sessions longer.

Unfortunately even good dialysis does not always remove enough phosphate. Therefore, it is always necessary to restrict phosphate levels in the diet, and it is usually necessary to take phosphate binding drugs.

Vitamin D medication
Since deficiency of vitamin D is one of the main causes of calcium and bone problems in people with kidney diseases, vitamin D can be given as replacement treatment.

Another vitamin D preparation may be used, especially if the PTH level is high. This is called calcitriol. It is more effective in reducing PTH levels that alfacalcidol and is often advised in people on dilaysis who have high PTH levels.
This is not quite so simple as it might sound, because vitamin D taken in food is not active. It needs to be converted to an active form, first in the skin by the effects of sunlight, and secondly in the kidneys. In severe kidney disease the final conversion step does not happen so that a special form of vitamin D has to be given which has already undergone this activation process.

The kidney stops converting vitamin D to its active form when down to about 40% of normal function. Anyone with kidney function down at this level should be considered for vitamin D replacement. However, if the blood calcium level is normal and the level of parathyroid hormone (PTH) is normal, vitamin D therapy is not always prescribed, as research has not shown universal benefits.

The type most commonly used is called ALFACALCIDOL which can be taken as a capsule - usually once a day in the morning. Side effects can include feeling sick - try taking it with food. Sometimes it is prescribed to be taken once or twice a week, in a bigger dose. Alfacalcidol is also available as an injection, and may be given after a session of haemodialysis.

An unwanted effect of alfacalcidol, when taken either as an injection or as a capsule, is that the level of calcium in the blood can go too high, so regular blood tests are necessary to monitor the blood calcium levels. Sometimes a person cannot take alfacalcidol because of repeated high calcium levels.

Medication to reduce phosphate absorption (also called phosphate binders)
Phosphate binders are a group of medicines which bind to phosphate in your food and prevent your body from absorbing the phosphate. They only work effectively in combination with controlling your diet.

Alucaps are a phosphate binder which contains aluminium. It is very effective at binding phosphate, but if taken over a long period of time, aluminium can build up in the body possibly causing memory problems. Side effects of Alucaps include constipation. Alucaps should be swallowed whole 10-15 minutes before meals.

Calcichew and Phosex (calcium acetate) are phosphate binders which contain calcium. Side effects include a chalky taste in the mouth, or sometimes the level of calcium in your blood can rise. Calcichew and titralac tablets should be chewed, and Phosex should be swallowed whole, 10-15 minutes before meals

Sevelamer (Renagel) is a new type of phosphate binder. It doesn’t contain calcium or aluminium. The capsules need to be swallowed whole with meals.
The dose you need to take of any of the above varies according to the phosphate level in your blood. You may need to take different numbers of tablets with each meal depending on how much phosphate is in the meal.

Kidney Transplantation
Unfortunately this does not put everything back to normal.

A successful kidney transplant is the best treatment for kidney failure, but it cannot reverse all the problems that have developed prior to the transplant. Even someone transplanted before they need dialysis may have some problems.

Usually, however, even though all the blood tests may not go completely back to normal after a kidney transplant, serious problems do not develop.

It is important to mention some problems that can occur:-

- Low phosphate levels can occur 2-8 weeks after a transplant if the kidney is too leaky. This can be treated with relaxation of phosphate restriction in the diet, and sometimes phosphate tablets.
- High calcium levels are common in people with kidney transplants. The calcium levels may go back to normal about 1 year after the transplant. In some cases, though, the calcium goes very high (over 3 mmol/l) in the first couple of months after a transplant, and it is necessary to operate on the neck to remove parathyroid glands.
- Other problems with bones can develop after a kidney transplant, especially osteoporosis (thin bones).

Medication to lower blood calcium levels (calcimetics)
A class of drug has recently been developed which mimics the action of calcium, and may be useful in people on dialysis with severe PTH problems. The class of drugs is called ‘calcimimetics’. the drug makes the body think there is more calcium in the blood than is the actual case. This reduces the production of excessive PTH. the blood calcium level can fall as a result, which is good if the blood calcium level is high. A reduction in the lood calcium level can also allow a higher dose of calcium-containing phosphate binders to be used to control the blood phosphate level, without at the same time causing a high blood calcium level.

The first drug in this class to become available in the UK is called Cinacalcet, with the trade name “Mimpara”. It can certainly reduce PTH levels in patients with very high PTH levels,
and is therefore a possible alternative to an operation to remove overactive parathyroid glands. It can cause nausea and sickness, but is generally easy to take. However, it is very expensive, and at present has been approved for widespread use by the National Institute for Clinical Excellence (NICE). If it is used, it will be prescribed by the renal specialist and will require careful monitoring of the blood calcium and PTH levels.

**Surgery to Remove Parathyroid Glands**

In some people the parathyroid glands go out of control and produce far too much PTH. In some cases the only treatment is surgery on the neck to remove the parathyroid glands. The medical name for this operation is parathyroidectomy.

**Why is parathyroidectomy performed?**

Parathyroidectomy is performed to remove parathyroid glands that are producing too much parathyroid hormone (PTH). Too much PTH causes high calcium levels in the blood and, over a period of time, can cause damage to the bones, blood vessels and heart.

There are usually four parathyroid glands, each one the size of a pinhead (0.1cm). In people with kidney failure needing parathyroidectomy, all of the glands are enlarged, sometimes to the size of a small pea (0.5cm).

Parathyroidectomy is also necessary in some people who do not have kidney failure. In these cases only one of the glands is usually enlarged.

**Are enlarged parathyroid glands cancerous?**

It is very rare for enlarged parathyroid glands in a kidney patient to be cancerous.

**Who does the operation?**

The operation is technically quite difficult, because the parathyroid glands can be very small and can sit in variable positions. Therefore the operation is performed by a specialist surgeon with particular expertise.

**What tests are needed before the operation?**

First, several blood tests to measure the PTH level will have been performed, to confirm absolutely that there is a need for the operation.

Because the parathyroid glands can be in variable positions, many surgeons ask for scans of the neck before surgery to try and localise the glands. Scans may use ultrasound (sound waves), X-rays, magnetic scanning (MRI), or radio-isotope (nuclear) techniques. Through an assessment of all the these tests, the surgeon will plan your surgery.
Because paralysis of a vocal cord is a possible complication of the operation, an ear, nose and throat (ENT) surgeon may perform an examination of the vocal cords before surgery. This does not involve an anaesthetic, just the surgeon looking at the back of the throat with a mirror or flexible telescope instrument. Some hospitals perform a vocal cord check on everyone, others only if there is a problem with the voice before the operation.

**How long does the operation take?**
The operation is performed under a general anaesthetic (you are asleep).

Although the operation does not go deep into the body, the surgeon has to operate slowly and carefully. Also, when the surgeon finds the parathyroid glands, it is common to send the samples to the pathology laboratory for an urgent check to make sure a parathyroid gland has been removed (and not a lump of fat or lymph gland, which can look the same). Therefore the operation often takes up to 2 hours.

Recovery from the operation is usually fast, with people being out of bed the next day and walking around the day after. However, because blood tests need daily monitoring for the levels of calcium, most people are in hospital for another 4 or 5 days after the operation.

**How much will the scar affect appearance?**
The surgeon needs to make a cut in the skin about 10cm (4 inches) long. This is made in one of the skin fold in the lower neck, along the line where a necklace might run. The scar normally heals very well, but is clearly in an area where it may be visible. This can affect someone’s appearance, though usually not badly. The scar can be covered by clothing – it would be under a roll-neck jumper or top, and is also below the level of a shirt with necktie. Some people wear a necklace that is the right size to lie just over the scar.

In most people, however, the scar is either virtually invisible, or does not turn out to be a social embarrassment.

**What are the complications of parathyroidectomy?**
As with any operation, there are possible complications.
Complications of any operation - Any general anaesthetic carries a risk to the heart, or of chest infection. For someone who is otherwise young and fit, even if they have kidney problems, these risks are not great. However, if someone is older with a history of heart trouble or chest trouble, there may be risks of complications and death. Each person should check with their own doctors about the risks in their case.

Bleeding in the first couple of hours after surgery - Surgeons are very careful to make sure there is no bleeding at the end of an operation on the neck. However, bleeding can occur. If massive bleeding occurred, a large bruise could develop and compress the windpipe, making it difficult to breathe. For this reason, the cut is normally closed so that the wound can be opened quickly. Fortunately massive bleeding is exceptionally rare (less than 1 in 100 operations), and there is a very careful watch kept on all parathyroidectomy patients for several hours after the operation.

Vocal cord paralysis, making speech abnormal - The vocal cords are the bands of muscle in the voice box that vibrate and make sounds – in other words, they make speech. Unfortunately the nerves which control the vocal cords run right past the positions of the parathyroid glands. If the nerve is cut, the brain cannot tell the vocal cord what to do and speech is affected. If one vocal cord is paralysed, speech is retained but sounds abnormal. If both are lost, speech is very difficult. One of the main jobs for the surgeon doing a parathyroidectomy is to find these nerves (one on each side) and make sure they are not damaged. The rate of vocal cord paralysis is about 1 in 100, unless there has been previous surgery on the neck, in which case the risk is two or three times as high. If there is a vocal cord problem, speech often improves over a few weeks after surgery, as the nerve has been damaged rather than completely cut, and can heal.

Low calcium levels - When excess PTH is suddenly removed from the blood stream, blood calcium levels can fall. This can be especially severe in people with kidney disease where the bones have been starved of calcium by PTH, as they can ‘soak up’ large amounts of calcium. Very low calcium levels can cause pins and needles or muscle spasms. It is usually necessary to give large numbers of calcium tablets after parathyroidectomy, and sometimes to give calcium through a drip into a vein.

Failure of surgery to reduce calcium and PTH levels - Sometimes the operation does not work. This may be because there are 5 parathyroid glands, or one is in an unusual place (even the upper chest), or because a gland in its normal position is missed. These problems can occur with the most careful and expert of surgeons. Further blood tests, scans and surgery are then required.
Some people have an operation in the arm as well. Why is this?

If all the parathyroid glands are removed, the body has a permanent tendency to low calcium levels, and large numbers of calcium and vitamin D tablets may be necessary for life. Therefore the surgeon may leave a tiny fragment of parathyroid gland behind, and this may regulate calcium levels normally, reducing the need for tablets. The fragment can be left in its normal position in the neck (the operation is then called ‘sub-total parathyroidectomy’). However, because a gland can become overactive some years later and need further surgery, some surgeons prefer to leave the fragment in a position where any future surgery will be easy to perform. Some surgeons put the fragment in one of the neck muscles, and some put it into one of the muscles in the forearm. These operations are called ‘total parathyroidectomy with autotransplantation’.

There is no scientific evidence to prove that one of these types of operation is better than the other, so different surgeons continue to perform these slightly different variations of parathyroidectomy. If an individual has questions about the type of operation that would be best in their case, it can be discussed with the surgeon.

What treatment is needed afterwards?

Most people with kidney disease who have had parathyroidectomy have to take calcium and vitamin D tablets for some time after the operation. If a portion of gland has been left behind by the surgeon and functions normally, it may be possible to reduce the numbers of tablets.

Long term monitoring of calcium, phosphate and PTH is always necessary, even after successful surgery.

Can the parathyroid glands enlarge again after surgery?

If someone continues to have kidney failure after parathyroidectomy, glands are under constant stimulation and regrowth can occur. Even when the surgeon knows all visible parathyroid tissue has been removed, there is a chance that many years later a gland will appear and more surgery will be needed.

If there is a successful kidney transplant, the stimulus to PTH production goes away or is reduced, and recurrence of PTH problems is rare (so long as there are not problems in the first few months after the transplant).

What is Calciphylaxis?

Calciphylaxis means the deposition of calcium and phosphate in parts of the body other than the bones. The calcium and phosphate form brittle, chalky material. In some cases it can resemble tissues of the body turning into bone. The chemical deposited is, strictly speaking, ‘calcium phosphate’, but it is often just referred to as ‘calcium’.
Severe calciphylaxis is rare but can have serious consequences. Kidney doctors are anxious to control the levels of calcium, phosphate and PTH to prevent severe calciphylaxis.

Calciphylaxis occurs at a faster rate when the levels of calcium and phosphate are high. Chemically, they come out of solution as calcium phosphate. The likelihood of the chemical reaction occurring depends on the levels of calcium and phosphate, and can be predicted by multiplying the blood levels together. The calcium-phosphate product should be less than 4.5. For example, if the calcium level is 2.89 mmol/l and the phosphate level is 2.24 mmol/l, the product is 2.89 mmol/l x 2.24 mmol/l = 6.47 - too high. If the calcium is 2.2 and the phosphate 1.75, the product is 2.2 x 1.75 = 3.85, in the acceptable range (note these examples will not apply in parts of the world where blood levels are measured in different units, such as the USA).

**Calciphylaxis and the heart**

Calciphylaxis can occur in heart valves, causing them to become chalky and eventually to narrow. The aortic valve, which controls the flow of blood out of the heart into the body, can be particularly affected. In some people who have been on dialysis for many years, surgery to replace the valve may be needed. This is a major procedure with a significant complication and death rate.

Recent research has also shown that the arteries supplying the heart (coronary arteries) can develop calcium deposits. The significance of these is not clear. The calcium is deposited in the middle of the artery wall, and is not directly associated with the types of fatty narrowing that causes heart attacks. Further research is necessary to show whether these deposits are important. However, it seems that good phosphate control reduces their appearance.

**Calciphylaxis and blood vessels**

Blood vessels throughout the body can develop calcium deposits, and this can contribute to narrowing, leading to poor blood supply to the feet or other parts of the body. Diabetes and atherosclerosis (narrowing due to cholesterol) also cause narrowing, and all these factors can act together to cause poor blood supply.

**Calciphylaxis and other tissues**

In theory any tissue can develop calcium deposition, but often, even though calcium can be seen on an X-ray, it does not cause any medical problems.
How is calciphylaxis prevented?
All the measures discussed here together with diet, good dialysis, phosphate binders and parathyroidectomy when necessary will reduce the chances of development of calciphylaxis.

What causes Pain in Bones and Joints?
Pain in bones or joints is a common problem in people with kidney failure, or with kidney transplants. It may be due to muscular sprains or arthritis which, of course, may occur whether there is kidney failure or not. Some types of bone disease may not cause pain, others can be painful. It is necessary to talk to your medical team to make a diagnosis – this leaflet is only designed to give helpful information after a diagnosis has been made.

There are some simple treatments you can use for bone and joint pains, once a more serious cause needing specific treatment has been ruled out.

Types of bone disease that can occur in people with Kidney Diseases
Many people with kidney disease do not develop bone disease. However, if they do, there are several types that may occur. Some of these are related to the calcium and phosphate problems mentioned above, and others are not. Some types of bone or joint disease may have developed even if the person had never had any problem with their kidneys.

Some diseases frequently seen in people with kidney diseases are detailed below. Other conditions seen less often (such as rheumatoid arthritis) are not included.

Bone disease due to high PTH (Renal Osteodystrophy)
This is the type of bone disease that occurs when the blood levels of PTH have been very high for a long time. PTH removes calcium from the bones, and the bones try to repair themselves, but cannot do so very effectively. In the early stages, all that can be seen are changes under the microscope if a bit of bone is removed for examination (a bone biopsy).

All kidney doctors try to prevent advanced renal osteodystrophy by medical treatment and parathyroidectomy. Preventative treatment does work, so that the frightening list of problems listed below is seldom seen.

Advanced renal osteodystrophy causes weakness and loss of bones, which can be irreversible. There is a tendency to fracture of bones. Also, bone tissue it lost, especially from the tips of the fingers and ends of the collar bones. This can cause stubby fingers and hunched shoulders. The spine can also be affected, causing curvature. As other bones try to repair themselves, there can be pain around the hips and shoulders, and broadening of the cheekbones and coarsening of the skin.
Adynamic bone disease
Adynamic bone disease has only been recognised in the last few years, and is not fully understood. Although the bones may have normal strength and overall appearance, they are under active. Normally bone is quite active, with constant reabsorption of bone and laying down of bone. In adynamic bone disease, both the reabsorption and laying down processes are slow. This may not be harmful to the bones themselves. Certainly in the short term, severe problems do not seem to develop.

However, the bones cannot help keep blood levels of calcium normal by ‘soaking up’ calcium from the blood when levels are high. Therefore people with adynamic bone disease are prone to high calcium levels, and may be at increased risk of calciphylaxis. It is therefore necessary to monitor the levels of calcium and phosphate very carefully in this condition. PTH levels are normal.

Osteoporosis
Osteoporosis means thin bones. Most people have heard of this condition, because it is very common in the general population. It is also a problem in people with kidney diseases. Osteoporosis, by itself, usually causes no problems. It is not until a bone breaks or a backbone is compressed that problems are recognised. Therefore there is an increasing tendency to check people with kidney disease for thin bones before any problems develop.

Thin bones can result in fractures, especially of the hip or wrist. Also, if the back is very osteoporotic, the backbones can get squashed or have ‘compression fractures’. This can lead to a loss of height, bent back and back pains (NB. there are many other causes of back pain).

Osteoporosis is found especially in women who have gone through the menopause, people who are immobile, and those who have been on steroids tablets (prednisolone) for a long time.

Osteoporosis is diagnosed by a special X-ray called a DEXA scan, and many kidney units are starting to screen patients at high risk of osteoporosis with these scans.

The treatment for osteoporosis consists of sensible exercise (the bones get stronger if they are used), a good diet and stopping smoking. If someone is taking steroid tablets, it maybe possible to stop them. Women may benefit from hormone replacement therapy and, finally, there are drugs which can strengthen bones.
**Osteoarthritis**
Osteoarthritis is one of the commonest forms of arthritis, and occurs in people with kidney trouble just as it does in the general population.

Joints are affected, most commonly the knees, hips and hands.

A particular problem with osteoarthritis in people with kidney trouble is the treatment for pain. Painkilling drugs most suitable for people with osteoarthritis can damage kidneys, and must either be avoided or used with extreme caution. These drugs are the NSAIDS (non-steroidal anti-inflammatory drugs). They are often prescribed, but can be purchased without prescription as ibuprofen (often under the trade names Nurofen or Advil).

**Dialysis Amyloid**
Amyloid is a general term for a range of conditions where there is microscopic deposition of material in the tissues of the body. It has a particular appearance under the microscope.

One particular type of amyloid can cause problems in people who have been on dialysis for over 10 years. It is called dialysis amyloid. Dialysis amyloid is caused by the build up of a chemical called ‘beta-2 microglobulin’. This normally passes out of the body through the kidneys. However, the plastic membranes used in haemodialysis are not as efficient as the human kidney, so that beta-2 microglobulin is not removed well by haemodialysis. Peritoneal dialysis removes it reasonably well, but dialysis amyloid can also occur if someone has been on peritoneal dialysis for many years.

The first sign of dialysis amyloid is usually around the wrist. Amyloid can build up and press on the nerve that supplies the thumb and first two fingers, causing weakness and pins and needles. This is called ‘carpal tunnel syndrome’(there are other causes of this apart from amyloid). An operation can reduce the pressure.

Dialysis amyloid can also cause weakness in the bones around the hips, or in the neck.

Dialysis amyloid is hard to treat. If there is a successful kidney transplant, the excess beta-2 microglobulin passes out of the body quickly. This is the only really effective treatment. By using a ‘high-flux’ dialysis membrane and long hours of haemodialysis, it may be possible to reduce the effects of dialysis amyloid in some cases.
Infection
Infections in the bones or joints are rare, but can be seen in people with kidney trouble. If someone on haemodialysis is prone to getting infections in the blood (perhaps because a plastic tube in the vein is used for dialysis), there is a risk. Infections may cause a joint to become enlarged and red, or cause the development of a severe and unusual pain in the hip or back. Treatment with antibiotics is effective, though surgery or removal of fluid from joints using needles may be needed.

Gout
Gout occurs in joints, which become suddenly swollen, red hot and very, very painful. Gout is caused by the build-up of a chemical called uric acid in the blood. This is normally removed by the kidneys, so gout can occur as kidney failure develops. Also, gout is common in people with kidney transplants, because some of the anti-rejection drugs cause retention of uric acid in the blood.

Sometimes uric acid can deposit in tissues outside joints, usually in the fingers or toes. A swelling containing a white cheesy material develops.

The treatment of gout is with painkillers, followed by preventative treatment once the painful attack has settled down. Preventative treatment is usually effective with a drug called allopurinol. Unfortunately this cannot be used in people with kidney transplants who are treated with azathioprine, because of a serious drug interaction.