



Genetics and Deafness

This factsheet aims to give an overview of the part genetics can play in deafness. It could be a useful starting point for people who think their deafness might be related to their family history, or for people who would like to get more information before starting a family. It may also be of general interest to people who want to gain a deeper understanding of some of the causes of deafness.

The factsheet covers the following topics:

- What is genetics?
- How are genetic conditions passed from one generation to the next?
- How many people are affected by inherited deafness?
- What is genetic counselling?
- How will genetic research benefit deaf people?
- What genetic research is being conducted into hearing loss?

WHAT IS GENETICS?

Genetics is the study of genes – the basic units of inheritance. Genes are passed down from one generation to the next, encoding family traits such as eye colour or height as well as vital information for normal body development, growth and function. Some types of deafness can also be inherited.

The genetic material is stored in the centre of each cell in the body and the genes are contained in packages called chromosomes. Each chromosome consists of tightly wound molecules of deoxyribonucleic acid (DNA). The genetic code consists of four chemicals, or bases, and it is the order of these bases that form the code telling the cells which protein to make. A human being's DNA is three billion bases long – this is the human genome.

Each person has 23 pairs of chromosomes, with one chromosome of each pair coming from the mother and the other from the father. The first 22 pairs of chromosomes (the autosomes) are numbered 1 to 22, whilst the twenty-third pair, which determines an individual's gender, are called the sex chromosomes. Women will have a matched pair of X chromosomes, whilst men have one X and one Y chromosome. The Y chromosome is very small and is important for determining the male sex.

Although genetic researchers have now produced maps of virtually all the human genome, the function of much of the DNA is unknown. However, there are 28,000 definite genes.

Genetic research has revealed why some families carry inherited conditions, including some kinds of deafness. Many families affected by deafness have benefited from genetic testing and counselling which provides parents and young deaf people with information about deafness: how deafness may be inherited on their family and their chances of having a deaf child. The rapid advances now being made in genetic research may lead to the development of many more such tests and ultimately offer the hope of developing new treatments.

HOW ARE GENETIC CONDITIONS PASSED FROM ONE GENERATION TO THE NEXT?

Though our genes are responsible for carrying family traits from one generation to the next, the genes can develop and carry genetic changes (mutations) to future generations.

If a parent has a genetic change in a gene important for normal hearing, it does not automatically follow that their children will be affected. There are four main ways that the genetic hearing loss can be passed on:

1. An autosomal dominant gene.

A gene carried by one of the 22 pairs of autosomes is known as an autosomal gene. If a genetic change (mutation) acts in a “dominant” way it means that, even though the corresponding gene in the other autosome of the pair is normal, the dominant gene will override it. Such an individual has a 50% chance of passing on the hearing loss to his/her child. Just as the chromosomes are in pairs, so are the genes. When people have a child, each parent passes on one gene out of each pair to the child, so a person with an autosomal dominant gene for hearing loss has a 1 in 2 (50%) chance of passing that gene (and the hearing loss) to their child.

2. An autosomal recessive gene

A genetic change (mutation) which is recessive will not be apparent unless both genes in the pair of autosomes carry the fault. Usually, both sides of the family will have carried the gene for generations but, since the gene is recessive, they will have been unaffected. Only when two parents, both carrying the same recessive gene, have a child is there a chance of their child being affected by a hearing loss.

When two carriers have a child:

- there is a 1 in 4 (25%) chance that the child will receive both hearing loss genes and therefore have a hearing loss
- there is a 1 in 4 (25%) chance that the child will receive neither hearing loss gene and therefore have normal hearing
- there is a 2 in 4 (50%) chance that the child will have normal hearing but be a carrier like the parents.

3. An X-linked recessive gene

The X chromosome is one type of sex chromosome. Genetic changes in genes on the X chromosome usually act in a recessive manner.

A woman who carries an X-linked recessive gene has a 50% chance of passing it on to each of her children but how this affects the child will depend on the sex of the child.

- A son who receives the X-linked recessive gene will have hearing loss because, as a male, he will only have one X chromosome – there will be no gene for normal hearing on his Y chromosome. The small Y chromosome mainly consists of genes involved in male sex determination.
- A daughter who receives the X-linked recessive gene will most likely receive a normal gene for normal hearing on the X chromosome from her father and therefore be a carrier like her mother with normal hearing.

Children of fathers with an X-linked recessive gene will also be affected differently:

- A male with the X-linked recessive gene cannot pass it on to his son because if he has a male child, he must have given his Y chromosome to him.
- A daughter who receives the X chromosome from her affected father will inevitably be a carrier because the father only has the one X chromosome with that gene to give to a daughter.

4. Mitochondrial DNA

In addition to the 22 autosomes each cell also contains an additional piece of DNA, known as mitochondrial DNA. This DNA is separate from the autosomes and is very tiny, only coding for 37 genes. Unlike the autosomes mitochondrial DNA is only passed on by the mother but to all of her children. A father does not pass mitochondrial DNA to any of his children.

HOW MANY PEOPLE ARE AFFECTED BY INHERITED DEAFNESS?

In the UK, about one in every 850 children is born with significant sensorineural (i.e. problems of the inner ear) deafness. Of these babies, half are due to genetic changes that have been passed on from the parents. The most common mode of inherited deafness is autosomal recessive, which accounts for around 75% of all cases. Autosomal dominant genes account for about 25% whilst X-linked and mitochondrial genes only account for about 1% of cases.

In around 30% of cases of inherited deafness, the hearing problems occur alongside other medical problems or minor clinical features (syndromal sensorineural hearing impairment or SSNHI), whilst 70% occur with no other problems (non-syndromal sensorineural hearing impairment or NSSNHI). There are many families with progressive hearing loss of later (adult) onset that are due to mutations. In fact, most of the cases of human autosomal dominant deafness show progressive hearing loss.

WHAT IS GENETIC COUNSELLING?

Genetic counselling is the term used to describe the process of explaining the genetic situation in a family to those concerned, in language they can understand. The aim is to give people information about genetics so that they can make informed choices for themselves, for example, whether they want to take a test, or what they want to do about the information they receive. Genetic counselling does not include therapeutic counselling (i.e. the type of counselling you might have after a traumatic experience or bereavement).

The identification of deafness genes has yielded important information for parents and young deaf people. Thanks to advances in genetic research it is already possible to look for genetic changes in some genes that have so far been identified, providing parents with information on the chances of giving birth to a deaf child. Although at the moment only a minority of people can benefit from this at the moment, in the near future, such testing could be widely available, for those who wish to have it.

Geneticists (doctors) and specialist nurses and counsellors work with parents and young adults to help them understand the cause of hearing impairment and the chances of future children being affected. In the first place, a detailed examination of the family history can help to determine the cause. This process will also include: information from the parents about the mother's pregnancy, labour and delivery; a review of the mother's and the child's medical records; an examination of any possible acquired causes – such as infections during pregnancy. The child (and any brothers and sisters) will also be examined for the presence of any symptoms or signs of syndromal causes (for example, eyes of different colour could be an indicator of Waardenburg's Syndrome).

If there is a syndromal cause, parents may be given precise information on the chance that a future child will inherit the gene. If the child has non-syndromal hearing impairment and the parents have normal hearing with no family history of deafness, the chance is between one in ten and one in six of a further child having a hearing impairment, unless genetic testing can show that the chance for a particular couple is higher, and if a recessive gene is identified as the cause then this chance becomes 1 in 4.

However it is important to understand that many genes are needed for normal hearing and not all of these have been identified yet. So although genetic testing may identify a definite genetic cause of hearing loss in some individuals, at the present time, it cannot confidently exclude a genetic cause for deafness.

HOW WILL GENETIC RESEARCH BENEFIT DEAF PEOPLE?

Genetic Treatments

The longer-term significance of genetic research into hearing impairment lies in its potential to offer a better understanding of the hearing process and what goes wrong when we develop hearing problems. Once scientists know which protein is coded by a deafness gene, they can find out what the protein does in a normal ear and how a genetic mutation affects its function.

However, despite the rapid pace of genetic research, experts are wary of raising unrealistic expectations. The prospect of developing new drug treatments based on this new knowledge, or directly replacing faulty genes – genetic therapy - is very real but it won't happen overnight, much more research is still needed.

WHAT GENETIC RESEARCH IS BEING CONDUCTED INTO HEARING LOSS?

Deafness Research UK has funded research that has led to a number of breakthroughs in our understanding of inherited deafness in recent years. Deafness Research UK researchers played an important part in the discovery of genes for a number of syndromal forms of deafness, including the isolation of genes responsible for:

- Waardenburg Syndrome Types I and II
- Treacher Collins Syndrome
- Pendred Syndrome
- Usher Syndrome Type 1b, and Type 1c

In 1998, a Deafness Research UK team became the first to identify mutations in a gene called Connexin-26, responsible for at least 10% of European families with a single child affected by non-syndromal sensorineural deafness. The discovery of this gene marked the beginning of an important new phase in our understanding of inherited hearing loss, following to the identification of many of the genes responsible for common forms of hearing loss. Perhaps as many as 100 different genes are thought to be involved in deafness. Mistakes (mutations) in any one of these can then result in deafness. Already more than 20 of these genes have been identified.

Deafness Research UK scientists also carried out a major new study of the genes that cause childhood deafness. The project represented an important step forward in the development of a national strategy for genetic testing and will help determine future priorities for research into the isolation of deafness genes.

Currently we have research teams undertaking research into genetic disorders that lead to deafness. One team is working on Branchio-Oto-Renal Syndrome (BOR), caused by a mutation in the gene EYA1. The research will aim to identify other genes that interact with EYA1, which potentially cause other deafness syndromes, and that may also be potential targets for treatment of BOR.

Another team part funded by Deafness Research UK is working on a national study into Usher Syndrome, the major cause of deaf-blindness in the UK. This study aims to correlate the symptoms with the genetic background of the sufferers, which will greatly improve genetic diagnosis of Usher Syndrome and will allow clinicians to give a more accurate prediction of the course of the disease.

FURTHER INFORMATION

If any of your questions concerning genetics and deafness have not been answered by reading this factsheet, contact the Deafness Research UK

Information Service for further assistance. Our Information team will either answer your enquiry directly or refer it to one of our scientific or medical advisers.

Open: 9.00 a.m. to 5.00 p.m., Monday to Friday (a message can be left at other times).

Freephone: 0808 808 2222

Textphone: 020 7915 1412

E-mail: info@deafnessresearch.org.uk

or click the 'ask question' option from our website homepage:

www.deafnessresearch.org.uk

If you would like genetic information about your deafness, you will need to have a consultation in a genetic clinic. There are 30 NHS centres offering genetic counselling for deafness around the country. To get an appointment at one of them, you will need to get a referral from your GP, paediatrician, ENT consultant or audiological physician

Contact A Family

209-211 City Road, London, EC1V 1JN

Helpline: 0808 808 3555

Website: www.cafamily.org.uk/ email: info@cafamily.org.uk

Contact A Family support families with disabled children. They have a leaflet called 'A Genetic Condition in the Family'; a medical directory of conditions, and can put parents in touch with other families in similar situations.

Genetic Interest Group

Unit 4D, Leroy House, 436 Essex Road, London N1 3QP

Phone: 020 7704 3141 /email: mail@gig.org.uk

The Genetic Interest Group is an alliance of organisations that support people affected by inherited conditions. Amongst other things, it has details of genetics services available in the UK.

Deafness Research UK is the only national medical research charity dedicated to helping people with deafness, tinnitus or other hearing problems.

Scientists are now predicting that within the next ten to fifteen years there could be a cure for some forms of deafness and much more effective treatments for tinnitus. Deafness Research UK is at the forefront of this work.

You can support us by making a donation or joining the Deafness Research UK League of Friends. For more information call us on 0207833 1733 or write to:

Deafness Research UK, 330-332 Gray's Inn Rd, London WC1X8EE
Charity no. 326915

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