



THE NEUROFIBROMATOSIS  
ASSOCIATION

## Neurofibromatosis Type 2

### Information for Patients and Professionals

## **NEUROFIBROMATOSIS TYPE 2 INFORMATION FOR PATIENTS AND PROFESSIONALS**

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# NEUROFIBROMATOSIS TYPE 2 (NF2)

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## **INTRODUCTION**

This booklet is mainly for people who have Neurofibromatosis Type 2, their relatives friends and professionals involved in their care.

It will give some basic information about Nf2 and we hope that you can use the information to ask more questions of the specialist who is treating you. We have tried, wherever possible, to include and explain medical terminology that you may encounter. Words printed in italics are explained at the end of the booklet.

## **ABOUT NEUROFIBROMATOSIS**

Neurofibromatosis (Nf for short) is the collective name for a group of conditions that cause *benign tumours* in the nervous system.

Nf occurs all over the world and affects men and women equally. Until 1970, in most medical books, the different types of Nf were not distinguished. They were all grouped together and called Von Recklinghausen's Disease or Multiple Neurofibromatosis.

This led to considerable confusion because the different types of Nf affect you in different ways.

As medical knowledge progressed it also became clear that the nerve tumours in the different types of Nf are not the same when examined under the microscope.

- Nf1 and Nf2 are different conditions
- If you have Nf1 it cannot turn into Nf2 and vice versa
- It is extremely unlikely that you would have both Nf1 and Nf2

## **There are two main types of Neurofibromatosis.**

### **Neurofibromatosis Type 1**

(Nf1 for short) affect 1 in 2,500 people. In Type 1 the tumours are called neurofibromas and mainly grow on small nerves in the skin.

People with Nf1 usually have a lot of flat brown skin patches, *called café-au-lait patches*. Nf1, for a lot of people, is just a skin condition. However people with Nf1 have an increased chance of having other problems.

These include difficulties with learning, bone problems and nerve tumours inside the body.

### **Neurofibromatosis Type 2**

(Nf2 for short) is rarer than Nf1, affecting about 1 in 35,000 people.

It causes benign tumours to develop on nerves within the body. Almost everybody with Nf2 develops tumours on both nerves of hearing. Benign tumours may also develop on the nerves running down the spine and on the coverings of the brain. The Nf2 tumours are called *Schwannomas* and *meningiomas*.

Some people with Nf2 also have a few benign tumours on the skin nerves and this is why Nf1 and Nf2 became confused. In contrast to Nf1 people have few, if any, café-au-lait patches.

**Doctors are now certain that Nf1 and Nf2 are completely different conditions. If you have Nf1 it cannot turn into Nf2 and vice versa. It is extremely unlikely that you would have both Nf1 and Nf2.**

**THIS BOOKLET IS JUST ABOUT NF2**

## NEUROFIBROMATOSIS TYPE 2 (NF2)

The fact that you are reading this booklet suggests that you have Nf2, or somebody you know does.

You may have had concerns for some time and find the following information gives you some answers. It is a rare condition and it is possible that your doctor may not have come across it before.

Finding out about Nf2 can be worrying and overwhelming. Understanding the cause and effects of Nf2 will help you to deal with it day to day, and to be aware of when to seek help from your Specialist.

It is a variable condition and not everyone with Nf2 will develop all the symptoms described here. Support is available through The Neurofibromatosis Association.

### WHAT CAUSES NF2?

**Nf2** is a genetic disorder that is caused by **a misprint in a single gene on Chromosome 22**. The altered gene will be present at birth but signs of the condition do not usually appear until later in life.

It may be passed on from parent to child at the time of conception or it may start in a family with no previous history of Nf2. About half the people who have Nf2 will be the first in their family.

#### **Nf2: its cause and inheritance.**

- misprint in single gene on Chromosome 22
- inherited from a parent OR
- with no family history starts as a new mutation of the gene
- has 50% or 1 in 2 chance of passing on misprinted gene

A person who has Nf2 has a 50%, or 1 in 2, chance of passing on the condition to each of his/her children.

For more detail please refer to sections on Inheritance and Genetic Testing.

## HOW DOES NF2 AFFECT YOU?

People who have Nf2 are at high risk of developing benign brain and spinal tumours. The growth of these tumours is unpredictable. Most are slow growing and cause minimal problems for years.

Others **may** lead to increasing problems over a few weeks. Although these tumours are not malignant their position may produce significant symptoms.

Small tumours can often be completely removed before leading to serious difficulty, so regular health checks are recommended.

**The problems that can occur in Nf2 will be described in more detail, but include:**

- *Schwannomas* that can affect the hearing and balance nerves, the spine and skin.
- *Meningiomas* which affect the *meninges* (the coverings of the brain).
- *Cataracts*.

Many of the tumours in Nf2 may never grow enough to cause symptoms and may never need to be removed.

Almost everybody who has Nf2 develops tumours, called **vestibular Schwannomas** (formerly known as acoustic neuroma), on the nerves of hearing to both ears. Each of these nerves (the 8th *cranial nerves*) has two parts.

The **cochlear nerve** carries information about sound from the ears to the brain. The brain interprets the information and gives us sound. The **vestibular nerve** carries information about balance to the brain.

Although the gene misprint is present from conception these tumours do not usually grow to a size where they cause symptoms until the teenage years, early twenties or even later.

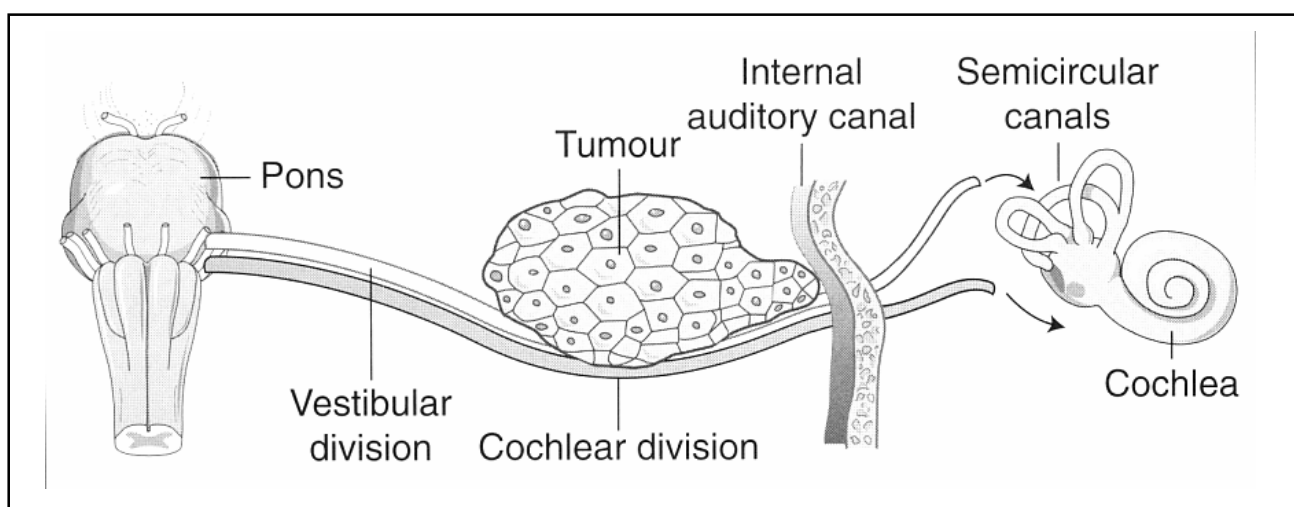
The early symptoms of vestibular Schwannoma may be gradual loss of hearing, ringing or roaring in the ears (*tinnitus*) and unsteadiness, especially when walking on uneven ground or in the dark.

A tumour on one side may grow at a different rate from the one on the other side. The size of the tumours may bear little relationship to the degree of deafness. For example, a small tumour may produce deteriorating hearing whilst a large tumour may only cause minimal hearing loss.

Less commonly a change in sensation of the face, weakness of the face muscles, headache or change of vision may be noticed. Earache is not usually a sign of a vestibular Schwannoma.

### **DIAGRAM SHOWING SITE OF VESTIBULAR SCHWANNOMA IN RELATION TO BRAINSTEM AND AUDITORY NERVE**

*Vestibular Schwannoma on the Auditory Nerve – the 8th Cranial Nerve*



The *Auditory Nerve* enters the side of the pons (a part of the brainstem) and consists of two parts: the cochlear nerve which carries information about sound from the ears to the brain and the vestibular nerve which transmits impulses from the semicircular canals in the inner ear. The semicircular canals affect balance.

Schwannomas that arise from the 8th Cranial nerve affect the head and neck as described above but if they grow large enough to push on the base of the brain (the brain stem) they may also affect the body.

Schwannomas are so called because they arise from Schwann cells that support and protect nerve cells. Schwann cells help to form the myelin sheath that provides the insulation that the nerves need to conduct information (similar to the covering of electric cable).

Although tumours on the eighth cranial nerve are most common and are the “signpost” for Nf2, most people also develop tumours on other nerves at some point.

A **spinal Schwannoma** that grows on a nerve as it leaves the spine (a nerve root) or grows big enough to press on the spinal cord may cause a change in sensation such as tingling or numbness, or pain and weakness of an arm or leg.

**Schwannomas** can also occur anywhere **on the skin**.

They are small, slightly raised areas, often with a roughened and pigmented surface. They rarely cause neurological symptoms but may rub on clothing or look unsightly. They can be successfully removed.

**Schwannomas** on the deeper nerves appear as swellings **under the skin** and can be painful when touched. They can be removed but a surgeon who specialises in *peripheral nerve surgery* should do this.

The **meninges** are the layers that cover the brain and spinal cord and this can be a site for growth of **meningiomas**.

**The problems that can occur in Nf2 include:**

- **schwannomas – benign tumours that can affect the hearing and balance nerves, the spine and skin**
- **meningiomas – benign tumours that affect the meninges (the coverings of the brain)**
- **cataracts**

**Regular *MRI scans* and neurological examinations enable on-going assessment of the growth of tumours and of their effect on the person.**

These benign tumours may not cause any problems, but if they press on the brain or spinal cord may cause a variety of neurological symptoms, for example – tingling, numbness, pain, weakness, headaches and occasionally seizures - depending on their location.

**Cataracts** are cloudy patches in the lens of the eyes. They are common in older people, but the ones that occur in Nf2 are present from early childhood.

They rarely cause a significant problem with vision but may indicate that a person has a fault in the Nf2 gene. Sometimes glasses need to be worn or the cataracts need to be removed by an operation.

Some people with Nf2 have a few brown patches on the skin. These are called **café-au-lait patches** and are completely harmless. They are caused by an increase in the skin pigment (melanin) and are flat, with a smooth round shape and they become darker if exposed to the sun. Not everybody with Nf2 has these.

There may be only one or two of them, and their presence, in people with a family history of Nf2, does not mean that they have definitely inherited the gene, as 10% of the population has one or two of them. (Café-au-lait patches are always seen in Nf1 and in greater numbers than in Nf2).

## **DISEASES RELATED TO NF2**

As doctors have studied Nf2 in more detail they have realised that there are some related conditions.

### *Mosaic Nf2*

When someone with Nf2 is the first person in their family to be affected, the way Nf2 affects them will depend on when the misprint or mutation occurred in the Nf2 gene. If it was in the egg or sperm they develop classical Nf2 because all the cells in their body have the misprint. If the mistake develops once the sperm has fertilised the egg, the problems will depend on when the mistake develops.

If it is very early in the developing embryo, the person will still have the Nf2 gene mistake in most but not all of the body.

Where the gene mistake arose later in the developing embryo, the person will only have Nf2 in part of their body. (for example - only half of their brain may be affected, or one arm or leg).

- The presence of a mixture of cells, some with normal gene copies and some with misprints is called **mosaicism**.
- About 10 – 20% of people with Nf2 have the mosaic form.
- People who have the mosaic form of Nf2 are more mildly affected and have a smaller risk of passing Nf2 to their children.

### **Schwannomatosis**

There is another condition, called **Schwannomatosis**, in which Schwannomas grow on nerve tissue. In Schwannomatosis tumours are largely confined to the spine and under the skin. Tumours in the head and cataracts are not present.

## HOW IS THE DIAGNOSIS OF NF2 MADE?

All the tumours that develop in Nf2 can occur as “one-off” problems in the general population. Doctors begin to think about a diagnosis of Nf2 when they see someone with a vestibular Schwannoma on both hearing nerves, multiple meningiomas, spinal Schwannomas or any combination of these.

Doctors may be alerted to Nf2 if there is a family history of these tumours, or when the tumours develop at a particularly young age.

When Nf2 is first diagnosed in a family it is because someone has gone to see a doctor with Nf2 related symptoms.

However when a parent knows they have Nf2 their children may be diagnosed before symptoms appear. This is discussed further in the section on genetic counselling.

Most of the tumours in Nf2 are identified by performing a brain or spine scan. There are two types of scan that can be used – the *CT scan* and the *MRI scan*. **The CT scan** (Computerised Tomography) uses X rays to produce cross sectional pictures of the head at different angles.

**The MRI scan** (Magnetic Resonance Imaging) builds a picture using magnetic vibrations instead of X rays. It is usually necessary to have an injection into the vein to help brighten the picture on the scanner. The MRI scan is the more accurate for identifying and measuring vestibular Schwannomas.

The MRI scan is the most accurate type of scan for identifying and measuring vestibular Schwannomas and for diagnosing other Nf2 tumours.

Both these types of scan are safe, do not cause pain and, in an adult, do not need an anaesthetic. These scans are also used to diagnose the other tumours that can occur in Nf2.

## TESTS AND TREATMENTS FOR NF2

Once a person has been diagnosed as having Nf2, it is recommended that they have a full initial assessment which includes a detailed neurological examination

When Nf2 is first diagnosed the following are recommended:

- neurological assessment – for example testing of balance, strength and sensation in the body
- hearing tests
- eye examination
- MRI scans of head and spine

(testing balance, and the strength and sensation in their bodies), hearing tests, eye examination and MRI scans of the head and spine.

This allows the person and the doctors to assess how Nf2 is affecting them, and to plan management.

The time around diagnosis can be difficult. A person who goes to the doctor's for symptoms from only one of their tumours, may find that there are others showing on the scan.

It is important for the person to remember that many of the tumours in Nf2 are slow growing and that some never grow to a size big enough to cause problems.

Another difficulty is discovering that your relatives may also be at risk of having Nf2. Having to tell them this is not always easy.

After the initial evaluation, discussions and decisions about treatment take place. They are based **mainly on the symptoms the person describes**, alongside the results of physical examinations, scans and hearing tests.

Unless one of the tumours is causing a lot of problems, the person may be advised to have no active treatment initially but just to have all the tests repeated after a period of time (usually around six to twelve months).

Having regular MRI scans and neurological examinations enables ongoing assessment of the growth of tumours and their effect on the person.

It is very important to have a detailed discussion with a specialist who is familiar with Nf2:

- to find out about the various options for treatment
- to consider the potential benefits and risks of any operation or treatment

## The Treatment of vestibular Schwannomas

No two people with Nf2 have vestibular Schwannomas that affect them in exactly the same way. *ENT* surgeons, neurosurgeons and neurologists will advise each person on the treatment options for them, based on physical examination, scan results and hearing tests.

Treatment will depend on the size of the tumours, whether they are pressing on the brain as well as the hearing nerves, how rapidly the tumours are growing and how much deafness the tumours have caused.

Vestibular Schwannomas grow on the hearing nerves that lie near to the nerves that supply power and sensation to the face – the Facial nerve or 7<sup>th</sup> Cranial Nerve. They also lie near to the balance part of the brain, and the brain stem through which the nerves pass from the main part of the brain to the rest of the body.

Operations in this area are therefore complicated.

They are best carried out by teams of ENT surgeons and neurosurgeons who have had a lot of experience in vestibular Schwannoma surgery, both in people with and without Nf2.

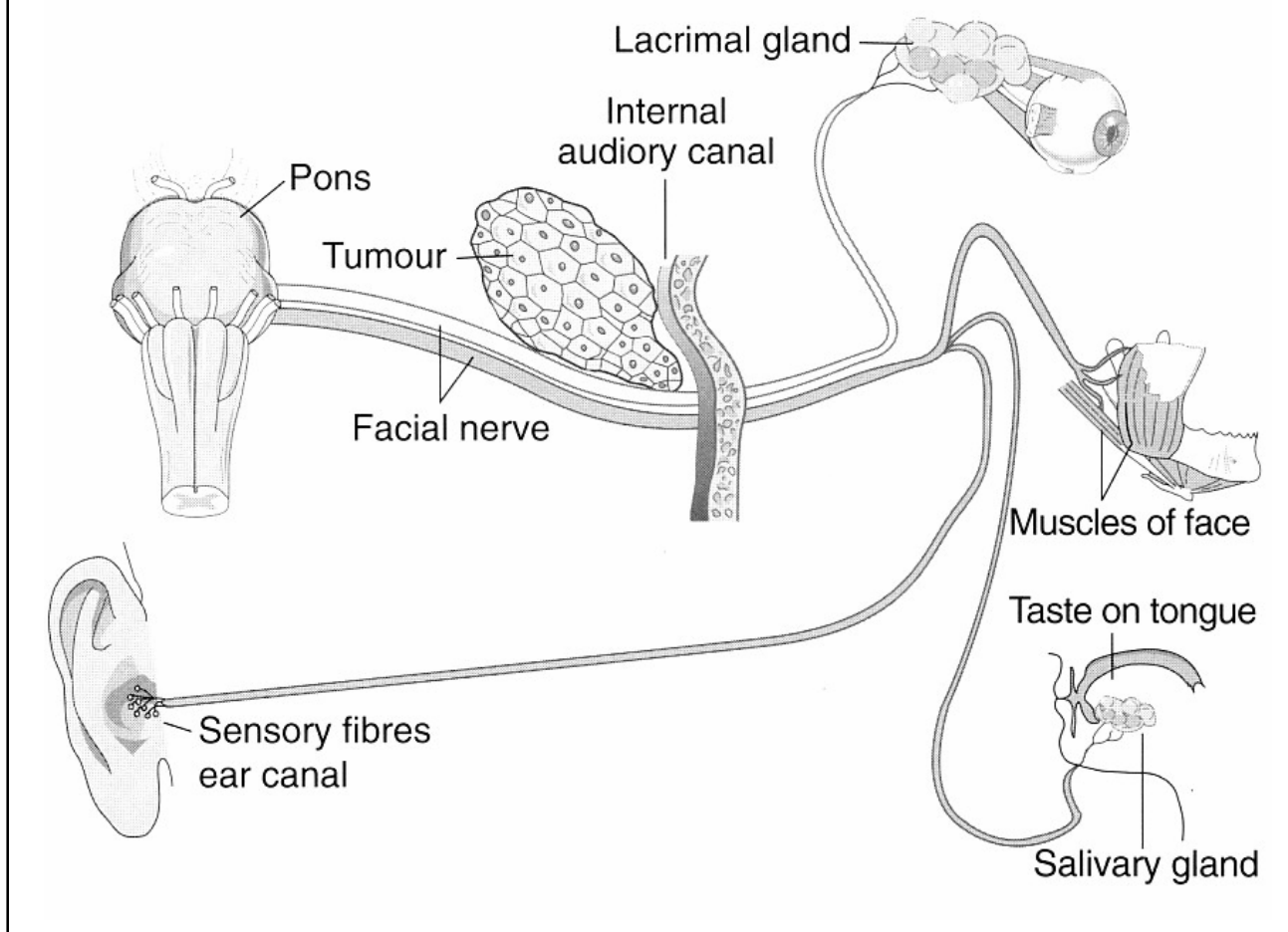
The treatment of vestibular Schwannomas will depend on:

- the size of the tumours
- whether they are pressing on the brain as well as on the hearing nerves
- how rapidly they are growing
- how much deafness the tumours have caused

It is difficult for surgeons to remove the vestibular Schwannoma and leave the patient with exactly the same level of hearing – often hearing is worse, or lost altogether, after the operation.

In larger tumours, some damage may be caused to the nerves to the face, the Facial Nerve. The smaller the tumour at the time of operation, the less chance this damage has of occurring.

## DIAGRAM SHOWING SITE OF VESTIBULAR SCHWANNOMA IN RELATION TO THE FACIAL NERVE



### The Facial Nerve – the 7<sup>th</sup> Cranial Nerve

The auditory and facial nerves are normally next to each other so every vestibular Schwannoma will involve the facial nerve.

The facial nerve arises from the side of the pons (a part of the brainstem) and supplies the muscles that move the face, the lacrimal and salivary glands, and carries taste sensation from part of the tongue.

Because surgery for vestibular Schwannomas can be difficult, a newer treatment has been developed which shrinks the tumours with x-rays (***the gamma knife, often called stereotactic radiosurgery, or fractionated radiotherapy***). These treatments are only possible for tumours under a certain size (approximately 3cm in diameter). Many people with smaller tumours find it a more acceptable option because it avoids major surgery.

**However, these treatments do have risks.** Some doctors are worried that by exposing the benign vestibular Schwannomas to radiation, there is a risk that the tumour would eventually become cancerous (probably many years after the initial treatment).

It is therefore advised that a decision to have gamma knife or stereotactic radiosurgery is only taken after discussion with doctors who are familiar with Nf2 and its treatment.

**A decision to have gamma knife or stereotactic radiosurgery should only be taken after discussion with doctors who are familiar with Nf2 and its treatment.**

A new technological development, the **auditory brain stem implant (ABI)** can now be offered to some Nf2 patients. This is a computer chip that is inserted into the brain at the time of an operation to remove a vestibular Schwannoma. It does some of the job of the normal hearing nerve.

It does not give a return of hearing, but gives an awareness of certain environmental sounds and is an aid to lip-reading. The ABI technology is improving all the time. This new treatment is only available in Specialist Nf2 Centres.

#### **An ABI user`s experience:**

*"I am more aware of things going on around me and this helps me to feel less isolated."*

*"It helps me to lip-read if I am talking to one person, but if I am one of a group of people I still can't work out who is talking, until it is too late."*

*"The ABI amplifies **all** sound so in noisy situations it isn't usually very helpful. I usually switch it off if I am at a party."*

*"It takes a while to get used to, but now I wouldn't be without it. I feel undressed without it."*

Alternatively it may be possible to have a more developed form of implant, called a **cochlear implant**.

These are usually used for treating adults who have become deaf for reasons other than Nf2 and children who are born deaf. It may be useful for the small number of people with Nf2 where a tumour has been removed without damage to the acoustic nerve.

**It is essential to have a detailed discussion with a specialist who is familiar with Nf2, to find out the various options that may be available and to consider the potential benefits and risks of any operation or treatment.**

Whichever treatment is chosen it is difficult to treat vestibular Schwannomas without causing damage to the hearing nerve and subsequent permanent deafness. It is therefore important to find out what help is available, at an early stage, for people who are losing their hearing.

A **Hearing Therapist** can assess the problems the vestibular Schwannomas are causing, advise whether a hearing aid would be helpful and give hints on how to live with tinnitus.

As people's hearing gets more difficult they can be introduced to lip-reading, signing and to various communication aids. Referral to a Hearing Therapist can be requested from your ENT consultant.

**Learning to lip-read and/or communicate by sign language is best undertaken whilst you have some useful hearing.**

### **The treatment of other Nf2 tumours**

The treatment of the other tumours that occur in Nf2 is usually more straightforward because the surgery is not close to such a complicated part of the nervous system.

For all of the other tumours in Nf2, surgeons would only suggest an operation if the person's symptoms from the tumour were worsening and permanent damage to the nerves was being threatened.

**Treatments are based mainly on the symptoms the person describes, alongside results of physical examinations and scans.**

**It cannot be stressed enough that many of the other tumours seen on scans in Nf2 may never grow enough to cause symptoms and may never need to be removed.**

### **IN SUMMARY**

People who have Nf2 need regular examinations to check their hearing and neurological function. Scans of the brain and spine, balance tests as well as eye examinations may be needed annually.

The timing of any surgery needs to be carefully considered and should be performed by an ENT surgeon and/or neurosurgeon with special expertise in Nf2. In some instances surgery should be delayed because some tumours may show very little growth over many years.

Because there are often a number of doctors involved in the care of people with Nf2 it is advisable to suggest that one of these act as a co-ordinator.

#### Operations to remove Nf2 tumours:

- should be carried out by ENT surgeons and neurosurgeons with experience of Nf2 surgery
- decision to operate will be based on symptoms the person describes
- take time to discuss benefits and risks of surgery and other options with specialists
- timing is important. Nf2 tumours often show little growth over many years

This could be one of the Specialists or the General Practitioner. There are also a few Specialist Nf2 Clinics in this country where a team of doctors work together to give a co-ordinated service.

**While the problems in Nf2 can be frightening, there is evidence of significant improvements in treatment methods that are very encouraging, and indicate real hope for patients to lead full lives.**

Your specialist will be able to put you in touch with Therapists who can advise about how best to manage balance difficulties and tinnitus. A Hearing Therapist can advise you about using different methods of communication, as it may be helpful to learn to lip-read or to learn sign language.

A Hearing Therapist can:

- assess whether a hearing aid would be helpful
- advise about managing tinnitus
- advise about different methods of communication

Referral to a Hearing Therapist can be requested from your ENT Consultant

Coping with the consequences of Nf2 can be very daunting and it often helps to share the worries by talking about them.

The Nf Association has a team of professionally trained Nf Specialist Advisors who support people with all forms of Neurofibromatosis. They are based in hospitals around the country and are available to offer support,

if requested. You can find out who covers the area where you live by contacting the Nf Association.

**The problems can be overcome and it is usually possible to find someone else who has been through a similar experience.**

## For more information and advice

<b>For more information about Nf2</b>	Ask your GP or Specialist to refer you to a Geneticist at a Regional Genetics Centre. The Nf Association has some Information Sheets which may answer some of your questions.
<b>To find out if other members of your family have Nf2</b>	Ask your GP or Specialist to refer you to a Geneticist at a Regional Genetics Centre.
<b>To ensure that different aspects of your care are co-ordinated</b>	Ask all Specialists to send details to one another or negotiate that one of them acts as co-ordinator.
<b>You would like to have contact with other people with Nf2</b>	Contact the Nf Specialist Advisor in your area via the Nf Association Head office.
<b>For advice about tinnitus</b>	Ask the Hearing Therapist at the Audiology Dept. Your ENT Specialist would refer you.
<b>You want a blood test to look for the Nf2 gene</b>	Ask your GP or Specialist to refer you to a geneticist at a Regional Genetics Centre.
<b>For support in adjusting to hearing loss and change of life issues</b>	Ask your hearing Therapist or Nf Specialist Advisor about the LINK Centre at Eastbourne
<b>For advice on communication — lipreading &amp; sign language classes</b>	Ask the Hearing Therapist at the Audiology Department or your local council about adult education classes.

## some suggestions

<b>For advice about how to minimise balance difficulties</b>	Ask the Physiotherapist or Hearing Therapist at your local hospital.
<b>To find out about exercises for facial weakness</b>	Ask your specialist to refer you to a Physiotherapist.
<b>You want support and an opportunity to talk through your concerns</b>	Contact the Nf Specialist Advisor in your area via the Nf Association Head Office.
<b>For advice and help with communication aids, e.g. Using the telephone, pagers, aids within your home</b>	Ask your local Social Service Department for a meeting with a Specialist Worker for the Deaf.
<b>To ensure that you are kept fully informed about your medical situation and to help you make informed choices about your treatment</b>	Ask specialists to write to you after clinic appointments to summarise your discussion and, where appropriate, to tell you the results of your scans and other tests.
<b>To discuss when &amp; how your children could be tested</b>	Ask your GP or specialist to refer you to a Geneticist at a Regional Genetics Centre.
<b>For advice about caring for your eyes</b>	Ask your ophthalmic surgeon.
<b>For help with speech and eating difficulties</b>	Talk to a Speech and Language Therapist at your local hospital.

## THE INHERITANCE OF NF2

The normal growth, development and function of our bodies depend primarily on the genes. We all have between thirty and forty thousand pairs of genes. We inherit one of each pair from our mother and one from our father. Each cell in the body contains a copy of all the genes.

They are arranged in a specific order on structures called chromosomes. Nf2 is caused by a spelling mistake (misprint, mis-copy or mutation) in one of the genes on chromosome number 22. So a person with Nf2 has one normal and one altered gene.

Nf2 is therefore a genetic disorder. When a parent with Nf2 has children he or she can pass on the spelling mistake in the gene. The chance of this happening is 50/50, or 1 in 2, for most people. The chances are the same whether it is the mother or the father who has Nf2. This kind of inheritance is called autosomal dominant.

About half the people who have Nf2 have no family history.

In them the genetic change has arisen by a mis-copy of the gene, or new mutation, occurring for the first time in them. This can either be the egg or the sperm they were made from, or it has occurred as they developed in their mother's womb. When the spelling mistake arises in the developing embryo, it gives rise to the **mosaic form of Nf2** (described under Diseases related to Nf2).

People who are mosaic for Nf2 have a mixture of cells in the body.

Because the change arose as they were developing in the mother's womb, they have some cells that have two normal copies of the Nf2 gene and some that have an abnormal copy (people with generalised Nf2 have a gene with the spelling mistake in all the cells of their body).

Perhaps as many as 20% of people with Nf2 who have no family history, have the mosaic form.

Because not all the cells are involved, this can mean that they have a milder form of Nf2, and also a smaller than 50% risk of passing the condition on.

- **Nf2 is a genetic condition that is caused by a misprint in a single gene on Chromosome 22**
- **it may be passed from parent to child at the time of conception. The chance is 50% or 1 in 2**
- **it may start in a family with no previous history of the condition**
- **it does not skip a generation**

## GENETIC COUNSELLING

When someone is diagnosed with Nf2 the patient's consultant often suggests referral to a clinical geneticist. In some Centres, clinical geneticists see patients with the specialist ENT surgeons and neurosurgeons in a combined clinic.

The role of the clinical genetics doctor is to draw up the family tree and to work out, with the family, whether Nf2 has started for the first time in the person recently diagnosed, or whether it has been inherited.

They also advise whether other family members need special tests to see if they could be at risk of having Nf2.

### Genetic testing in Nf2

A blood test is now available to analyse the Nf2 gene to look for spelling mistakes. This kind of genetic testing is referred to as a **direct gene test**. If a spelling mistake is found in someone's Nf2 gene then this not only confirms their clinical diagnosis but also gives a way that other family members could be offered genetic testing.

Finding the spelling mistake on the blood sample is not an easy process and results can take up to six months to come through. With present technology, the genetic change is not detected in all the people we know who have Nf2.

In some cases this is because they have mosaic Nf2 and the change will not be present in the blood cells.

Scientists are developing tests that may help mosaic Nf2 to be picked up by looking at other tissue samples, such as tumours that have been removed.

#### Direct gene test

- a blood test that looks for the actual misprint in the Nf2 gene
- the misprint is not detected in all people who we know have Nf2

#### Linkage test

- a blood test that tracks markers for the Nf2 gene through the family
- used when 2 or more people in the family are known to have Nf2

Both genetic tests can be arranged through the Geneticist at your Regional Genetic Service

Another kind of genetic test can be used in families where two or more people have Nf2, but where it has not been possible to find the exact spelling mistake in the gene. This kind of test is called a **linkage test** and it tracks markers for the Nf2 gene through the family.

Once the markers for Nf2 in the family have been identified they can be used to predict whether another person in the family has a high or low risk of developing Nf2.

In a family where a direct gene test or linkage is possible, then one of the ways it can be used is for prenatal or pre-implantation genetic diagnosis. This is discussed in more detail in a separate information sheet.

### Tests for children who are at risk of having Nf2

When children who are at risk of having Nf2 are born, or when somebody is diagnosed with Nf2 and already has children, it is important that the children have check-ups.

The best possible health care for people with Nf2 can be given when the diagnosis is made as early as possible.

**If the children are from a family where genetic testing for Nf2 is possible,** then one of the ways to do this is by a blood test.

If the children do not have the Nf2 spelling mistake then they are not at risk of the condition. If they do have the spelling mistake then they can be offered follow up checks so that Nf2 can be closely monitored.

**The timing of the blood tests in children** at risk of Nf2 is variable. Some parents feel that they want to know whether the children have the gene in the first few months of life.

Other people feel it is better to let the children have general clinical checks in childhood and only have the blood test at a later stage. This may be around the age of ten years when hearing tests and scans, to pick up early Nf2 related problems, would start. Another option is to leave the decision entirely with the children, when they reach an age when they can decide for themselves whether or not they want a test.

**Regular hospital checks are advised** for children at risk of having Nf2. Because some of the eye problems in Nf2 can affect the vision from very early on in life, an eye examination is recommended in the first few months of life.

If this is normal, then no other regular checks are advised (unless the child has any problems) until later in childhood – around the age of ten years when annual clinic assessment and hearing tests begin.

**MRI scans to pick up tumours in Nf2** are carried out at any time if the child has problems suggestive of an Nf2 related tumour, or around the age of ten to fourteen years as a screening test.

If tumours are found, and the children are diagnosed as having Nf2, they are then followed up in the same way as their affected parent.

**If someone is at risk of Nf2, but a genetic test is not possible**, then it is usually recommended that they continue with the screening checks for Nf2 until around the age of thirty.

By then, unless they are from a family where people have developed their Nf2 very late in life, they will have grown through the age when they would develop problems related to Nf2.

**Children at risk of having Nf2 should have:**

**In first few weeks of life**

**Eye examination**

**Aged 10 years**

**Annual clinic assessment and hearing test**

**Any time, if problems arise which are suggestive of Nf2**

**MRI scan**

**From aged 10 to 14 years**

**MRI for screening purposes**

**A blood test to look for the spelling mistake in the Nf2 gene is at the discretion of the parents. This may be at an early age, or at a time when children can make their own decision about testing.**

## **RESEARCH**

The isolation of the Nf2 gene in 1992 was a major step forward in Nf2 research. This helped scientists to look at what the Nf2 gene does in the normal situation and how it causes tumours to develop when it has a spelling mistake.

By understanding this, it is hoped that ways to control the action of the mis-copied gene will eventually be developed.

Other areas of research that impact on Nf2 are the continuing improvements in the kind of MRI scans that are available.

Approaches to treating vestibular Schwannomas are also improving all the time with the development of improved surgical techniques.

Many specialists in the field feel that, eventually, the best approach to treating Nf2 will be through a drug that controls the tumour growth. Research is beginning to look at what kind of drugs could be used.

## THE NEUROFIBROMATOSIS ASSOCIATION

**The Neurofibromatosis Association** was founded in 1981 and has the following aims:

- To provide accessible, up to date **information** on Neurofibromatosis – not only to those who are affected, but to doctors, therapists and other professionals.
- To promote **awareness** and understanding of the problems encountered in the disorder and to improve clinical care.
- To establish and maintain a network of professional **Neurofibromatosis Specialist Advisors** – who are able to support and offer practical help and advice to those who are affected and to their families.
- To provide opportunities for mutual **support**.
- To fund **research** into finding a treatment and, ultimately, a cure for the disorder. We also sponsor scientists to attend International meetings where their input is helping in the search for an effective treatment.

If you would like more information about Nf2, the Association or about the service offered by the Nf Specialist Advisors, please contact:

**The Neurofibromatosis Association**  
**Quayside House, 38 High Street**  
**Kingston on Thames**  
**Surrey KT1 1HL**  
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Email: [info@nfauk.org](mailto:info@nfauk.org)

Website: [www.nfauk.org](http://www.nfauk.org)

The Nf Association, if requested, will be able to put you in touch with a Nf Specialist Advisor in your region. He/she is hospital based and is there to provide support, information and advice, not only for those affected but also for their families and professionals concerned with their care.

Recognising that Nf1 and Nf2 are two distinct conditions, all Nf2 members of the Nf Association receive a supplement designed specifically for people affected by Nf2, along with the quarterly general Nf Association Newsletter. The Nf Association provides opportunities for people with Nf2 and their families to meet others and spend time together. Events include Weekend breaks where people can also get information from experts, and social get-togethers in informal settings around the country.

**The Neurofibromatosis Association has a team of Nf Specialist Advisors who offer support and information. Contact us on:**

#### [EXPLANATION OF TERMS USED IN THIS BOOKLET](#)

**Auditory Brainstem Implant or ABI** – is designed to produce a sensation of hearing by electrically stimulating a structure in the brain stem called the cochlear nucleus.

**Auditory nerve** – Also known as the acoustic nerve or the 8<sup>th</sup> cranial nerve. Connects each inner ear to the brain and carries nerve impulses for hearing and balance.

**Benign** – A term used to describe a tumour that grows slowly by producing new cells and does not spread to other parts of the body. Not malignant, not cancer. See also Tumour

**Bilateral** – On both sides.

**Brainstem** – The stalk-like part of the central nervous system connecting the base of the brain with the top of the spinal cord.

**Café-au-lait patches** – Flat brown patches on the skin caused by an increase in skin pigment.

**Cataract** – A clouding of the lens of the eye.

**Central Nervous System** (sometimes abbreviated to CNS) – the brain, brainstem and spinal cord.

**Chromosome** – String of genetic information carried by the cells of the body. Each person receives 22 non-sex chromosomes and 1 sex chromosome from each parent at conception. A complete set of these 46 chromosomes is replicated within every cell in the body.

**Cochlear Nerve** – carries information about sound from the ears to the brain.

**Cranial Nerves** – The 12 pairs of nerves that spring directly from the brain and brain stem. They include the nerves for smell, sight, eye movement and sensation, hearing, taste and head movement.

**CT scan** (computerised tomography) – A special type of Xray which can provide cross-sectional pictures of the head, spine and internal organs.

**ENT** – Ear nose and throat

**Fractionated Radiotherapy** – the delivery of small doses of radiation over a number of treatment courses.

**Gamma knife** – highly focussed radiation therapy, given as one treatment. Also called Stereotactic Radiosurgery.

**Gene** – Individual piece of genetic information. Genes are strung like beads in a predefined order on the chromosomes. Since each person has two copies of each chromosome, one from each parent, they also have two copies of each gene.

**Malignant** – a term used to describe a tumour which grows in a rapid, uncontrollable pattern and which may eventually spread to other areas (metastasize). See also Tumour.

**Meninges** – The three layers of membrane that surround and protect the brain and the spinal cord.

**Meningioma** – Tumour that grows from the cells of the meninges.

**MRI scan** (magnetic resonance imaging) – This technique does not use Xrays but relies on the magnetic property of the body to produce detailed pictures of the inside of the body. It is particularly useful for detailed pictures of the brain, nerves, muscles, internal organs and cartilage.

**Mosaic** – a genetic term. In Nf2 it is used to describe a person who only has the Nf2 gene misprint (mutation) in some of the cells of the body.

**Mutation** – Change in the genetic material (DNA) of a cell.

**Myelin** – The fatty white material that forms a sheath around nerve fibres and acts as an insulator.

**Peripheral Nerve** – A nerve outside the Central Nervous System – for example, the nerves in the arms and legs.

**Schwannoma** – Tumour which grows from cells which line the nerves of the body. These cells, called **Schwann Cells**, not only protect the nerves but also provide them with the insulation they need to conduct electrical impulses to and from the brain.

**Stereotactic radiosurgery** – see Gamma knife

**Tinnitus** – Buzzing, ringing, whistling or roaring noises in the ears.

**Tumour** – An abnormal growth of cells. Tumours may be malignant in which case they are called cancers, or non-malignant (benign). Non-malignant tumours do not aggressively invade surrounding tissues or spread to other parts of the body, but they may cause significant symptoms depending on their location.

**Vestibular nerve** – Carries information about balance to the brain.

The Neurofibromatosis Association has taken reasonable care to ensure that the information contained in its publications is accurate. The Neurofibromatosis Association cannot accept liability for any errors or omissions or for information becoming out of date. The information given is not a substitute for getting medical advice from your own GP or other healthcare professional.

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