



Trisomy 9 mosaicism



Trisomy 9 mosaicism (T9M) is a rare genetic condition caused by having an extra chromosome (trisomy) in some of the cells of the body. Like most other chromosome disorders, this makes developmental problems more likely. All the same, the effects of a chromosome disorder can vary very much between individuals and this is especially true of people with a mosaic form of a disorder, where cells do not all have the same chromosome or gene content.

Chromosomes are made up mostly of DNA. They are structures in the nucleus of the body's cells that carry genetic information known as genes. Chromosomes usually come in pairs, one chromosome from each pair inherited from the father and the other from the mother. They are numbered 1 to 22 approximately from largest to smallest, in addition to the sex chromosomes, X and Y, making 46 chromosomes in all.

In trisomy 9 mosaicism there is an extra chromosome 9, making a total of 47 chromosomes, in some cells in the body. The remaining cells have the usual number of 46 chromosomes, with two copies of chromosome 9 in each cell.

Diagnosis: the karyotype

When you are told about your child's chromosome disorder, you are often given a karyotype. This is a way of describing what the chromosomes look like. In trisomy 9 mosaicism, the karyotype usually looks something like this:

47,XY,+9[15]/46,XY[85]

There are two different cell lines, separated by /

In the first cell line:

47 The number of chromosomes in the cells in this cell line

XY The two sex chromosomes, XY for males; XX for females

+9 There is an extra chromosome 9

[15] Out of 100 cells – 15 + 85 – examined, 15 have the extra chromosome 9

In the second cell line:

46 The number of chromosomes in the cells in this cell line. 46 is the normal number

XY as above

[85] Out of 100 cells examined, 85 have the normal number of chromosomes

The karyotype often tells you the proportions of cells with and without the extra chromosome. However, there is no clear link between this level of mosaicism and the degree to which an individual will be affected. In addition, the levels of mosaicism usually vary in different tissues, and so the level in blood may be different from the level in brain cells etc and thus not helpful in predicting health or cognitive abilities.

Sources and references

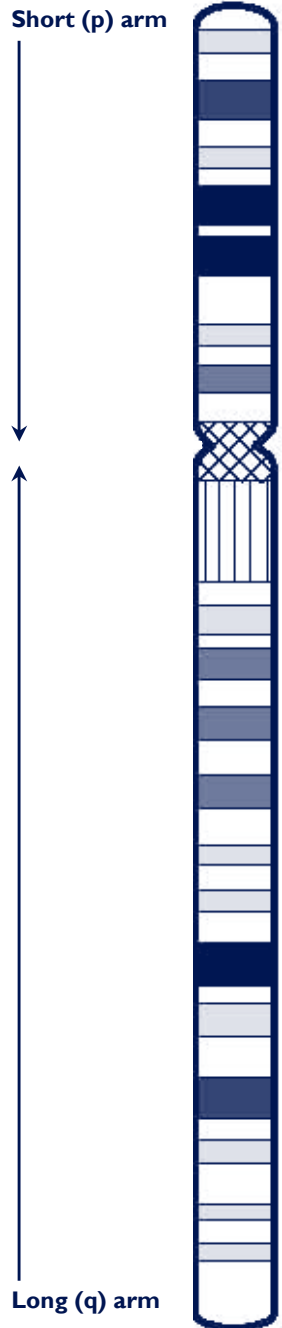
This leaflet explains some of the features that are the same or similar between people with trisomy 9 mosaicism. The information is drawn partly from the published medical literature: the first-named author and publication date are given to allow you to look for the abstracts or original articles on the internet in PubMed (<http://www.ncbi.nlm.nih.gov/pubmed>). Additional information is drawn from *Unique's* database. When the text was revised in 2011, *Unique* had 60 member families with the diagnosis, aged up to 44 years. Fourteen *Unique* member families completed a detailed questionnaire in 2003-4.

How rare is T9M?

Trisomy 9 mosaicism is certainly rare, but no one knows exactly how often it occurs. This is partly because some people may be so mildly affected that they are never diagnosed. When this leaflet was written, more than 60 people with trisomy 9 mosaicism had been described in the medical literature, but they are almost certainly just the tip of an iceberg. There appear to be more females than males: of the cases in the medical literature, three quarters are female, and of *Unique's* 60 member families with trisomy 9 mosaicism, 46 have an affected daughter and twelve a son.

Compared with other chromosomes, T9M is one of the commoner mosaic trisomies. In a large group identified by amniocentesis, 17 per cent of mosaic trisomies involved chromosome 9, making T9M the fifth commonest trisomy detected (Hsu 1997; *Unique*).

What geneticists and paediatricians can tell you about trisomy 9 mosaicism is based largely on the published cases as well as what is known about chromosome 9 from people with full trisomy 9 (an extra chromosome 9 in every cell in the body) and people with extra material, known as a duplication, from part of chromosome 9. Chromosomes have two arms, one short, called the p arm, (at the top in the diagram on the right) and one long arm (at the bottom). There are similarities between individuals with trisomy 9 mosaicism and those with duplications of 9p. Some individuals have an extra chromosome made up of two copies of the short arm, giving four copies of the short arm in all. They have a syndrome known as tetrasomy 9p and they too have similarities with individuals with trisomy 9 mosaicism. *Unique* publishes leaflets on both these disorders – [Duplications of 9p](#) and [Tetrasomy 9p](#) – and these are available on request or from *Unique's* website.



Long (q) arm

Chromosome 9



Key reported features



5 years



16 years

Individuals with trisomy 9 mosaicism can vary very much one from another. Most have developmental delay but a few do not. Many have some difficulties with learning, but the degree varies and a few people have no learning difficulties. The pattern of any birth defects is also different from one individual to another. The list below shows the most common features that have been found in groups of people with trisomy 9 mosaicism. Individual babies and children will almost certainly be different from the general group. They may be affected in some ways but not in others and the effects can be slight or more obvious.

- Similar facial appearance
- Low birth weight
- Slow growth and short stature
- Developmental delay
- A degree of learning difficulty
- The palate (roof of the mouth) may be split (cleft) or high and narrow
- Heart conditions, most commonly a hole between the two lower heart chambers
- The hands and feet may be unusually formed. Occasionally, babies are born with club foot (talipes equinovarus) or with a curved sole to the foot, known as 'rocker bottom feet'. Fingers may be bent or overlap
- Minor abnormalities of the reproductive system, particularly in boys
- Structural anomalies of the brain
- Unusual features of the kidneys
- Limited joint movement; easily dislocatable or dislocated joints, particularly the hips
- Unusually small eyes (microphthalmia) and vision defects
- The gaps between the bones of the skull (fontanelles) may be unusually wide at birth

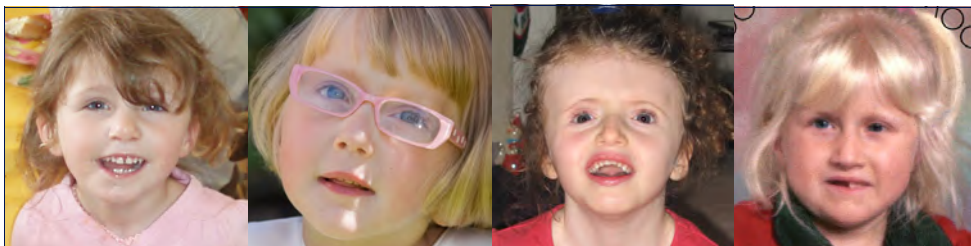
(Lewandowski 1977; Sanchez 1982; Kaminker 1985; Levy 1989; Stoll 1993; Tarani 1994; Arnold 1995; Lindor 1995; Wooldridge 1995; Cantú 1996; Saneto 1998; Schinzel 2001; Gérard-Blanluet 2002; Morava 2002; Chen 2003; Bruns 2011; *Unique*)

Will the pregnancy be different?

Most babies grow slowly in the womb and the diagnosis of intrauterine growth retardation may be the first sign of a problem. Levels of amniotic fluid may also be unusual, with too little fluid (oligohydramnios) occurring three times as often as too much (polyhydramnios). Some mothers have noticed less fetal activity, but in other cases the pregnancy was uneventful.

The medical literature suggests that delivery is usually around or slightly before term, with babies arriving between 36 and 40 weeks. *Unique* records suggest that at least one baby in five is born early, before 37 weeks and delivery as early as week 30 has also been described. Slow growth in the womb means that babies are typically small for dates. Birth weight in one series ranged from 1.361-3.232 kg (3lb-7lb 2oz) and babies known to *Unique* have been even smaller at birth (Stoll 1993; Tarani 1994; Arnold 1995; Wooldridge 1995; Cantu 1996; de Ravel 2001; Schinzel 2001; Stipoljev 2003; Bruns 2011; *Unique*).

Appearance You may find that your child looks a little like other children with T9M.



3 years

4 years

5 years

6 years



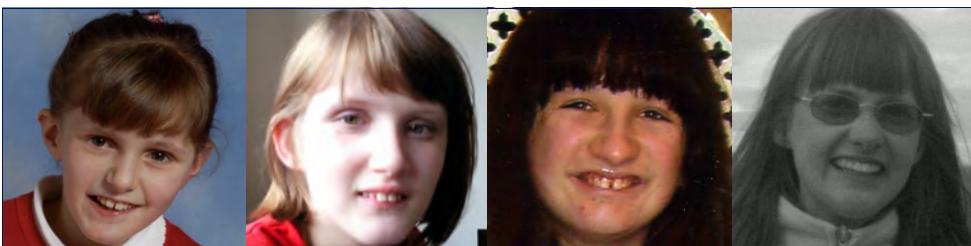
3½ years

5 years

7 years

10 years

18 years



10 years

13 years

14 years

16 years

Very occasionally children with T9M have quite obviously unusual facial features, usually involving the development of the middle of the face. The nose may not have developed fully and *Unique* has one member in whom it did not develop at all, a feature also described in the medical literature. A cleft lip can also occur. Irregular patches of differently coloured skin are a common finding in people with mosaic chromosome conditions. Uneven growth rates on each side of the body may also occur, so that the limbs on one side of the body may be short and the face may look asymmetrical (Wilson 1983; Kaminker 1985; Arnold 1995; Wooldridge 1995; Saneto 1998; de Ravel 2001; Gérard-Blanluet 2002; *Unique*).

Growth



Babies typically start out in life small and remain short. In *Unique's* experience, weight gain is usually slow and children have remained short for their age, although some show catch-up growth and have an average height. There is little information on the heights that adults reach, but one 17-year-old boy was 163 cm (5' 4"), putting him in the lowest three per cent of the population for height (Willatt 1992; Morava 2002; *Unique*).

“ Once fed on expressed breast milk initially by tube and then by bottle, our daughter caught up quickly. She went on to solids at 3½ months and has never looked back. She now has a very healthy appetite and loves cooking.

Feeding

There is almost no published information on feeding in babies and children with trisomy 9 mosaicism, although one study found that 80% of babies had feeding difficulties. The information here comes from the experience of family members of *Unique*. Babies typically have a combination of feeding difficulties, making feeding the most consistent problem faced by parents. Every family that responded to the *Unique* survey reported feeding difficulties and in some families they were considerable. However, by the age of 4 or 5, most children were able to eat small quantities of a variety of foods including fruit, vegetables and pizza.

Many babies initially had low tone (hypotonia) in the muscles of the mouth and face, causing them to have a weak suck. Some babies also had problems with lip closure and difficulties co-ordinating sucking with swallowing. A very high palate added to the problems for some babies and babies with a cleft palate (see page 12) will need specialist support with feeding. An additional problem for some babies was gastro-oesophageal reflux, where feeds return readily up the food passage. Gastro-oesophageal reflux occurred very commonly among the *Unique* families and nine out of 32 affected individuals (28 per cent) experienced aspiration pneumonia caused by inhaling feeds.

Breastfeeding can be a real challenge as babies may not gain weight reassuringly. Giving expressed breast milk from a bottle with an adapted teat may allow easier sucking, and giving formula supplements allows high calorie milks to help weight gain. Some babies with T9M have breastfed successfully but this is not possible for all. To cope with reflux, babies who bring their feeds back can be carefully positioned and only given small feeds but in *Unique's* experience many babies needed prescribed feed thickeners added to drinks as well as prescribed medication to reduce gastric acid output. Transition to solids was typically late and most babies needed solids puréed or cut into bite-sized portions for much longer than typical babies as long-term difficulties with chewing, especially meat, were very common.

All families who were given expert support by a feeding team, speech and language therapist or occupational therapist reported that it was helpful.

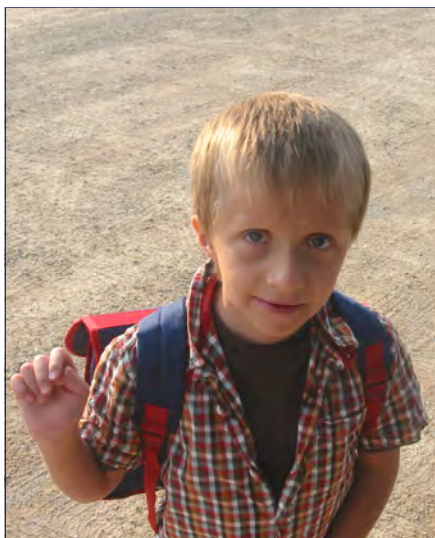
A baby who cannot meet their own nutritional needs can be tube fed or have a gastrostomy, where a tube is placed to allow feeding direct to the stomach. In *Unique's* experience, most children's feeding difficulties were managed without tube feeding. Severe gastro-oesophageal reflux can be controlled with a surgical procedure known as a fundoplication.

Some children who have had long term feeding difficulties as babies can be left with negative attitudes towards food and may be helped by joining a behavioural feeding programme.

Children with chromosome disorders can be vulnerable to dental problems and should have regular dental check-ups. In one child with undiagnosed toothache, chewing improved after extensive dental treatment (Levy 1989; Bruns 2011; *Unique*).

“ She was a very slow feeder as a baby and now eats very small meals and does not like chewing meat. Pizza and sausage go down a treat! - age 11

Learning and schooling



Six years

The range of learning ability is extremely broad, ranging from one child with an IQ of 126, measured at the age of 2, through to others with only mild delay to others with severe learning disabilities. Out of 18 *Unique* members, two had no learning disability, four had a mild difficulty, in two this was moderate, in seven the disability was severe and in three the degree of difficulty was unknown. Within *Unique*, one girl with no learning difficulties took the full range of school leaving examinations at the usual age (Frydman 1981; Saneto 1998; *Unique*).

The snapshots that you can read here give a hint of what some children were achieving at specific ages.

- An 11-year-old girl with mild to moderate difficulties was functioning emotionally and educationally as a 6 to 7-year-old. She could write her name and simple words and was progressing to writing sentences. She dictated to an adult and then copied the resulting script. She could shop with a variety of coins. She understood complex instructions but needed them to be repeated. She started education in a mainstream nursery in a very small group and moved to a primary school for children with moderate learning difficulties where the slower pace suited her well.
- A 5-year-old with severe learning difficulties attended a mainstream nursery and a nursery for children with severe learning disabilities. He used photographs to show his choices of activity, selected books and looked at them with an adult. He joined in number rhymes and songs. He was making good progress with sorting and matching and could sort objects by function and association. He painted, drew and was becoming more focused on sand, water and dough activities.
- A 4-year-old knew her letters, shapes and colours, could follow directions and activate mechanical toys. She could count to 26 and backwards from ten to one.

“Alert and observant.

Speech and communication

Most children known to *Unique* or who have been described in the medical literature have had some speech delay. Eventually, some children acquired enough speech or words to express their needs, but this was not possible for all. Typically, babies and children were sociable and this encouraged a rich variety of non-verbal communication. Babies usually communicated at first with smiles, vocal noises and gestures and progressed to using pictures, objects, touch-screens and a signing system before words emerged. In general understanding was better than their ability to respond with words.



Three-year-old twins: (left) with typical chromosomes; (right) with trisomy 9 mosaicism

Snapshot views show what different children have achieved at different ages.

- An 11-year-old girl had a wide vocabulary and used long and complex sentences. She started talking at 3 and understood much more than she could relate. However, her speech was often unclear and when frustrated or upset she stuttered. Her formal assessment showed that she communicated successfully and provided relevant information but that speaking could be effortful
 - A 10-year-old communicated by signing, pushing, pulling, gestures, vocal noises and using a picture exchange system
 - A 5-year-old used Makaton signing, gestures and photographs. He made sounds and responded to simple directions such as *Show Mummy*
 - A 4-year-old who started to talk at 2 was using 4 to 6-word sentences. Although she understood fully what was asked of her, her expression was limited. For example, instead of saying *I want a cracker*, she would say *I'll show you in here*, then take the adult to the fridge or pantry and say *cracker*
 - A two-and-a-half-year-old growing up in a bilingual home understood more than he could express but could sign 2 to 3-word sentences as well as making vocal noises, saying a few words, pushing, pulling and pointing
- “No speech yet, but when Hannah gets excited she flaps her arms and uses a lot of eye pointing and touching to get our attention. She laughs a lot ... and can cry ... and understands more than we give her credit for - age 4

Mobility and activity

Babies are generally quite delayed in sitting and walking but in *Unique's* experience most eventually achieved these mobility milestones. There were marked differences between individuals: the average age at which children sat unsupported was 17 months and on average they could walk with their hands held or with the support of a frame, furniture, walls or bars by 31 months. By the age of five years, many could walk independently for short distances. Children who sat relatively early usually also



3 years



3½ years



8 years



11 years



5 years



10 years



11 years

appeared to walk early. Only a small minority crawled, on average around their second birthday. Others wriggled on their backs, bottom-shuffled, rolled or slid along the floor (Saneto 1998; *Unique*).

Many children had hypotonia, a muscular floppiness that makes sitting and walking even harder. A common feature of trisomy 9 mosaicism is also dislocated joints, especially the hips, for which some degree of immobilisation in a harness, splint or plaster cast is usually needed in babyhood. Other joints may be unusually stiff or flexible and need supporting. Four children in the *Unique* series were born with talipes (club foot) and three more children had other unusual foot positions (flat, out-turned) that made walking difficult. One had rocker bottom feet, where the sole of the foot curves outwards.

A spinal curve (scoliosis, kyphosis) or torticollis (turning movement of the neck so the head is held to one side) was also common.

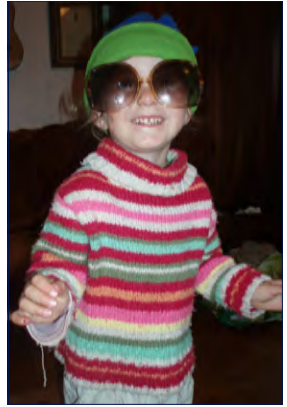
Physiotherapy (physical therapy) and assessment for joint supports, standing and walking frames are likely to be important. Once walking, children may well benefit from supportive orthopaedic footwear such as Pedro boots and some children who fall frequently need a protective helmet.

- “ Her weak ankle joints and poor co-ordination have meant many falls and bumps.
- “ At 5½, he can walk about half a mile holding a hand or several metres independently. He can propel himself a short distance in water with arm bands and a swim ring.
- “ She has difficulty with off-centre movements and alternating limb movements, so running is difficult.

Despite these early challenges, some children went on to sporting achievements. An 11-year-old held a 400-metre swimming certificate. Others enjoyed dancing and horse riding. A 4-year-old was climbing, running and jumping. She climbed stairs alone at three years and mastered a tricycle by age four although she found it hard to manoeuvre. She could not swim yet but loved water and floated in a life vest. She had started a gymnastics class and tried everything with minimal help but was a little slower than other children.

Behaviour

“She is loving, always smiling, she has a great sense of humour. She keeps us right.



3 years

Unique was not able to discern any consistent pattern in the effects of trisomy 9 mosaicism on a child's behaviour. Overall, behaviour appeared to be in line with a child's ability to learn and to communicate their needs and feelings. Parents of younger children frequently commented that their child was affectionate, happy and placid. Distressing behaviour like hand-biting or chewing might occur when a child was frustrated and imaginative attempts to understand and meet the child's needs lessened or stopped it. Frustration could make older children's behaviour challenging but temper tantrums were not a noticeable feature. Two children were hyperactive and two more had a formal diagnosis of attention deficit disorder. None of the children known to *Unique* had a diagnosis of autistic spectrum disorder and in general, children were good social communicators. One child showed intense social anxiety away from home and one child had some repetitive actions, including head banging, and wore a protective helmet. Another had an irrational fear of taps and hot air hand driers (*Unique*).



3½ years

“She has totally overwhelmed us all both in what love and total trust she has for us but also in the capacity in which we can give the same back to her

“No behavioural issues at all. Very placid, very sweet - age 5

“Lauren was moderately un-self-confident as a toddler and it took a significant amount of time for her to start talking. At 4, she would eagerly talk in small groups but not in large ones. She is very alert and observant and follows directions. She will now say Hi to people but no further communication unless they are family - age 4



6 years

Any sleep disorders?

The *Unique* survey found no sleep problems associated with behaviour. However, three children had sleep apnoea (pauses in breathing during sleep). This is also mentioned in a research report of a two-year-old. In one child removing the tonsils and adenoids resolved the problem, but one child required a cPAP (continuous positive airways pressure) device to keep him oxygenated during the night (Lindor 1995; *Unique*).

Medical concerns

■ Palate

Occasionally, babies with trisomy 9 mosaicism are born with a split in the roof of the mouth (cleft palate). Less often, the palate is intact but there is poor closure of the tissues of the soft palate at the back of the mouth (velopharyngeal insufficiency) or a very high arched palate, making feeding difficult. Much more rarely, there is a cleft in the upper lip. Any clefts can be repaired with a surgical operation and in the meantime you will be offered help and support with feeding. For practical information, contact your national Cleft Lip and Palate Association (Wilroy 1985; Ginsburg 1989; Levy 1989; Khoury-Collado 2004; Bruns 2011; *Unique*).

■ Heart conditions

Many babies with trisomy 9 mosaicism have been described in the published medical literature with a heart condition and because this association is well-known, babies and children can expect to have a thorough cardiac assessment. This does not mean that all babies will be found to have a heart condition – at least one baby in three and perhaps more will not. All the heart conditions discovered have been present at birth; none have developed later in childhood.

The most common problems were a hole between the lower or upper chambers of the heart (ventricular septal defect, VSD or atrial septal defect, ASD); persistent ductus arteriosus (a channel that is open during fetal life to allow the blood to bypass the lungs fails to close as expected around the time of birth) and right-sided placement of the heart. Hypoplastic left heart syndrome (underdevelopment of the left side of the heart) has also been reported.

In the *Unique* group of children, there were fewer serious heart conditions (10/32 – 31 per cent). Of these, only four children (12 per cent of the total) had a defect that needed to be corrected with surgery. These included two children with Fallot's tetralogy (a complex condition in which the main concerns are that the pulmonary artery that takes the blood to the lungs has an unusually narrow entrance and there is a hole between the two ventricles, the pumping chambers of the heart); one child with a large hole between the chambers on either side of the heart and one with Ebstein's anomaly, an anomaly of the right side of the heart (Arnold 1995; Wooldridge 1995; Saneto 1998; Schinzel 2001; Bruns 2011; *Unique*).

■ Genitals and reproductive tract

In the medical literature and in *Unique*'s experience, boys were commonly born with minor genital anomalies, particularly undescended testes and/or hypospadias, where the hole normally at the end of the penis was on the underside. If necessary, both conditions can be corrected with a surgical operation. The penis may also be small. Problems were less common in girls (Arnold 1995; Wooldridge 1995; *Unique*).

■ Brain and central nervous system

Your child may be offered a scan to check how the structures of the brain have been formed. This is because some children with trisomy 9 mosaicism have an unusual brain structure. There may be an enlargement of the ventricles within the brain with excess fluid. A small number of children are found to have a particular pattern of anomalies

known as Dandy-Walker syndrome. In most cases, it is not necessary or possible to treat any structural anomalies found in the brain, but where there is an increasing amount of cerebrospinal fluid that can be drained a shunt may be inserted.

During embryonic development, the forebrain divides into the left and right sides of the brain known as cerebral hemispheres. In a very small number of babies, this division remains incomplete, giving rise to a spectrum of unusual structural arrangements that sometimes involve the face as well. The condition is known as holoprosencephaly. Treatment may well be possible to repair defects of the upper lip or nose.

Within the *Unique* series, effects on the brain were varied: three families reported hydrocephalus (excess fluid within the brain). Three families reported loss of brain tissue, in two children with delayed myelination (the maturing process of insulation of the fibres that connect the nerve cells in the brain), and in another in association with other anomalies such as a thinned corpus callosum (the band of nerve fibres that connects the two halves of the brain) (In one baby the corpus callosum was missing Kaminker 1985; Herranz 1987; Tarani 1994; Lindor 1995; Wooldridge 1995; Gérard-Blanluet 2002; Murru 2002; Bruns 2011; *Unique*).

■ Joints



Eleven years

Loose joints that dislocate easily are common in children with mosaic trisomy 9 and over half of all babies with the disorder were born with dislocated hips or elbows. In the experience of *Unique*, fourteen out of 32 families (44 per cent) mentioned this and in the 2003 survey, unusually mobile joints were mentioned by eight out of 12 families (67 per cent). From these families, four children were born with dislocated hips and needed to spend months in a brace, splint or plaster and three of them needed surgery. Five children also needed braces or orthopaedic footwear to support their ankles while walking. One girl was diagnosed with developmental hip dysplasia at the age of 10.

If children are born with clenched and overlapping fingers or toes or stiff, contracted joints (arthrogryposis), these may straighten with passive stretching exercises, regular physiotherapy, splinting or, if necessary, surgery. One child had a mildly stiffened arm that needs exercise to keep it straight and another baby had more limited movement in its shorter leg (Arnold 1995; *Unique*).

■ Kidney and urinary tract problems

Your child may have imaging of the kidneys and urinary tract to check for any unusual features and start any treatment necessary. A variety of unusual features has been described such as cystic kidneys, where fluid-filled sacs form in the kidneys, usually during fetal life. A solitary cyst may not interfere with function unless it is large but multiple cysts may stop the affected kidney from working. A multicystic kidney may be removed if it is causing discomfort. Another possible problem is hydronephrosis - enlarged kidneys, for which there are many causes, including a blockage in the drainage

of urine, reflux of urine from the bladder, a double ureter leading from the kidney to the bladder and a non-functioning, cystic kidney; treatment of hydronephrosis depends on the cause. But problems occur in only a minority of children, so that most have a healthy renal and urinary tract. In the *Unique* group, only two children had a kidney defect. Three children had one or two 'duplex kidneys' where the kidney forms in duplicate, and another child had one malformed kidney (Wooldridge 1995; Schinzel 2001; Bruns 2011; *Unique*).

■ Bone structure and skeleton

Your baby or child will be carefully examined for any unusually formed bones. Many different anomalies have been seen, most of them of no great importance, such as an extra thirteenth pair of ribs, small collar bones or short thigh bones. Very occasionally, a bone may be missing; this has been seen in the forearm and in the hand. Occasionally, the bones on either side of the body may grow at a different pace, so that one leg is shorter than the other. One *Unique* child has a bony protuberance on the spine (Qazi 1977; Ginsburg 1989; Tarani 1994; Stipoljev 2003; *Unique*).

■ Spine

In some children, the spine may have a noticeable curve or develop one in childhood. When the curve is lateral or sideways, this is known as scoliosis; a forward curve is called a kyphosis. One underlying cause of an increased curvature of the spine may be hypotonia (low muscle tone). While a mild degree of curvature may not need treatment, a more marked curve can be treated with support or bracing and in severe cases, supports can be inserted surgically to keep the spine straight. In the *Unique* series, six out of 32 families (19 per cent) reported a spinal curvature but of these, four children required monitoring rather than active treatment. A rapidly progressive scoliosis has been observed, but this has not affected anyone in *Unique's* membership (Arnold 1995; Lindor 1995; Wooldridge 1995; Morava 2002; *Unique*).

■ Seizures

Seizures are not common in children with trisomy 9 mosaicism and in *Unique's* experience have affected only a minority of children (10-15 per cent). Where information has been provided, families said that antiepileptic medication kept them under control and there was no obvious link between structural anomalies of the brain and seizures (Tarani 1994; Wooldridge 1995; *Unique*).

■ Disorders of the digestive tract

The digestive tract may not develop correctly. In one child, inflammatory bowel disease (Crohn's disease) developed in babyhood, much earlier than usual. One *Unique* member had duodenitis (inflammation of the first part of the small intestine), for which a dairy-free diet was prescribed (Levy 1989; Wooldridge 1995; *Unique*).



8 years

■ Respiratory tract infections

Coughs, colds and chest infections appear to be relatively common in babies and children with chromosome disorders, including mosaic trisomy 9. In some children these may be caused or aggravated by aspiration of regurgitated feeds, in which case a thickener added to drinks may help. Abnormal lung segmentation has been described, but it is not known whether this adds to the problems (Saura 1995; Wooldridge 1995; *Unique*).

“ My son has had very frequent colds and coughs with persistent respiratory tract infections and needed supplementary oxygen for more than a year. Advice on postural drainage and chest percussion has helped and he has had his adenoids and tonsils removed. By 5, the infections though still frequent are less severe.

■ Teeth



Dental development is commonly disrupted in children with chromosome disorders and this is particularly true when the formation of the midline structures of the face is involved. Dental care can be difficult and as painful teeth can stop a child from eating, it is important to have prompt treatment. One child described in the medical literature lost all her adult front teeth due to severe caries. Three *Unique* children have needed extensive dental work, and two of them needed multiple extractions, while one child had the full set of milk teeth removed. Another child had fluoride treatment

as she had abnormally thin enamel on her pre-molars (Morava 2002; *Unique*).

■ Eyesight

The eyes are commonly affected in children with trisomy 9 mosaicism. The eyes are typically small and the optic nerve that links the eyes with the brain may also be affected. There is a wide variety of possible effects, including cloudy corneas (front part of the eyeball, usually transparent) and developmental defects of the inner structures of the eye. This means that problems with vision are common and families can expect regular check-ups.

Within *Unique*, eight families out of 12 (67 per cent) reported a visual disturbance, with problems ranging from cortical visual impairment, where the brain does not correctly interpret what the eye sees, to very much less severe problems including strabismus (squint), amblyopia (preference of one eye over the other) and long sight. One child had ptosis (a hooded upper eyelid that is important if it obscures vision); another does not blink with one eye and has a missing tear duct. Four children (12 per cent) were registered partially sighted or blind or could only see light. One member of *Unique* was 10 years old before the loss of vision in one eye and impaired eyesight in the other were discovered (Ginsburg 1989; Wooldridge 1995; *Unique*).

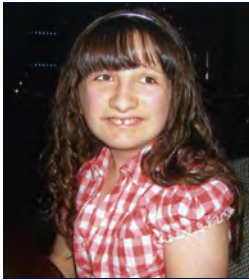
■ Hearing

Eight *Unique* children (25 per cent) had some level of hearing impairment. This might only be transient, but three children were impaired enough to need hearing aids. Glue ear was common and four children (13 per cent) had hearing tubes inserted (*Unique*).

Outlook

Doctors are usually cautious about the prospects for a baby with trisomy 9 mosaicism. This is partly because early reports in the medical literature suggested that many babies with full trisomy 9 (that is, no cells with normal chromosomes) did not survive beyond their first year. However, this is a very bleak outlook and while in *Unique's* experience, six families have lost a child, most often a very fragile and tiny baby, at least seven members are adults, the oldest 44 years. There are also almost certainly older people with T9M.

As far as an individual baby or child is concerned, your child's paediatrician is best placed to answer the question about expected lifespan because s/he will know how far the disorder has affected any major organs, such as the heart or brain.



13 years



16 years



18 years



14 years

Personal care skills and independent living

Time will tell how much trisomy 9 mosaicism has affected your child and once you know this, probably by the time your child starts school and certainly by secondary school transfer, you will have a clearer idea of their prospects as an adult.

Unique's records show that as a broad generalisation children co-operated with dressing, washing and teeth cleaning from early primary age and sometimes sooner.

“Lauren only needs help with her socks and shoes. She matches her outfits with her hair ties!! She washes and dries herself and even likes to wash her hair. She likes to brush her teeth but I help - age 4

How is T9M detected and diagnosed in pregnancy?

Trisomy 9 mosaicism can be diagnosed before birth or afterwards. One *Unique* member was only diagnosed in her mid-teens. But a diagnosis in pregnancy faces parents with a possible decision.

The first signs that a pregnancy is affected by a chromosome disorder may come from routine antenatal tests. Maternal serum screening in early pregnancy may show a raised level of alpha fetoprotein or anomalies may be suggested by the early pregnancy dating scan. However, these screening tests can also give normal results.

To diagnose a chromosome disorder, it is necessary to examine the chromosome material from the pregnancy and the baby. This is usually done by chorionic villus sampling (CVS) in early pregnancy at 11-13 weeks or by amniocentesis in mid pregnancy. Diagnosing chromosome mosaicism such as T9M is extremely difficult and requires more than one chromosome study, often with waits of days or even weeks between results. To help establish the effects of the extra chromosome on your baby, you will also be offered detailed ultrasound scans, ideally performed at a fetal wellbeing centre. The fetal medicine team looking after you will reach a judgement based both on these scans and on the chromosome studies and will offer support in the very hard task of reaching a decision on the results.

Chorionic villus sampling (CVS)

CVS samples cells from the developing placenta, removed either through a fine needle passed through the abdomen and the wall of the uterus or through a catheter passed through the cervix.

The CVS may show an extra chromosome 9 in every cell examined (non-mosaic or full trisomy 9) or in some of the cells (mosaic trisomy 9). You will then usually be offered detailed ultrasound scans to check the baby's growth and to look for any anomalies. You will also probably be recommended to have a further chromosome study by amniocentesis.

Amniocentesis

For an amniocentesis, a hollow needle is passed into the sac around the baby and a small quantity of the amniotic fluid is drawn off. The amniotic fluid contains cells shed by the fetus.

If no cells with trisomy 9 are found in the amniotic fluid, the baby may be unaffected, but this is not guaranteed and you will be offered further tests and scans.

If all the cells from the amniotic fluid contain an extra chromosome 9, you will be offered ultrasound scans to help to determine how your baby is affected.

If some trisomy 9 cells are found in the amniotic fluid alongside cells with a normal chromosome make-up, the situation is difficult. A few babies may be unaffected by trisomy 9 mosaicism even when cells with the extra chromosome 9 are found in the amniotic fluid and other babies are apparently only affected in minor ways.

Detailed ultrasound scans will help make the situation clearer, but the fetal medicine team may suggest either a repeat amniocentesis or a cordocentesis. In this procedure, offered by a few specialist centres, a fine needle is passed through the abdomen and the

wall of the uterus into the umbilical cord and a small quantity of the baby's blood is drawn off. Finding cells with the extra chromosome 9 in the baby's blood will show that she or he is affected, but will not necessarily be helpful in revealing which body systems are affected or how severe any effects are. Sometimes no cells with the extra chromosome 9 are found in the baby's bloodstream. Unfortunately this is not a guarantee that the baby is unaffected as cells with the extra chromosome may be found in other parts of the body (Sherer 1992; Merino 1993; Saura 1995; Stipoljev 2003; Kosaki 2006).

“Briony is a treasure I cannot imagine life without. We were given a choice at amnio, I am just so glad we chose not to terminate.

Why did it happen?

The causes of chromosome disorders such as T9M are not yet fully understood but it is known that nothing you did before you were pregnant or during pregnancy could have caused it and also nothing you could have done would have prevented it.



Five years, with older sister

In general, older mothers are more likely to have babies with certain extra chromosomes (a trisomy) and this may possibly be true of mothers of babies with trisomy 9 (Schinzel 2001). However, most mothers with a baby with T9M are no older than other mothers.

To answer the question 'Why did this happen?' the first step is to examine the parents' chromosomes. In most couples, both parents turn out to have normal chromosomes and in this case a trisomy is very unlikely to happen again.

In a few families, one parent is found to have a structural rearrangement of one chromosome 9.

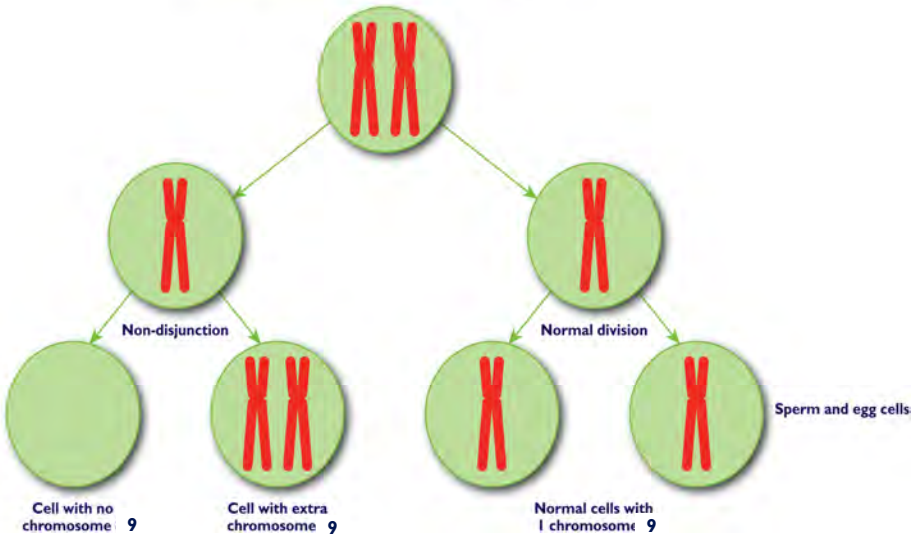
One arrangement is known as an inversion, where a segment of chromosome 9 has broken off, swivelled round 180 degrees and reinserted itself into the chromosome. The inverted segment contains the point where the long and short arms meet (the centromere) and is technically known as a pericentric inversion. It has been suggested that the presence of this type of inversion may possibly make conceiving a baby with trisomy 9 mosaicism more likely but this is not certain (Willatt 1992; Arnold 1995; Stipoljev 2003).

How did it happen?

Trisomy mosaicism arises in one of two ways. During the formation of the sperm or egg cells there is sometimes a failure in the natural process by which chromosomes separate. As the cell divides, one chromosome (number 9 in this case) fails to separate, leaving the cell with an extra chromosome. This failure to separate is technically known

as **non-disjunction** (see diagram below). Non-disjunction causes a trisomy, or three copies of chromosome 9, rather than the normal two copies.

How non-disjunction can arise



A later attempt to correct the mistake by eliminating one extra chromosome 9 may be partly successful, leaving two independent cell lines, one with an extra chromosome 9, the other with the extra chromosome deleted – so the usual chromosome number. This correction process is called trisomy correction or trisomy rescue.

Trisomy mosaicism can also arise after conception when the fertilised egg is dividing and multiplying. At one division the two copies of chromosome 9 fail to separate properly (non-disjunction) and one new cell receives a second copy of the chromosome while its partner cell is left one chromosome short. The cell line that is one chromosome short usually dies off, but the cell line with 47 chromosomes continues to divide and multiply alongside cells with 46 chromosomes.



Seven years old

Support and Information



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