Congenital and acquired ear deformities; treatment modalities

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CHAPTER 1

General introduction

INTRODUCTION

From a functional point of view, our external ears are no more than an ornamental addition to our heads. Though they assist a little bit in catching the direction of sounds and somewhat in thermoregulation, their main role is a social one. Ears are never considered an especially beautiful feature like large breasts, full lips or spotless skin, but if they are different they are noticed, and may be a reason for ridicule. They carry our glasses and people adorn them with jewelry. They are part of what humans do.

1. helix
2. triangular fossa
3. antihelix
   superior crus
4. antihelix
   inferior crus
5. root of the helical crus
6. concha
7. tail of antihelix
8. tragus
9. anti-tragus

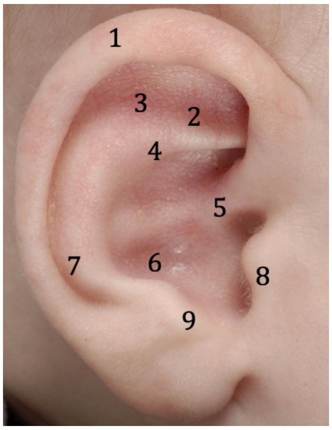

Figure 1. Anatomy of the external ear

EAR MALFORMATIONS VS DEFORMATIONS

The external ear consists of elastic cartilage with a firmly attached skin envelope. The external ear, also known as the auricle or pinna, is made of skin, cartilage, and seven intrinsic muscles[1].

From the fourth week to ninth week of gestation, the auricle, the auditory canal, and the middle ear are formed from an ectodermal protuberance of the first two branchial arches. The shape of the external ear is given by the embryonic development of six mesenchymal hillocks around the first brachial cleft. (Figure 2.) Hillock one, two and three at the mandibular arch and hillock four, five and six on the hyoid arch. Incidents in the development or failure of differentiation of parts of this complex can result in various types of ear malformation; some elements of the ear are simply not there or misplaced. Often these ear malformations are part of syndromes that affect the brachial clefts such as Goldenhar- or Treacher Collins syndrome[2, 3].

The more severe malformations are anotia, lobular microtia, and concha type microtia, the resulting shape depends on which hillock is absent. In these cases the middle ear is also affected. (Figure 3 and 4)

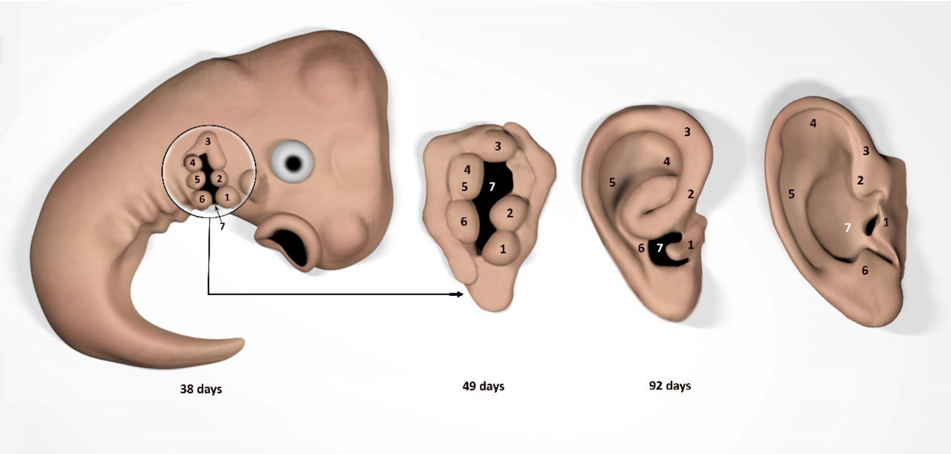

Figure 2. The development of the ear from the hillocks. Numbers correspond with the original hillock location in the embryo (Illustration: Raymond Toelanie. After Weerda, Surgery of the auricle).[3]

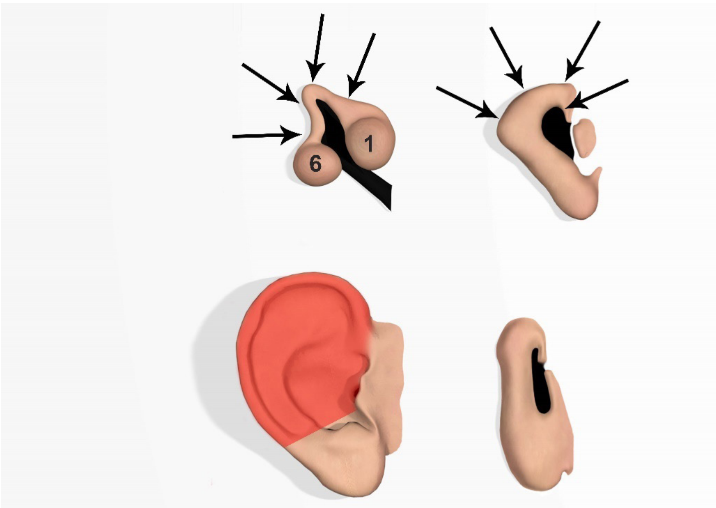

Figure 3. Malformation of hillocks 2 to 5 resulting in a lobular microtia (illustration: R. Toelanie after Weerda[3])

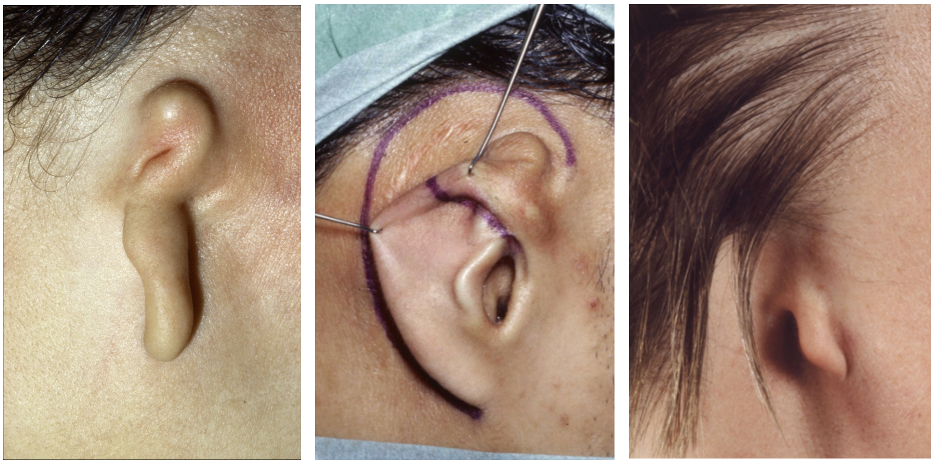

Figure 4. Examples of lobular microtia, concha type microtia and anotia

Ear deformations

A more common group of abnormal ear shapes are considered ear deformations. They have a normal chondro-cutaneous component. The ear bends towards the normal shape by digital pressure. In that light they do not directly seem to be the result of abnormal morphogenesis; external pressure or a different course of the seven intrinsic and four extrinsic muscles is often proposed as the cause deformed ears[4,5.] Hunter and Weerda however classified deformed ears as a Grade I dysplasias[1,3.]

Constricted ear

The constricted ear is an example of an auricular anomaly that can be seen as an ear deformation when subtile or as a malformation of hillock 3 when severe: In the latter the constricted ear looks as if the rim of the ear has been tightened as if by a purse string. It is characterized by four features; lidding, decreased vertical height of the ear, protrusion and low ear position [6]. In the past, it has also been referred to as `lop ear' and `cup ear. [7.] (Figure 5 and 6)

Stahl's ear

Another example of an ear deformation is the Stahl's ear with an anti-helical crus perpendicular to the helical rim and abnormal kinks of the helix It is sometimes also called a Spock ear, in reference to Leonard Nimoy's character in the Star Trek television series and movies. (Figure. 7.)

Figure 5. Example of a constricted ear. Type IIb according to Tanzer[6.] classification

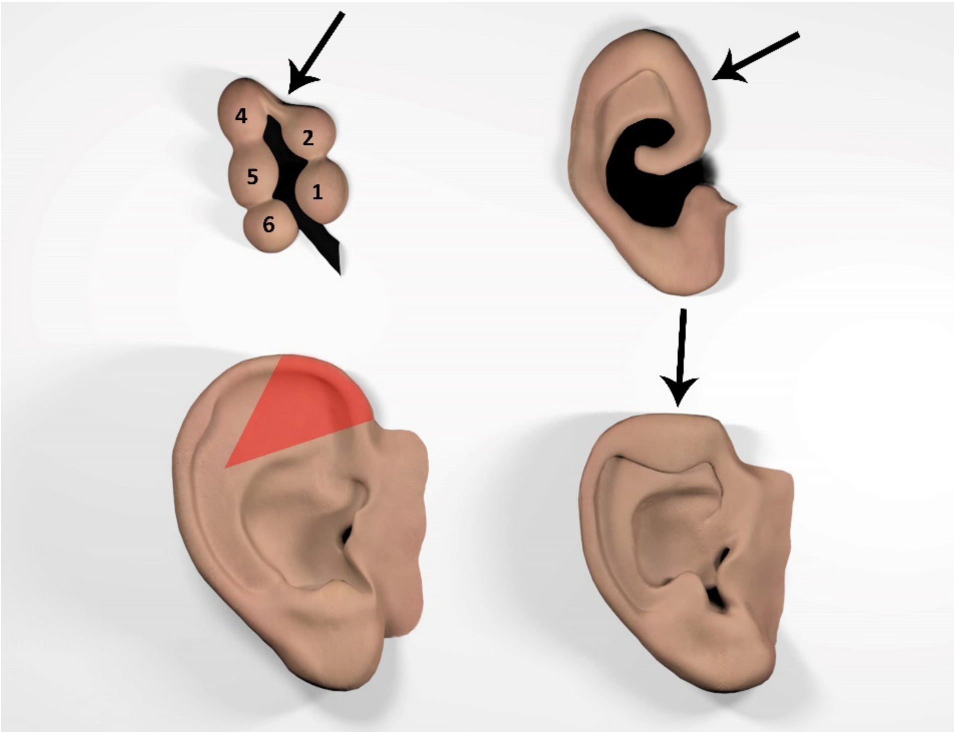

Figure 6. Malformation of hillock 3 resulting in a constricted ear. (Illustration: R. Toelanie after Weerda[3])

It is an isolated deformity and it is suggested that this deformity is a result of an abnormal auricular transverse muscle during embryogenesis[4,5,8], Weerda[3] on the other side, sees it as a cleft between hillock 4 and 5. (Figure 8) Fact is that the additional fold, and absent helix completely correct as forced in the preferred shape in the first weeks of life[9].

Figure 7. Stahls ear in a baby before (left) and after ear splint therapy (right)

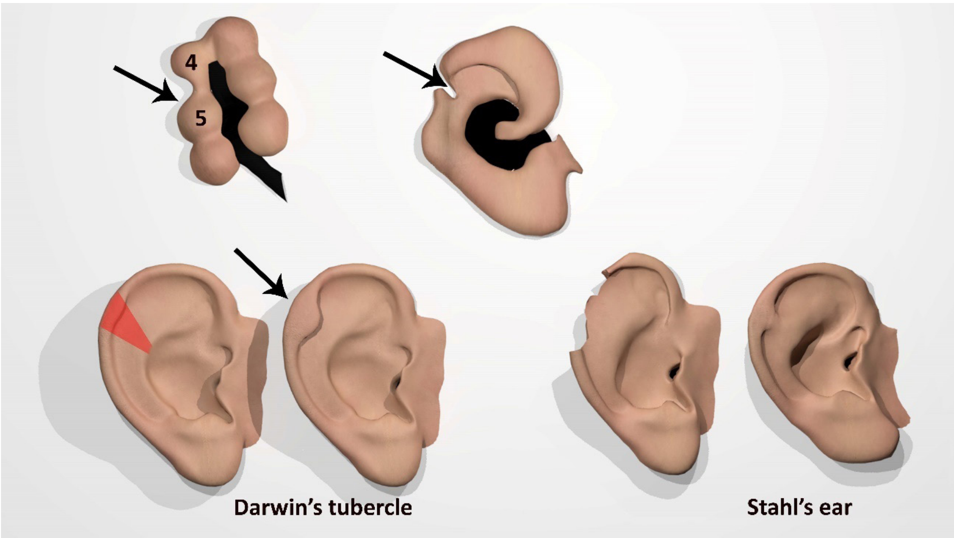

Figure 8. Cleft between hillocks 4 and 5 resulting in absent helix and an additional fold as suggested by Weerda.[3] (illustration: R. Toelanie after Weerda)

Prominent ears

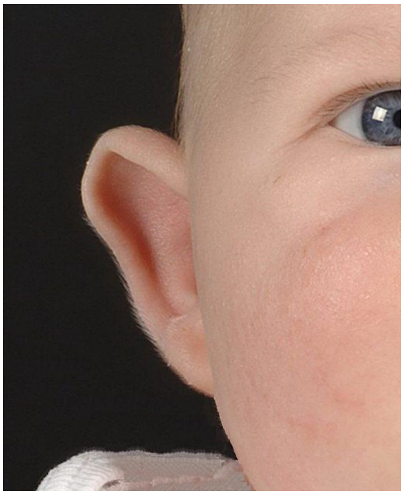

Figure 9. A baby with a prominent ear with an absent antihelical fold

An ear gets its prominence from either a flat antihelical fold or a deep concha or both. (Figure 9 and 10) A different course of the seven intrinsic and four extrinsic muscles is often proposed as the cause[5]. It is hard to quantify a prominent ear; In adults the normal mastoid-helical distance is 15-21 mm.[10,11] Byrd measured an average projection of the helical rim of 5.3 mm in newborns and stated that more than 8 mm is a prominent ear for a baby[12]. Prominence can also be expressed by the angle between helix and mastoid, more than 40 degrees is considered prominent.[10,11]

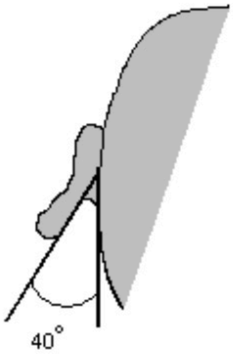

Figure 10. Mastoid – helical rim angle (left) Mastoid – helical rim distance (right)

Prominent ears are common; with an estimated incidence of approximately 5%, affecting men and women equally[13].

Surgical correction of protruding ears is usually performed after the age of 5-6 years when most of the auricular growth has taken place, the child is motivated to have the ears corrected and basically understands what happens during and after surgery. In most cases, the postoperative course is uneventful, though serious complications like chronic pain, skin necrosis and shape deformities can occur[13] (figure 11 and 12)

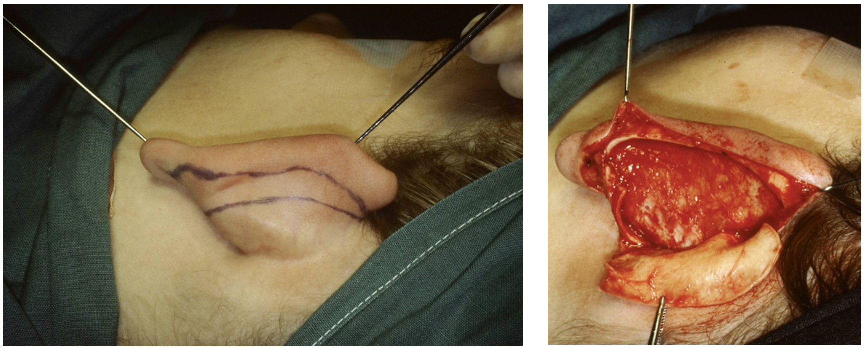

Figure 11. correction of the articular cartilage through anterior scoring.

Figure 12. Complications after surgical correction of protruding ears.

a. Sharp damaged antihelix (left) b. Deformed helix (right)

Figure 12. Complications after surgical correction of protruding ears.
c. Skin necrosis after surgical correction, too tight bandage

The operative correction of prominent ears is one of the few widely accepted surgical procedures performed in children for aesthetic reasons. It is shown to profoundly improve self-confidence and happiness. Moreover, it is very effective to prevent bullying[14].

In the Netherlands, with just below 17-million inhabitants among which 2.8-million under the age of twenty, each year around 2500 people receive surgical correction of protruding ears[15,16]

NON-SURGICAL CORRECTION OF EAR DEFORMITIES

In new born babies there is a small window of opportunity to reshape ears using a splint and possibly avoid surgery . Since the first publications from Japan in the late 1980s, many authors demonstrated that permanent correction can be achieved by "forcing" the ear into the desired position by splinting for several weeks.[17,18]

It is assumed that it is the high level maternal estrogens at birth that make ear cartilage especially pliable[17.]. These levels quickly drop to almost zero at six weeks of age, subsequently making cartilage less pliable and moldable.[19-23.]

The external ear anomalies suitable for splinting have in common that no skin or cartilage is absent. Splinting can be performed in many ways, provided that the ear is permanently kept in the desired shape without distorting it.[18] (Figure 13 and 14)

Figure 13. a,b,c Ear splints applied to a prominent ear.
(commercially available splint developed by dr. D.T. Gault[24] was used (Earbuddies™).

Figure 14. A prominent ear before and after splinting.

In **chapter two** we review the literature on the methods of non-surgical correction of ear deformities. We review indications and the duration of the treatment performed, and summarise the results and possible complications.

In **chapter three** we describe a prospective study that tries to answer the main questions that literature could not tell:

- Until what age can splinting be reasonably offered?
- What is the duration needed to splint in relation to patient's age?
- Are there differences in results and duration of treatment related to the nature of the auricular deformity?
- Is it possible to quantify prominent ears?

Following our research from chapter three we recommend to treat before the age of six weeks and preferably earlier. To make this possible we need a system in which this therapy is actively suggested to parents. **In chapter four** we ethically evaluate such a system as by molding perfectly healthy newborn ears we reach the boundary between treatment and enhancement in medicine[26,27].

- Pro's and contra's of active suggestion for the individual and the public;
- Is it possible to making molding part of the official national screening program?

EAR PIERCING

In **chapter five** we discuss another way in which human culture interacts with ears. Culture provides not only an idea of the preferred ear shape, people also like to alter and highlight their external ears by earrings and piercing. Popularization of high earpiercing, through the cartilage, led to a series of reports on perichondritis in just-pierced ears, and subsequent ear deformities for which plastic surgical reconstruction was sought.[28-31.] (Figure 15)

Figure 15. Cartilage loss after perichondritis

Figure 16. Classical spring loaded piercing gun

A piercing-stud breaks the barrier of the skin and soft tissues and introduces bacteria to the damaged cartilage which can induce infection. The literature suggested that a piercing gun, mainly used by jewellers to pierce the lobule, will give excessive cartilage damage, making those ears especially prone to infection. (Figure 16) Therefore, some authors favors the piercing needle, as used in piercing studios[28-32]. However, the assumptions on tissue trauma through the different piercing methods were never tested, there was just a series of articles all quoting their predecessors. The Dutch Ministry of Health, Welfare and Sport was preparing new regulations for piercing and tattoos in 2006 and considered a ban on spring-loaded piercing guns for high ear piercings based on the literature. They asked the expert opinion of the promotor of this thesis. This led to the human cadaver study presented in **chapter five** dedicated to the following question;

- Is there a histological difference in the extent of damage to ear cartilage using different piercing techniques?
  - Paying attention to detachment of perichondrium
  - Tears in the cartilage
  - Loose cartilage fragments or cartilage flaps

CONSTRICTED EARS

Chapter six The classification and treatment of constricted ears.
As earlier described in this chapter, constricted ears can be seen as an ear deformation when subtle or as a malformation when severe. It is characterized by four features; lidding, decreased vertical height of the ear, protrusion and low ear position.[6] In the past, it has also been referred to as 'lop ear' and 'cup ear'.[7]

In 1975, Tanzer classified constricted ears in three groups and two subgroups (Table 1).[6] This classification is still in use today and there are many proposed reconstruction techniques for this according to Tanzer, 'curious' group of auricular deformities, none of them however superior.[3]

Table 1. Tanzer classification of constricted ears.

Tanzer group		
I	Helical collapse only	
IIa IIb	Deficiency of scapha, superior crus, and fossa triangularis create collapse of upper helix, resulting in loss of vertical height, lidding and protrusion	IIa: no supplemental skin needed to expand the auricular margin
		IIb: no antihelical crura, considerable height reduction. Supplemental skin necessary to expand the auricular margin
III	Attachment of anterior helix close to the lobule, the auricle is pouch-like and the ear is usually low-set.	

The improvements in ear reconstruction published by Brent,[33,34] Nagata,[35] Firmin[36] and Park [37] all using costal cartilage as donor material, make better outcomes possible. It is therefore that a new classification for constricted ears is proposed in which the more severe groups are classified as an ear malformation and treated accordingly. (Figure 17)

An alternative technique for correction of group IIA and IIB deformities, is proposed using a T-strut of costal cartilage to reconstruct the underdeveloped or missing superior crus of the antihelix.

RECONSTRUCTION OF ACQUIRED EAR DEFORMATIONS USING RIB CARTILAGE

Figure 17. Lobular type microtia before- and after reconstruction with a rib cartilage frame.

Costal cartilage is an ideal material for plastic surgeons to create spare ear-parts; It provides a frame in full ear reconstruction, or a strut to support the helical rim in a constricted ear as shown in **chapter six.** In **chapter seven** a block of rib cartilage it is used to form a base for the iatrogenic "sunken ear" after canal wall down mastoidectomy. In **chapter eight** rib cartilage is used to reconstruct a helical crus of an ear deformed as a result of a spider bite. They form only a few examples of this versatile treatment modality.

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CHAPTER 2

Non-surgical correction of congenital deformities of the auricle: a systematic review of the literature.

J Plast Reconstr Aesthet Surg. 62: 727-36, 2009

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ABSTRACT

Background

Splinting is an elegant non-surgical method to correct ear deformities in the newborn. Since the late 1980s, many authors demonstrated that permanent correction occurs by forcing the ear into the proper position for several weeks. The external ear anomalies suitable for splinting have a common feature that no skin or cartilage is absent; the protruding, lop and Stahl's ears are good examples of these anomalies. Surprisingly, this technique is relatively unknown to plastic surgeons and is hardly ever communicated to the general public.

Purpose of study

To review the literature on non-surgical correction of ear deformities, focussing on indications, technique, results and possible complications.

Methods

A systematic literature search was performed in July 2008 using PubMed. Twenty papers were suitable for review.

Results

Splinting can be performed in many ways, provided that the ear is permanently kept in the desired shape without distorting it. It is disputable until what age splinting therapy can reasonably be offered-opinions vary from 'newborn only' to well up to 3 or 6 months of age. A rigid fixation seems to allow correction in older children. The time needed to splint for permanent correction depends upon the age at the time of starting the treatment. For a newborn, 2 weeks often suffice, whereas for older children splinting time becomes more variable-up to 6 months. Most patients we treated had lop, Stahl's or prominent ears. In a case series in Japan, cryptotia was the most frequent deformity encountered. Most authors made their own judgement on the results, categorising their outcomes from poor to excellent, or asked a lay opinion. Fair-to-excellent results were reported in 70-100% of the cases. The results tended to be poor in older children. Recurrence was seldom described clearly in the literature and was probably listed as poor result. No serious complications occurred and skin irritation was seen sporadically.

Conclusions

Ear splinting is an elegant technique that should be practiced on a wider scale than is done today. Hopefully this article will challenge authors to perform prospective studies.

INTRODUCTION

Otoplasty is a common cosmetic surgical procedure for the plastic surgeon. It is performed in children to avoid their being teased and to improve their appearance. Surgery is delayed until after the age of 6 years, when most of the auricular growth has taken place. Especially in younger children, correction is often performed under general anaesthesia. In most cases, the postoperative course is uneventful, though serious complications can occur.[1] The first medical publications on non-surgical correction of congenital auricular deformities were published in the late 1980s by Japanese plastic surgeons.[2-7] They demonstrated that by forcing the ear into the proper position and maintaining it there for several weeks, permanent correction may occur.

The external ear anomalies suitable for splinting have a common feature that no skin or cartilage is absent. The ear bends towards the normal shape by digital pressure. Hunter classified this as a Grade I dysplasia[8] (modification from Weerda[9]). These anomalies are also described as ear deformations and are distinct from malformations like microtia.[10] It is not possible to bend the ear to a normal shape in ear malformations. Ear deformations do not seem to be the result of abnormal morphogenesis. However, it seems that either external pressure or malinsertion of the seven intrinsic and four extrinsic muscles may cause deformed ears. Although several distinct shapes exist,[8] protruding ears are the most common variant. Other deformities are lop ear with its drooping upper pole, Stahl's ear with an anti-helical crus perpendicular to the helical rim and abnormal kinks of the helix. Cryptotia is more common in the Asian population and is seen as a hidden upper helix, buried under the temporal skin.

Objectives

The goal of this article is to review the literature on the methods of non-surgical correction of ear deformities. We review indications and the duration of the treatment performed, and summarize the results and possible complications.

MATERIALS AND METHODS

A literature search was performed in July 2008 using the PubMed service of the US National Library of Medicine that includes citations from MEDLINE and other life science journals for biomedical articles dating back to the 1950s. Initial searches focused on the text words: ear, auricular deformities, splint, non-surgical and correction. The medical subject heading (MeSH) terms 'ear' AND 'splints' were also used. All abstracts from English, Dutch, German or French papers were scanned for potential relevance. In addition, manual cross referencing was performed. We excluded articles that only reported on the treatment and not the results, unless specific remarks on the author's experiences and results were made.

In total, 20 papers were included for review. Of the reviewed articles, we listed the splinting materials and methods used **(Table 1),** as well as the age of the children at the start of the treatment, the duration of splinting, the nature of the deformities treated, the outcome measure, the results, the length of the follow-up, the complications mentioned and the character of the study **(Table 2**). The results for the different deformities, if specified, are listed in **Table 3**. The results related to age, if specified, are listed in **Table 4**.

RESULTS

Ear-splinting materials and methods

Table 1 provides a summary of the various ear-splinting materials and methods used. Most authors used a bendable, rounded splint placed in the scaphal hollow to define the anti-helical fold and to serve as a supporting pillar. The splinted ear is then fixed to the head using a tape or a bandage.[12-17,19,24-27] One author (Gault[13]) developed a commercially available splint (Ear buddies®). Yotsuyanagi preferred a rigid splint which sandwiched the ear from both sides.[18,22,23] This reflects the occurrence of cryptotia among a large number of his patients, a condition that can only be corrected with such a splint.[28]

Another interesting concept for the treatment of protruding ears, named the Auri method, was presented by Sorribes[21] in which a specially designed plastic clamp that squeezes the cartilage is used during the night, followed by a double adhesive strip during daytime to maintain correction. In most cases, splints were fixed by plastic surgeons, but Tan[17] showed that nurses who are familiar with the indications and technique can successfully fix them as well. Parents can be taught to replace the adhesive tapes when necessary. Most of them found this easy to do.[17] The patients retain the splints 24 h a day, and only have them changed when the tape comes loose. Discontinuous use was associated with poor results.[14,21] Treatment continues until the desired shape persists without splints. This is assessed during those moments when the tape is renewed.[3,6,7,11-13,16-20] After permanent correction is achieved, some patients continue splinting (mostly for a week) to keep up the result.[13,15,22-24] Tan stopped therapy if 4 continuous weeks of splinting failed to produce any results.[13,16,17] The time needed to splint for permanent correction depends on the age when the treatment was started. For a newborn, 2 weeks often suffice,[12,15] whereas for older children splinting time becomes more variable. Few authors give detailed information on age and duration of treatment.[7,11,13,16,27] These individual data are shown in **Table 4**. Some authors[12,14,15,26] treat only newborns and have a standard regime as shown in **Tables 1 and 2.** Yotsuyanagi reported on the treatment of much older children (0-14 years). [18,22,23] Interestingly, the mean duration of treatment was only 2.1 months, while the patients were of an average age of 3-6 years.[18]

Indications for treatment: age and deformity

Several authors state that only newborns should be treated.[11,12,14,15,20,24-27] Matsuo, one of the first to publish on this method, states that correction should be started immediately after birth (realistically, at latest by the third day after birth) in order to obtain satisfactory and irreversible results.[3] Later he makes an exception for protruding ears and cryptotia; in which he finds splinting worthwhile up to 6 months of age.[6] Tan reports in his last two articles, based on his earlier experiences in which he treated children up to 5 months of age,[13,16] that splinting can best be done before 3 months.[16,17] Muraoka reported good results in children up to 5 years of age using tape alone.[7] Sorribes treated children with protruding ears up to 5.5 years with a specially designed clamp,[21] Yotsuyanagi treated children, mainly with cryptotia, up to 14 years of age using a rigid splint.[18,22,23] In 243 patients, he presented a slow decline in the success rate from 91% in newborns to 33% in 9 year-olds.[23]

Table 1. Various ear-splinting materials and methods used

First author	Year	Splint material	Splinting method
Matsuo[3,6]	1984 1990	Aluwax® + tape+ bandage. protruding ear: bandage only. cryptotia: dynamic splint	A.
Muraoka[7]	1985	tape only	A.
Brown[11]	1986	dental compound (Aluwax®) +tape	A.
Bernal-Sprekelsen[12]	1990	dental compound or bone wax + tape	B. two weeks after one week tape only
Tan / Gault[13]	1994	Soldering wire in 8F catheter + steri-strips®. + benzoin tincture	A. + continued for variable period
Merlob[14]	1995	soft, elastic double faced loop padding (Velfoam®) + foam strips	B. four - six weeks
Oroz[15]	1995	first: dental compound + Steri-strip®. later: steel wire in silicon tube+ steri-strip® + cap	B. two-three weeks, followed by cap one month
Tan[16,17]	1997 2003	soldering wire in 8F catheter + Steri-strips®	A.
Yotsuyanagi[18]	1998	thermoplastic material enclose ear from posterior and anterior side	A.
Furnas[19]	1999	benzoin tincture on skin + dental compound or wire in silastic tube + tape. after few days followed by foam tape around copper wire core + tape. when shape is stable: tape only	A. re-applied daily
Ullmann[20]	2001	Putty soft® (vinyl polysiloxane) + Steri-strips®	A.
Sorribes[21]	2002	specially designed clamp (night) + double adhesive tape behind ear(day)	A.
Yotsuyanagi[22,23]	2002 2004	thermoplastic material enclose ear from post+ ant side	A. + night splint several weeks after correction
Schonauer[24, 25]	2003 2008	wire in 6F silastic tube + Steri-strips®	A. +one week or more continued
Smith[26]	2005	wax + Medpore® tape	B. one month
Lindford[27]	2007	wire in 6F silastic tube + adhesive skin closure strips	A.

A. Ear splinted 24 hours/day until permanent correction occurred
B. Ear splinted 24 hours/day fixed period

Nature of the deformity

All kinds of ear deformities were treated as shown in **Tables 2 and 3**. However, most patients had lop, Stahl's or prominent ears. The larger series from Japan demonstrated that cryptotia was the most frequent deformity.[6,18,22,23] Differences in results and duration of treatment related to the nature of the auricular deformity are often mentioned in articles without accompanying data. It is often stated that lop ears and Stahl's deformities in newborns are particularly easy to treat, and prominent ears need to be splinted for a longer duration.[22,23,26] Matsuo advises treating lop and Stahl's ears only during the neonatal period and states that cryptotia and prominent ears can be treated up to 6 months of age.6 **Table 3** seems to reflect this: especially, prominent ears are more often treated with poor results. Some authors state that constricted, cup or shell ears are less suitable for splinting as this is a malformation and it is hard to overcome the tensions in the cartilage.[7,15,16] Others seem to have corrected these ears with good results.[11,20,24] Of course, this may have been possible in less severe cases in which there was no cartilage shortage.

Assessment of the results

Most authors define their outcomes as 'poor/improved/fair/ satisfactory or good and excellent',[7,11,13,15,16,18,20,21,23-27] and select the patients for the different categories themselves. Others have lay panels[20] or ask the opinion of the parents.[17,20,21] Improvement of position in prominent ears can be detected by the decrease in the distance from the helical rim to the mastoid process.[16,21] **Table 2** gives an overview of the results.

Fair-to-good results are presented in 70-100% of the cases. Results tend to be poor in older children; Yotsuyanagi showed in 243 patients a slow decline in success rate, from 91% in newborns to 33% in 9-year-olds.[23] In addition, Sorribes, who treated children up to 5.5 years, had a lower success rate, with more 'fair' than 'good' results.[21] This could also be due to the nature of the deformity treated; prominent ears are more often treated with less good results as shown in **Table 3**. Most authors do not specify their results. Comments in the articles on the differences in results and duration of treatment related to the nature of the auricular deformity are often not accompanied by data.

Table 2. Overview literature on nonsurgical correction of congenital deformities of the auricle

First author year	N.	age at start	splint time	deformities	results	R	compli cations	Outcome score by	follow -up	com ments
Matsuo[3,6] 1984 1990	?	0 – >6M	<1W: few W at 6M: few M	? lop ear ? Stahl ear ? prominent ? cryptotia	not specified “good”	?	?	author not specified	?	expert opinion
Muraoka[7] 1985	9	5M -5Y mean: 3Y	3M -6M mean: 4.3M	4 Stahl ear 2 cup ear 1 cryptotia 1 rim kink 1 prominent	7 good 2 fair	?	no	author + pictures in article	?	case reports+ studies in rabbit ears
Brown[11] 1986	5	2D - 3M	3W -2M	2 lop ear 1 cup ear 1 Stahl ear 1 prominent	4 good 1 fair (prominent)	?	no	author + pictures in article	?	case reports + technique
Bernal- Sprekelsen[12] 1990	43	1 – 3D	2W	14 lop ear 14 long antihelix 12 third crus 11 flat rim helix 9 Stahl ear 5 cup ear 5 prominent 4 shell	not specified “good”	No	no except passing redness	author not specified	2M – 1Y	expert opinion + technique
Tan / Gault[13] 1994	14	0D – 5M mean: 1M	2W- 5.3M mean:9.3W	4 Stahl 2 lop ear 2 shell 2 rim kink 2 prominent	9 good 5 fair	No	no	author	6M-35M mean: 14M	retro spective
Merlob[14] 1995	30	0-14D	4-6W	10 cup ear 9 prominent 6 lop ear 5 Stahl ear	18 good 5 fair 7 poor	1	no	author	3 – 5M	retro spective
Oroz[15] 1995	53	<6D	2 – 3W	16 prominent 14 lop ear 9 cup ear 8 lobe evertion 6 Stahl ear	37 good 16 fair	2	no	author	1 – 5Y mean: 3Y	retro spective

Tan[16] 1997	32	1D – 10W mean: 17D	5 – 21W mean: 9.1W	21 lop ear 8 prominent 2 Stahl ear 1 invert concha	30 good 2 poor	No	no except passing redness	author+ parents + helix – mastoid distance	2M	retro spective
Yotsuyanagi[18] 1998	50	1Y – 14Y mean: 3.6Y	Mean: 2.1M	26 cryptotia 5 lop ear 5 stahl ear 3 prominent 3 shell 8 other	27 good 11 fair 9 poor 3 gave up	6	no	Author	2Y	retro spective
Furnas[19] 1999	?	<4M	± 6W	?	?	?	?	?	?	technique
Ullmann[20] 2001	92	<10D most: 3D	6 – 12W	28 lop ear 24 prominent 20 constricted 20 Stahl ear	80 good 12 fair	No	no	parents + medical student	6M	retro spective
Sorribes[21] (Auri method) 2002	56	2W – 5.5Y	1 – 10M mean: 5.5M	56 prominent	19 good 31 fair 6 poor	4	14 skin irritation 3 squeeze marks	author + parents + helical – mastoid distance	10M	pro spective
Yotsuyanagi[22] 2002	290	0 – 16Y mean: 3.1Y	1 – 4M Mean:1.9M	? cryptotia ? Stahl ear ? shell ear ? prominent ? lop ear ? other	good/ fair poor (+recurrence) gave up	▯	?	author	?	expert opinion
Schonauer[24] 2003	36	new born	2 – 6W	10 helix contour 10 prominent 9 constricted 7 Stahl ear	23 good 5 fair 8 gave up	No	no	author	2 -6M	retro spective

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Table 2 CONTINUED.

First author year	N.	age at start	splint time	deformities	results	R	compli cations	Outcome score by	follow -up	com ments
Tan[17] 2003	44	1D – 15W mean: 24D	1W – 14W mean: 7	17 lop ear 14 prominent 8 cup ear 5 kinked ear	38 good 6 poor	No	4 ears skin irritation	author + parents	2 – 11M mean: 8M	retro spective
Yotsuyanagi[23] 2004	275	0 – 9Y	?	128 cryptotia 39 Stahl ear 26 prominent 24 lop ear 13 shell ear 45 other	197 good (+ fair)	?	?	author not specified	?	expert opinion retro spective
Smith[26] 2005	69	<2W	1M	41 lop ear 13 Stahl ear 12 prominent 2 cryptotia	62 good	?	no	author	1M	retro spective
Lindford[27] 2007	5	2D- 3D	3W-1M	2 constricted 2 prominent 1 Stahl ear	5 good	No	no	author + pictures in article	?	case report technique
Schonauer[25] 2008	72	< 14D	3W- 6W	mild deformities, compressed ear 28 vertical 18 horizontal 10 focal	1 fair 9 satisfactory 46 good	No	2 superficial skin necrosis	author	2 – 12 M	retro spective

N= Number of ears treated R= recurrence D= day, M= month, Y=year.
good= "excellent, "corrected" ", "good" fair= "improved", "satisfactory", "fair" poor= "no effect", "recurrent", "poor".

Table 3. Results for the different deformities, if specified

First author year	Deformities	Results good	Fair	Poor	Gave up	
Muraoka[7] 1985	4 Stahl ear 2	4		2		
	cup ear 1					
	cryptotia	1				
	1 rim kink	1				
	1 prominent	1				
Brown[11] 1986	2 lop ear	2				
	1 cup ear	1				
	1 Stahl ear	1		1		
	1 prominent					
Tan/Gault[13] 1994	4 Stahl	4				
	2 lop ear	2				
	2 shell		1			
	2 rim kink		2			
	2 prominent	1	1			
Oroz[15] 1995	16 prominent 14	12	4			
	lop ear	14				
	9 cup ear		9			
	8 lobe evertion	5	3			
	6 Stahl ear	6				
Tan[16] 1997	21 lop ear	21		2		
	8 prominent	6				
	2 Stahl ear 1	2				
	invert concha	1				
Yotsuyanagi[18] 1998	26 cryptotia	16	6	2	2	1
	5 lop ear	2	1	1		
	5 stahl ear	2	2	1		
	3 prominent	1		2		
	3 shell	2		1		
	8 other	4	2	2		
Ullmann[20] 2001	28 lop ear	25	3	4		
	24 prominent	20	3	2		
	20 constricted	17				
	20 Stahl ear	18				
Sorribes[21] 2002	56 prominent	15	23	6		
Schonauer[24] 2003	10 helix contour	6	2		2	3
	10 prominent	4 8	3			
	9 constricted	5	1			
	7 Stahl ear		2			
Yotsuyanagi[23] 2004	128 cryptotia	105				
	39 Stahl ear	29				
	26 prominent	14	good or			
	24 lop ear	13	fair			
	13 shell ear	8				
	45 other	28				
Smith[26] 2005	41 lop ear	41				
	13 Stahl ear	13	good or			
	12 prominent	8	fair			
	2 cryptotia	0				
Lindford[27] 2007	2 constricted	2				
	2 prominent	2				
	1 Stahl ear	1				
Schonauer[25] 2008	compressed ear			3		
	28 vertical	25	4	2 1		
	18 horizontal	13				
	10 focal	8				

Table 4. Age versus time needed to splint and result, combined data

Age	A	Splint time (W)	Result	Deformity
1D	TG	1.4	g	Stahl ear
1D	TG	1.4	g	lop ear
1D	TG	2	g	Stahl ear
1D	TM	6	g	lop ear
1D	TM	8	g	lop ear
1D	TM	10	g	lop ear
2D	TG	3	g	lop ear
2D	Br	4.3	g	lop ear
2D	TM	5	g	lop ear
2D	TM	8	g	lop ear
2D	TM	8	g	Inv.concha
3D	Li	3	g	Stahl ear
3D	Li	4	g	prominent
3D	Li	4.3	g	constricted
3D	TM	6	g	lop ear
3D	TM	7	g	Stahl ear
3D	TM	9	g	prominent
3D	TM	12	g	prominent
3D	TM	24	g	prominent
4D	Br	3	g	Stahl ear
4D	TM	8	g	lop ear
6D	Br	4.3	g	cup ear
10D	TM	6	g	lop ear
10D	TM	6	g	lop ear
2.5W	TM	6	g	lop ear
3W	TG	3	g	Stahl ear
1M	TG	8	f	rim kink
6W	TM	6	g	lop ear
6W	TG	23	f	shell ear
7W	TM	6	g	lop ear
2M	TG	15	g	prominent
9W	TM	10	g	lop ear
9W	TM	17	g	Lop ear
10W	TM	10	p	prominent
3M	Br	9	f	prominent
3M	TG	23	p	prominent
5M	TG	14	g	Stahl ear
5M	Mu	13	g	prominent
2Y	Mu	13	g	Stahl ear
2Y	Mu	17	g	rim kink
3Y	Mu	17	f	cup ear
3Y	Mu	17	f	cup ear

Table 4 CONTINUED.

Age	A	Splint time (W)	Result	Deformity
3Y	Mu	26	g	cryptotia
4Y	Mu	17	g	Stahl ear
5Y	Mu	21	g	Stahl ear
5Y	Mu	26	g	Stahl ear

D=day W=week M=month Y=year g=good f=fair p=poor
A= author Mu = Muraoka[7] Br =Brown[11] TG= Tan/Gault[13] TM= Tan/Mulliken[16] Li= Lindford[27]

Elasticity of the cartilage

According to Matsuo et al. and Yotsuyanagi et al., it is the ease with which the auricle can be manually folded into the desirable shape that predicts the splinting time needed and the chance of success.[6,18,22,23] It seems that age and nature of the deformity influence elasticity of the cartilage. Tan observed weaker cartilage in breastfed children.[16] All these comments are anecdotal. Only Sorribes performed a standardised measurement of the stiffness of the auricle at the start of treatment using a dial tension gauge by pressing the arm of the instrument towards the lateral part of the ear, making an anti-helix. The tension was measured on the scale when the anti-helix was maximally folded. Children with good results had less-resistant ears, although the group was too small to have significant results.[21]

Recurrence

Few recurrences are reported separately in the literature, probably because they have been placed in the 'poor result' category. For some authors, the follow-up time might have been too short to notice recurrence.[14,16,20,24,26] Yotsuyanagi[18] andSorribes[21] mention the highest recurrence rate as12%and 7%, respectively; however, they both treated older children.

Complications

No serious side effects were mentioned. Potential effects like skin loss by pressure necrosis or swallowing of splints were never reported. Transient skin irritation was seen sporadically.[12,16,17,21] Schonauer[25] observed two cases of superficial skin necrosis that healed uneventfully.

Control groups

The ears of newborn infants are often a bit distorted due to their pliability and the external pressure in the birth canal. This spontaneously resolves in the first few days after birth. It is questionable if all these children should be treated. Matsuo seriously addressed this question, when, at some point, half of the newborns in the nursery of his hospital wore splints on their ears and obstetricians started to complain. He observed the natural changes of the auricular shape in 1000 Japanese babies from birth to 1 year. His results[6] are shown in **Table 5**. This showed a strong decline in lop-ear deformity and a rise in protruding ears. Tan also observes an increase in prominent ears in the first year. In a retrospective questionnaire administered to 79 parents of children with protruding ears, the deformity was seen at birth in 61% of the cases. At 6 months of age, 86% was observed. At the age of 5 years, this had risen to 100%.[29]

Control groups were followed up by three authors. Smith saw spontaneous improvement in seven of 13 ears: two were lop ears and two were Stahl's ears.[26] Merlob found no spontaneous improvements in a group of 20 neonates.[14] Sorribes treated only one ear in a case of bilateral prominent ears; no spontaneous improvements were observed in the 32 untreated ears.[21]

Table 5 Natural changes of 1000 babies auricular shapes from birth to 1 year old[6]

Deformity	At birth	One month old	One year old
Normal ear	44.8%	68.3%	83.9%
Lop ear	38.1%	16.9%	6.1%
Stahl ear	8.7%	1.2%	1.3%
Prominent ear	0.4%	4.4%	5.5%
Other deformity	8.0%	9.2%	3.2%

Treatment mechanism

The external ear is easily pliable during the neonatal period due to the flexibility of the cartilage. Matsuo was the first to suggest that this is due to the high levels of oestrogen received from the mother.[3] The pliability of cartilage depends on the composition of the extra-cellular matrix and especially on the amount of hyaluronic acid[30]; the production of which is up-regulated by oestrogen.[31,32] The oestrogen levels in newborns are very high. During pregnancy, plasma oestrogen concentrations rise in the mother and the foetus by a factor of 100. They drop in the first few days to a level comparable with older children at 6 weeks of age.[33-35] It is assumed that pliability of the cartilage drops with it as well.[3] If the ear is forced into the right position during this period, the shape can be permanently changed. However, other mechanisms may also play a role. Muraoka bent and fixed the auricular cartilage of 5-week-old rabbits and observed increased cartilage thickness compared to the control group. The maximum thickness was reached at 6 weeks, after which the thickness declined to slightly more than that of the control group at 12 weeks. At that stage, the ear was fixed in the bent form.[7]

DISCUSSION

This literature analysis demonstrates that there are still many unanswered questions regarding the usage of ear splints. It is evident that splinting is an elegant method to correct ear deformities in the newborn, but it is unclear whether all deformed ears should be splinted. As Matsuo showed, many ear deformities spontaneously resolve during the first months after birth.[6] Lop ears especially tend to straighten out as the cartilage gets stiffer. This could obviously influence the good results seen in the literature with regards to the treatment of lop ears with splints.[13,15,16,20,26] It may be better to wait for a month to observe the natural change in this particular auricular deformation, especially if the deformity is mild. Prominent ears seem to have a different nature as their prevalence only seems to rise with age[6,29] and no spontaneous improvements have been reported. As they take longer to treat with poor results in older children, they should be splinted as early as possible. Splinting can be performed in many ways, provided that the ear is kept in the desired shape without distorting it. As Tan reported, parents can be taught to replace the adhesive tapes when necessary.[17] It is even questionable whether this easy, noninvasive technique should only be done by plastic surgeons or can even be performed by a physician. Gault[13] is already offering splints to parents, without prescription, through the Internet.

It is disputable until what age splinting therapy can reasonably be offered, considering the expected result, time and effort that needs to be invested. Opinions vary from 'newborn only' [11,12,14,15,20,24-27] until well up to 3[16,17] or 6 months of age.[6,7] A more rigid fixation than only a splint and tape seems to allow correction in much older children.[18,21,22,23] Many experts found that after a certain age, splinting becomes unsuccessful and advise against it. It is unfortunate that there is no agreement about this maximum age and that their personal experiences were never clarified by patient data.

In the literature, there is no comprehensive evidence on the length of time needed for splinting. A study that specifically focusses on the time needed to splint in relation to age may clarify this. However, it might even be more effective to focus on the relation between the ease with which the auricle can be manually folded to the desired shape, the splinting time needed and the ultimate chance of success.[6,18,22,23] Until now, only Sorribes performed a standardized measurement of the stiffness of the auricle at the start of treatment.[21] It is worthwhile to focus on this phenomenon as measurement of ear stiffness could be a good clinical indicator of whether splinting therapy can be successfully applied in the individual child, making age or the nature of the deformity less important.

How to assess the results

The desired outcome e a normal looking ear e is easy to imagine, but hard to capture in measurements. Only in the case of prominent ears, some form of measurement is possible.[16,21] In adults or older children, the normal mastoid-helical distance is 15-21 mm.[36,37] Unfortunately the normal distance in newborns has never been defined. In surgical correction, outcome can be scored according to an objective list, for example, the list of goals in otoplasty for protruding ears by McDowell and Wright.[36,37] This cannot be applied to ear splinting, but an adjusted scale may be considered.

Need for publicity

The non-operative treatment of auricular ear deformities is an elegant technique that should be practiced on a much wider scale than is done today. Unfortunately, itis relatively unknown to plastic surgeons and hardly ever communicated to the general public. As a result, children are seldom referred at the age when splints can be applied. It is hoped that this article will provide an impetus to perform prospective studies addressing the relation between patient age, degree of deformity, stiffness of the cartilage, the time needed to splint and the treatment outcome.

Conflict of interest

The authors have no conflicts of interest.

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CHAPTER 3

A prospective study on non-surgical correction of protruding ears, the importance of early treatment.

J Plast Reconstr Aesthet Surg. 65: 54-60, 2012

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C.C. Breugem
M. Kon

ABSTRACT

Objectives

Splinting is an elegant method to correct ear deformities in the newborn. However evidence is lacking on the relation between age and efficacy and duration of the treatment. We prospectively studied these questions on protruding ears in 132 babies.

Methods

A splint in the scaphal hollow was used in combination with tape (Earbuddies®). Treatment continued until the desired shape persisted. Results were judged from photographs and mastoid-helical distance was measured.

Results

In 132 babies 209 ears were treated. Twenty-four patients had no follow-up,27 stopped therapy for skin irritation and fixation problems. In the remaining patients results were good in 28%, fair in 36%, poor in 36%. Efficacy deteriorates with age; with fair or good results in 66.7% if therapy started before the sixth week. Older children needed to be splinted longer. The antihelical fold was easier corrected than a deep concha (correction in 69.8% versus 26.8%).

Conclusions

Considering splinting therapy for protruding ears, a reasonable chance of success can only be offered to parents of children up to six weeks of age. It is favorable if the deformity is mainly due to a flat antihelix.

INTRODUCTION

Splinting is an elegant method to correct ear deformities in the newborn, avoiding surgery with possible complications.[1] Since the first publications from Japan[2-7] in the late 1980s, many authors demonstrated that permanent correction can be achieved by forcing the ear into the desired position for several weeks. The external ear anomalies suitable for splinting have in common that no skin or cartilage is absent.[6-8] The protruding, lop and Stahl's ears are good examples. Splinting can be performed in many ways, provided that the ear is permanently kept in the desired shape without distorting it.

Despite the promising articles, large prospective studies are lacking. Our literature review in 2008[9] revealed only 20 useful papers, many of which only reported personal experiences without actual patient data. Recently an article was added by Byrd carefully describing his experiences with his Earwell device® (Becon Medical).[10] However, there are still many unanswered questions regarding the usage of ear splints.

The first question is to what age splinting therapy can still be offered to result in an acceptable correction of an ear deformity. Several authors state that only newborns should be treated,[10-19] while others find splinting worthwhile up to older ages.[5,20-27] Unfortunately these statements are often anecdotal. Matsuo, one of the first to publish on this method, states that correction should be started immediately after birth in order to obtain satisfactory and irreversible results.[3] Later he makes an exception for protruding ears and cryptotia; in which he finds splinting worthwhile up to six months of age[4] Tan reports that splinting can best be done before three months.[20,21,27] Muraoka reported good results in children up to five years of age using tape alone.[5] Sorribes treated children with protruding ears up to 5.5 years with a specially designed clamp,[24] Yotsuyanagi treated children, mainly with cryptotia, up to 14 years of age using a rigid splint.[22,25,26] In 243 patients, he presented a slow decline in the success rate from 91% in newborns to 33% in 9-year olds.[26] Byrd reports a decline in success rate to 50% when splinting is begun after the third week and recommends to splint at the end of the first week of life to identify those infants who may demonstrate self correction.[10] Knowing the age until which splinting can reasonably offered is of importance when the treating physician is dependent on referral from other caregivers. Especially in the situation, as in the Netherlands, where splinting therapy is not well known, children are almost never referred in the first 48 h after birth.

Secondly there is no comprehensive evidence of the time needed for splinting. Two weeks seems to suffice in a newborn.[12-14] For older children splinting time becomes more variable and several months are described.[5,10,20-27] However, the relation between patient age and the time needed to splint remains unclear. This makes it hard to give a good prediction of the duration of the treatment to parents.

Thirdly it is suggested that some auricular deformities are more easily corrected by molding than others, but these differences in results and duration of treatment related to the nature of the auricular deformity are often mentioned in articles without accompanying data.[4,10,18,25,26]

To clarify these three questions we conducted a prospective study focusing on the relation between age at the start of the treatment and success rate and the relation between patient age and the time needed to splint. As the nature of the deformity seems to influence the results we decided to study these questions on protruding ears only. As protruding ears can be the result of a deep concha or a flat antihelix or both, and the one deformity could be better correctable than the other, the presence of both was evaluated before- and after splinting therapy.

MATERIALS AND METHODS

Babies with protruding ears, as recognized by the parents and the author, were treated. The ears had only deformational abnormalities, meaning that with digital pressure the ear could be forced into a normal shape.[8] A bendable, rounded splint is placed in the scaphal hollow to define the anti-helical fold and to serve as a supporting pillar. The splinted ear is then fixed to the head using a tape. The commercially available splint developed by dr. D.T. Gault[27] was used (Earbuddies Ltd®). During the first visit to the outpatient clinic the parents were taught how to place the splint and the adhesive tapes. The babies retained the splints 24 h a day, and only had them changed when the tape came loose. With the splints on, the ears were not allowed to get wet. In order to prevent skin irritation a Cavilon® barrier film was used every time before re-applying the splint and tape. If necessary, some hair was shaved to accommodate the tape. To the parents treatment length was suggested as described in the protocol from dr.Gault.[27]However they were asked to continue treatment until the desired shape persisted without the splint and tape. This was assessed by the parents when they changed the tape. After permanent correction was achieved, splinting was continued for another week. If four continuous weeks of splinting failed to produce any correction of shape, therapy was stopped. Therapy was also stopped if serious skin irritation occurred. Results were evaluated shortly after removal of the splints and again after one year. The results were judged by the first author from a standardized photo series made before and after the treatment. In accordance with literature they were classified as "good" if an anatomically normal ear was achieved, "fair" if despite improvement part of the deformation persisted and "poor" if the ear maintained its deformity.[9] Examples are shown in **Figure 1a-f** and **Figure 2a-f.**

Figure 1a–f:

left: protruding ear due to a flat antihelix and deep concha in a 10 weeks old boy.

right: same boy after 12 weeks of splinting therapy. Good result.

Figure 2a-f:

left: protruding ear due to a flat antihelix and deep concha in a 22 weeks old boy.

right: same boy after 18 weeks of splinting therapy. Fair result; a deep concha persists.

The presence of a deep concha or a flat antihelix was noted before- and after splinting therapy. The widest mastoid-helical distance was measured pre- and post-splinting using a small ruler. Statistical analysis was performed using SPSS 15.0 (Statistical Package for the Social Sciences) Using Pearson chi-square, Kruskal Wallis chi-square and Bonferroni Multiple comparisons test. For all analyses. $P < 0.05$ was defined as statistical significant difference.

Concordance

As the results of splinting therapy are based on the estimation of one single observer, these observations were objectified by consultation of three independent observers (plastic surgery residents) who scored the same pre- and post-splinting photo series. Cohen's weighted Kappa was calculated. Values higher than 0.8 are considered to be excellent concordance, values 0.6-0.8 as good, 0.4-0.6 moderate, 0.2-0.4 fair and below 0.2 poor.[28,29] As ear splinting and measurements were considered standard medical practice, no permission was needed by the medical ethical committee.

RESULTS

Between January 2008 and May 2010 the protruding ears of 132 children, 63 male, 69 female were splinted. In 77 children both ears were treated, which makes a total of 209 ears. The mean age when splinting was started was 8.8 weeks (range: 0 week-39 weeks, st dev. 5.6) **(Figure 3).** In the 81 patients that fully completed splinting therapy results were good in 28%, fair in 36%, poor in 36%. In all cases of bilateral protruding ears but one, both ears had the same result, to avoid paired data these were used in further statistical analysis as one result. Agreement with the other three observers of the photo series was 'moderate'; Cohen's weighted Kappa was 0.47, 0.43 and 0.58 respectively (95% confidence interval of Kappa did not cross the zero value which allows the conclusion that significant concordance exists).

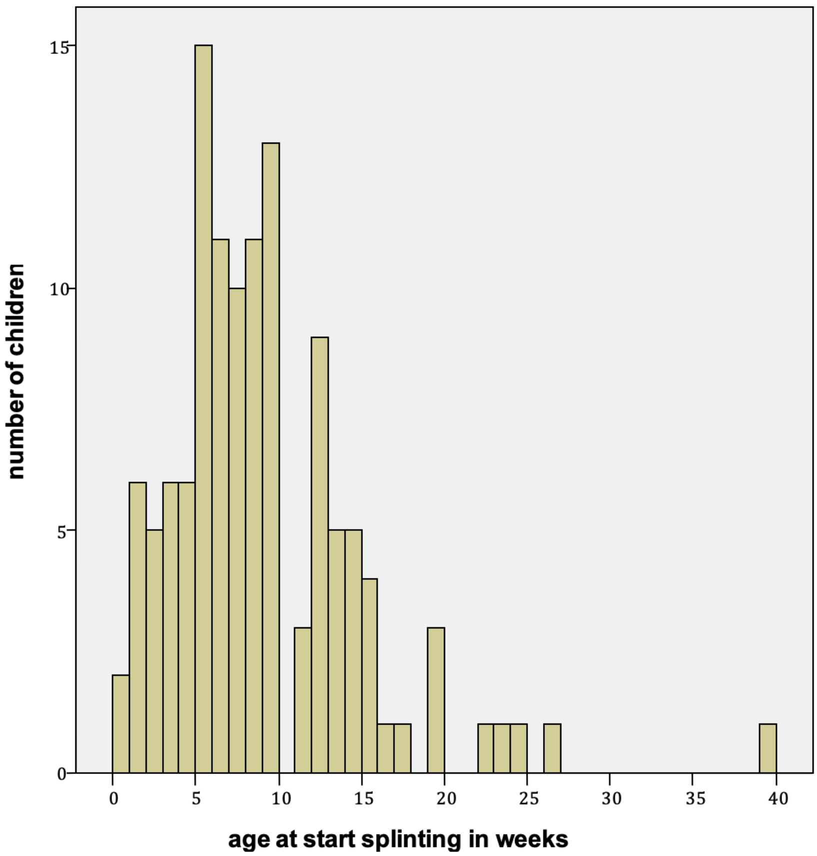

Figure 3. age in weeks at the start of ear-splinting therapy, distribution of patients.

Twenty-four patients were lost to follow-up, 27 stopped therapy for skin irritation and fixation problems. **(Table 1).** There is a significant negative correlation between age and result; with fair or good results in 66.7% if therapy started before the sixth week and less fair or good results in the older age groups (Pearson chi-square, p = 0.011). Also the time needed to splint for a fair or good result significantly increases with age (Kruskal Wallis chi-square p = 0.001) **(Table 2, Figure 4)**.

Table 1. Results of ear splinting therapy

Outcome	N patients	Specifications
lost to follow up	24	-
not completed	27	17 fixation trouble 10 skin irritation
finished therapy	81	23 good result 29 fair result 29 poor result
Total	132	-

Table 2. Results in relation to the age at the start of splinting therapy

	Outcome of splinting therapy				
Age at start therapy	Good	Fair	Poor	Not completed	Total
0 through 6 weeks	12 (30.8%)	14 (35.9%)	7 (17.9%)	6 (15.4%)	39
7 through 12 weeks	9 (19.6%)	10 (21.7%)	14 (30.4%)	13 (28.3%)	46
> 13 weeks	2 (8.7%)	5 (21.7%)	8 (34.8%)	8 (34.8%)	23

The presence of a deep concha or a flat antihelix or both was noted before- and after splinting therapy in 77 children who completed splinting and had pre- and post-photo's available. The concha was deep in 56 patients but only 15 showed a corrected concha after splinting (26.8%) The antihelix was flat in 63 children before splinting, afterward 44 patients were corrected (69.8%) The Pearson Chi-square test shows a correlation between the nature of the protruding ear deformity and a fair or good outcome (p Z 0.003).

Before splinting, the mean maximum mastoid e helical rim distance was 17.9 mm (range: 9-25 min st. dev: 3.1 mm). **Figure 5** shows the outcome of splinting therapy
and Δ mastoid- helical rim distance. The poor results show a mean increase in distance of +3.8 mm. In case of a fair result the mastoid -helical rim distance stayed merely the same with an increase of 0.95 mm in children with a good result the mastoid-helical rim

distance was decreased with a mean -2.5 mm. If the means are compared (one-way ANOVA, groups are normal distributed) there is a significant difference between the Δ mastoid - helical rim distance of the poor and the good outcomes (Multiple comparisons test: Bonferroni).

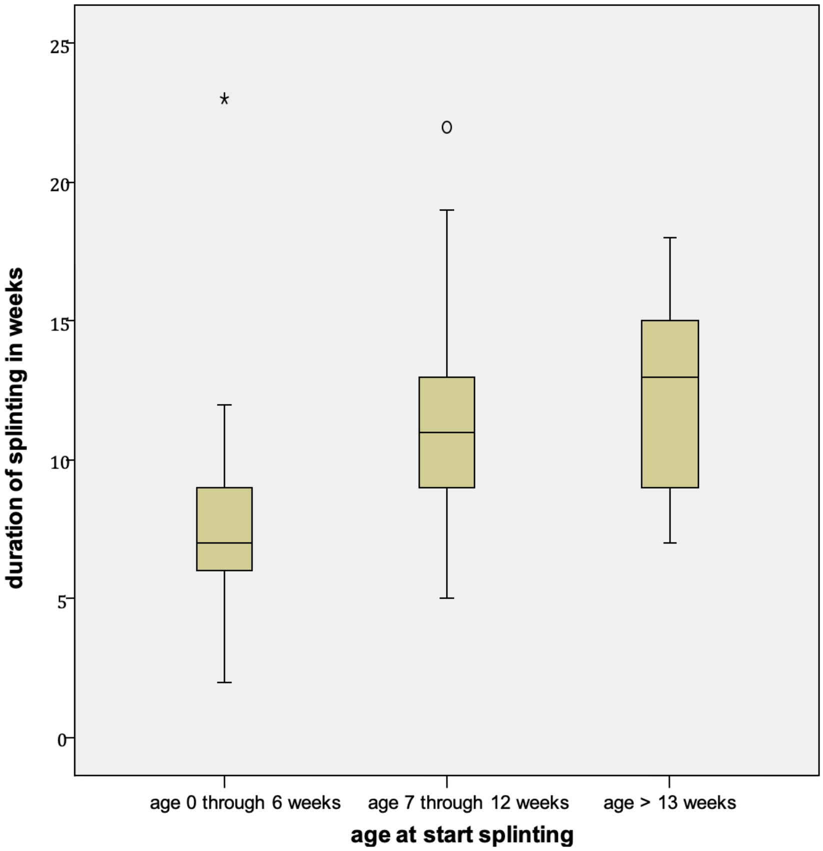

Figure 4. The relation between the age of the child and the time needed to splint for a fair or good result

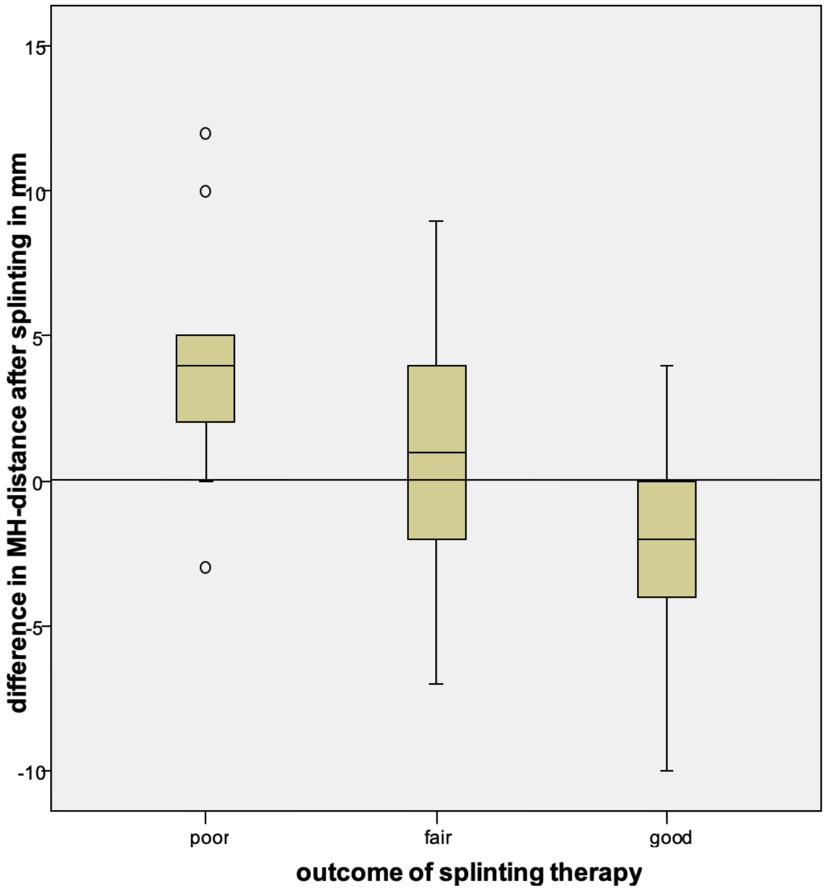

Figure 5. Outcome of splinting therapy and Δ mastoid – helical rim distance in mm.

DISCUSSION

The desired outcome; a normal looking ear, is easy to imagine, but hard to capture in measurements. Only in the case of prominent ears, some form of measurement is possible.[20,24] In adults the normal mastoid-helical distance is 15-21 mm.[30,31] Byrd measured an average projection of the helical rim of 5.3 mm in newborns and states that more than 8 mm is a prominent ear.[10] The normal increase of this projection with the growth of the head in the first months was never studied. An objective measurement was seeked but not found in the change in mastoid - helical rim distance. Although there is a significant difference on group level, for the individual child this measurement gave no indication of a possible successful outcome. Only a small decline in distance was measured before and after treatment even if a clearly good result was found. The head of a baby grows much in its first year of life, and the mastoid - helical rim distance seems to grow with it as well. In the literature on ear splinting the judgment on the results were empirically made by the authors, categorizing their outcomes from poor to excellent, or a lay opinion was asked. Fair-to-excellent results were reported in 70-100% of the cases. The results were said to be poor in older children but clear data are lacking. No serious complications occurred and skin irritation was seen sporadically.[9]

When compared to the literature the results from our study are unsatisfactory. However, splinting is not common in the Netherlands and we had a large proportion of patients that presented late. This study subsequently demonstrates the importance of starting splinting soon after birth. Several other authors state that only newborns should be treated[10-9] and mentioned poor results in older babies. This anecdotal information is supported with our study.

No control group was added to this study. Based on literature it seems safe to say that protruding ears do not self-correct. Although Matsuo showed that most auricular shape deformities spontaneously resolve in the first year of life, he observed a rise in protruding ears.[4] Merlob found no spontaneous improvements in a group of 20 untreated neonates with protruding ears. And poor results in cases where the treatment was discontinuous.[11] In the study of Sorribes only one ear was treated in a case of bilateral prominent ears; no spontaneous improvements were observed in the 'control ear'.[24]

Our best results are seen in babies up to 6 weeks of age, with a fair or good result in 66.7% of them. The success rate in children beyond that age becomes unacceptably low. No children younger than 3 days of age were treated. If more true newborns were included in this study we probably would have seen better results.

Judged from the presumed working mechanism behind ear splinting the time needed to splint for permanent correction depends upon the age at the time of starting the treatment. Pliability of cartilage seems to depend on the amount of hyaluronic acid in the extra cellular matrix.[32] The production of which is up regulated by estrogen.[32-34] During pregnancy plasma estrogen concentrations rise in the mother and the fetus by a factor of 100. They drop in the first days after birth to a base level in six weeks.[35] It is assumed that pliability of the cartilage drops with it as well.[3] If the ear is forced in the right position during this period, the shape can be permanently changed. The literature seems to support this assumption. If splints are applied within 48 h after birth, two weeks of splinting seems to suffice.[12-14] For older children the relation between patient age and the time needed to splint remains unclear.[5,10,20-27]

Although our study demonstrates a clear relation between age and the time needed to splint for permanent correction it is still not possible to exactly predict how long splints should be worn by an individual patient, and whether greater persistence in wearing splints beyond the suggested period would have improved outcome in our study. It is likely that the stiffness of the cartilage is an important factor determining the end result. In our population sample, the more floppy anti-helical fold was far easier to correct than the stiffer concha. (correction in 69.8% versus 26.8%) A similar observation was made by Byrd.[10] Patients with poor outcomes often had a conchal crus leading to (recurrence of) prominent ears. This is a reason why Byrd states that the concha needs more support in molding than can be achieved by a stents and tape alone.10A more rigid splint, like Byrds Earwell® device,[10] Yotsuyanagi's rigid splint[22,25,26] and Sorribes Auri method[24] may be better suited to correct the stiffer concha.

Recommendations

Overall, in our patient group with protruding ears (mainly between one and four months of age), more than four babies had to wear splints to get one good result. Although no serious side effects can occur with this therapy it can be a bit of a nuisance to keep tape and splint for weeks fixated to an active baby. One can argue if it is all worthwhile in this age group. For the true newborns we expect this to be very different. We will continue to offer splinting therapy to these children and hope to report better results.

Collaboration with midwifes, obstetricians and pediatricians is vital for early referral. For the older babies specific recommendations can now be made to parents based on this study: In protruding ears a reasonable chance of success can be offered to parents of children up to six weeks of age. It is favorable if the deformity is mainly due to a flat antihelix. They should expect a mean splinting time of ten weeks for a good result. In

Stahls ears or helical rim deformities chances of success are probably better even up to later ages.

Conflict of interest

None.

Funding

None, no study sponsors.

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CHAPTER 4

If it ain't broke don't fix it? Ethics of proactive splinting of deformed newborn ears.

J Plast Reconstr Aesthet Surg. submitted, under review.

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ABSTRACT

Neonatal ear splinting is a proven and safe method to mold deformed ears into a more common shape. Based on our earlier studies we recommend to only consider splinting before the age of six weeks and preferably within the first week after birth. This can be done by initiating a system in which this therapy is actively proposed to parents. In this paper we ethically evaluate such a system.

By molding perfectly healthy newborn ears we reach the boundary between treatment and enhancement. On the level of the individual, the advantages outweigh the drawbacks, but on the level of society it is more complicated. Making molding part of the official national screening program fails if based on WHO criteria. Moreover, by offering regular ear-molding we change the norm and promote hyperparenting. We may give parents the fear and guilt to miss the opportunity.

However, if we argue that on the individual level infants benefit from ear splinting, than active detection of ear deformities allows parents to choose timely from the full range of options, including splinting and a wait-and-see approach. We subsequently seek to optimally inform the individual without setting up a full-blown public health program.

The ease in which it is possible to timely offer splints to parents of newborns depends on the infrastructure of health care systems Key will be for everyone involved, public or commercial, to responsibly educate and facilitate.

INTRODUCTION

Non-surgical correction of protruding ears

Prominent ears are a common human feature. Though literally standing out, "odd ears" do not have to be a burden. Still, operative correction of prominent ears is regularly performed and remains (one of the few) generally accepted aesthetic surgical procedures performed in children. This procedure improves self-confidence and happiness. Moreover, it is effective to prevent bullying[1.] Though largely cosmetic in nature, studies show that having a minor anomaly such as prominent ears may provoke a higher anxiety score compared to a severe congenital facial deformity. [2]

Surgical correction of protruding ears is usually performed after the age of 5-6 years when most of the auricular growth has taken place and the child is motivated. In children, correction is mostly performed under general anesthesia. The postoperative course is usually uneventful, though complications like chronic pain, skin necrosis and shape deformities can occur[3] . Whether the costs are reimbursed depends on the health care- and insurance systems. In the Netherlands, with just below 17-million inhabitants among which 2.8-million under the age of twenty[4], each year around 2500 people receive protruding ear correction.[5]

In newborn babies, there is an opportunity to reshape ears using a splint, which avoids potential surgeries later in life . Since the first publications from Japan in the late 1980s, many authors demonstrated that permanent correction can be achieved by "forcing" the ear into the desired position by splinting for two to twelve weeks, depending on age[6]. It is assumed that it is the high level of maternal estrogens at birth that make ear cartilage especially pliable. These levels quickly drop to almost zero at six weeks of age[7], and subsequently the ear becomes less moldable. Splinting can be performed in many ways, provided that the ear is permanently kept in the desired shape for a specific period of time.

Often ears are a bit distorted at birth. Most often this resolves spontaneously in the first few days of life. So early detection leads to over treatment. Rim kinks and lop ears can dissolve, protruding ears do not.[8,9,10] Ear anomalies suitable for splinting should have a normal cartilage shell. Protruding, Stahl's-, cup- and lop ears are examples. Splinting cannot correct deficient tissue in ear malformations like microtia.

Large prospective studies on the therapy are few[8,11,12], Which makes questions like the age until treatment can reasonably be offered and initiated unclear. Many authors treat only newborns while others find splinting worthwhile up to older ages.[6]

In 2012 we published a prospective study of our results of ear splinting in 132 babies with protruding ears using a commercially available splint and tape (earbuddies®). Our study focused on the relation between age at the start of the treatment and success rate and on the relation between patient age and the time needed to splint[12] . Best results were seen in babies where treatment was initiated within six weeks after birth, with a fair/ good result in two-thirds of patients. The success rate in children beyond six weeks of age deteriorated to an unacceptably low level. In older children, longer splinting was required, generally it is suggested to splint for as many weeks as the child is old. Subsequently the window of opportunity is short and our recommendation was to only consider splinting before the age of six weeks and preferably within the first week after birth. But especially in countries where home birth is popular, plastic surgeons usually see these babies late. This brings up the question whether professionals should be actively propagating this therapy to all new (soon to be) parents. In this paper we ethically evaluate active detection and treatment of deformed newborn ears.

Advantages of active detection and treatment of deformed newborn ears.
At first glance there is much to gain if all deformed newborn baby ears were detected and splinted immediately after birth. Ear splinting by a maternity nurse or infant health care worker allows a quick start of therapy without the need to refer to a hospital.

Active detection lowers the age at the start of splinting, which improves outcome and lowers effort. While the risks of complications from splinting therapy are very limited, this intervention could prevent future harm in a number of ways. First, detection and correction during infancy is likely to reduce the number of surgical interventions later in life, thus preventing complications associated with surgery, the psychological impact of hospital care and the risks of exposing young children to general anesthesia.

Second, psychological harm due to bullying and feelings of low self-confidence (however unjustified) are being avoided. Hence, splinting is an effective, non-invasive way to prevent these degrading experiences.

From our clinical experience, parents of babies where splinting therapy is or could have been an option often state; "if only I would have known this earlier". Active detection of ear deformities allows parents to choose timely from the full range of options, including splinting and a wait-and-see approach, Do we have an obligation to inform parents of their options?

Figure 1. Protruding ear in a newborn

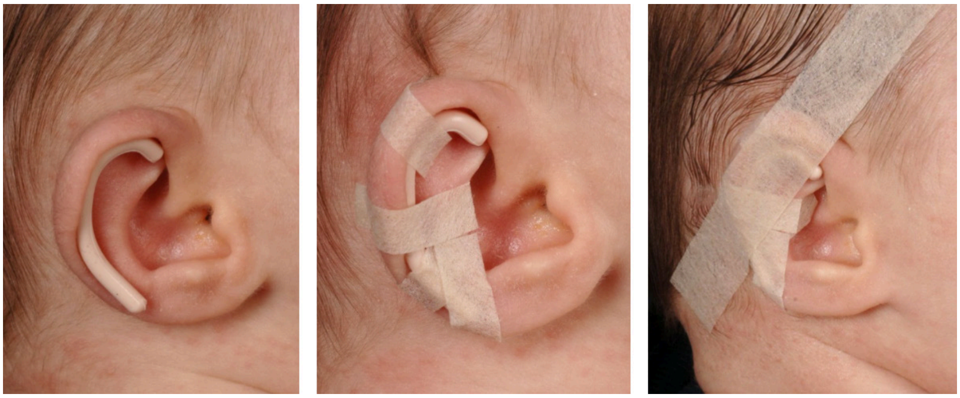

Figure 2. Ear splinting therapy, technique

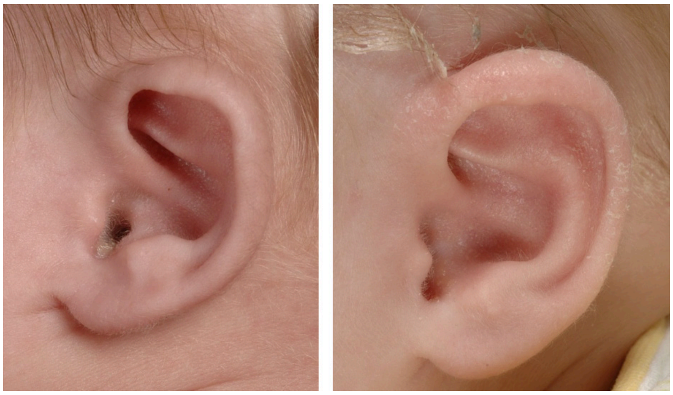

Figure 3. Protruding ear before and after splinting therapy

"Right to an open future" arguments, which dictate that a parent should not make decisions that violate a child's future capacity to make autonomous decisions, do not have much argumentative force here[13] ; splinting is a decision that cannot be postponed without consequences: waiting until maturity enables children to choose freely whether they want to correct their ears, but deprives them of the opportunity to do so without surgery.

Drawbacks

In this section a distinction is made between risks for the individual and the drawbacks for society.

Individual drawbacks

The individual drawback is the risk associated with manipulating the ears into the desired shape. Arguably, professionals who splint ears might violate the principle of nonmaleficence, one of the key principles of bioethics that dictate that healthcare workers should avoid harm. Luckily, the risk of complications in ear splinting is limited to skin irritation [11,8,12] Although risks associated with improving traits for mere cosmetic reasons in minors are hard to justify[14] , low-risk cosmetic interventions , such as braces, are commonly performed in children. In addition, surgical correction of protruding ears is commonly done in children from the age of five[1,3] , where children are still unable to make autonomous decisions. In sum, risks associated with splinting should be assessed relative to risks of other cosmetic interventions that are already accepted.

Over-treatment

The second question is whether professionals are able to select the right babies. Ears, a bit distorted after birth, could spontaneously reshape[7]. Consequently, early detection could lead to over-treatment. This is ethically problematic because in these cases patients are pointlessly exposed to physical and psychological risks, no matter how small . Also, the resources spend on these patients are in vain. Overtreatment also occurs when, years later, it turns out beauty ideals have changed; protruding ears may become a fashionable asset no sensible person wants to correct.

Uncertainty for parents

A further concern is that parents may feel unduly pressured by professionals pointing out they may miss out an unique opportunity. This results in parents making decisions out of anticipated regret. Uncertainty may also be evoked by the huge amount of information that is piled upon young parents already. Adding detection and splinting of deformed ears may contribute to further medicalization of the postpartum period. It is our experience that many parents that currently seek information about splinting had ear surgery themselves, active detection would bring parents to our office that never thought about this option before.

SOCIETAL DRAWBACKS

Burden on the health care system

Nonsurgical correction of deformed ears is not well known by the general public, but many health care professionals involved in newborn treatment are also unaware of the possibilities of splinting. It could therefore be expected that a proactive screening program would increase the numbers of babies to be treated. This may be a burden on the system, as there are many other important infant health issues to care for.

Splinting is not a job for healthcare professionals

Central to an ethical debate on the disadvantages of active promotion of molding perfectly healthy newborn ears is acknowledging that the boundary between treatment and enhancement is reached. Enhancement interventions are criticized as practices medical professionals should not pursue as these activities do not serve the proper goals of medicine.[15] One could argue that professionals should cure diseases rather than improve certain traits in order to comply with the contemporary ideal of beauty. [16]

In the philosophy of medicine, no agreement exists on the definition of disease. Probably the most well-known theory is Christopher Boorse's biostatistical account of disease, that defines disease as not having the range of functional abilities typically associated with the species.[17] According to this influential theory, deformed ears would not be a disease because they do not affect the execution of functions. However, theories that claim to provide objective standards for the demarcation of health and disease (also referred to as descriptive theories) have been criticized for failing to define what "normal" is or why these definitions, such as statistical deviance, are morally relevant.[18]

Contrary to descriptive theories, normative and constructivist accounts of the health-disease distinction state that societal views are indispensable for distinguishing healthy from ill.[19] According to these views, one could argue that deformed ears may be splinted because society or cultural norms define this trait as worthy of being treated. There is a general recognition in today's society that the correction of protruding ears by medical professionals is justified, which can be inferred from the fact that surgery on protruding ears is often covered by health insurance companies (for example, in the Netherlands the procedure is covered up to 16 years of age). The drawback of approaches that led society decide on what the category of diseases encompasses is that these theories fail to determine the limits of medical intervention and coverage:[18] To include deformed ears on the list of essential medical activities may give rise to an open-ended and seemingly unlimited list of traits that parents want to manipulate. Hence, other criteria than societal acceptance and statistical accounts of normalcy are needed to decide whether splinting is a warranted medical practice.

4

Splinting changes the norm.

By enhancing certain features in individuals, practitioners also affect the population's average. This argument is most famously put forward in the debate on prescription of growth hormones to short statue children without growth hormone deficiency: this increases the average height in society, making previously average children relatively small [16]. Likewise, regular splinting has the potential to change the norm; people who currently consider their ears normal may seek treatment in the future.

Splinting makes society more perfectionistic

The second lesson from the enhancement debate is the underlying tendency that is promoted: the increasing pressure to perform. Michael Sandel famously addressed the ethics of self-improvement[20] and argued that enhancement represents a drive to master our nature, a push for perfection. As far as children are concerned, Sandel warns for what he calls 'hyperparenting'; a desire to alter a child's characteristics rather than to lovingly accept features some may describe as imperfections[20,21] . Indeed, splinting ears may be part of a deeper inclination to reshape our children to the image of our own ideals. Splinting tries to influence the child's social status by changing the child instead of its social environment.

After analyzing advantages and disadvantages (shown in **table 1**) we conclude that, especially for the individual with deformed ears, splinting and taping is ethically justified due to its proven effect and potential to prevent harm while involving minimal risks. Moreover, early detection and correction is responsive towards the autonomous wishes of parents. Even though splinting is situated in a grey area between treatment and enhancement, it is comparable with other accepted customs like braces. However, things are more complicated on the societal level. If ear splinting is officially and pro-actively promoted from within the health care system or the government, then we bring across the message that deformed ears are a serious problem that needs to be addressed officially.

Table 1. Ethical analysis of advantages and drawbacks of active detection and splinting of deformed newborn ears.

Advantages	Drawbacks
Allowing to be perceived as "normal"	**Individual level**
Non-invasive technique , avoiding possible surgery, anesthesia and its drawbacks	Risks (skin irritation from splint usage)
Active detection allows early start with improved outcome	Risk of overtreatment (some ears correct by themselves)
No doctor needed to correct ears	Medicalization of postpartum period:
Being responsive to parents wish to correct deformities	Imposing on parents a previously unperceived medical problem
	Societal level
Informing parents timely about the full range of options	Burden on the health care system
	Regular splinting changes the norm
	Official promotion by the health care system channels perfectionism

Screening

Nevertheless, we still want to reach out to the individual in order to provide the full range of options within a very limited timeframe. Therefore, a tempting opportunity would be to take a look at the external ears during the national first week hearing test and inform parents of a present ear deformity and the possible therapy. Yet, strict criteria apply for carrying out an official screening program, as stated in 1968 by Wilson and Jungner and adopted by the World Health Organization[22] (an update of these criteria was released in 2008[23]). Ear splinting fails to meet several criteria, as shown in **table 2**.

Table 2. WHO screening criteria that are debatable in case of ear splinting

WHO screening criteria	evaluation	+ / +/- / -
1 (W&J) the disease should be an important health problem.	**A deformed ear is not a disease**	-
2 (W&J) There must be a generally accepted treatment method for the disease.	It is in the eye of the beholder if protruding ears warrant the application of a splint on a newborn.	+/-
7 (W&J) The natural course of the disease to detect must be known.	Often ears are a bit distorted after passing through the birth canal. This spontaneously resolves in the first days. Early detection leads to over treatment.	+/-
8 (W&J) There must be agreement on who should be treated. *3 (WHO) The screening target must be established*	What is seen as a deformed ear is easy to imagine, but hard to capture in measurements.	+/-
1 (WHO) The screening program should respond to a recognized need	Ears normally stick out in a variety of angles and our assumption that this would set children apart from the crowd may be culturally determined and change over time.	+/-
4 (WHO) The effectiveness of the screening program should be scientifically proven.	As there is no screening program now, a pilot study would be necessary, especially as a larger screening program would change the setting of splinting by a plastic surgeon in the hospital to one at home by a health care worker	+/-
5 (WHO)The program should be a coherent set of training, education, practice test, care and program management.	As splinting of deformed ears is not generally known, there should be a proper number of health care professionals be trained. A pro-active screening program would raise the numbers of babies to be treated. Ideally this is done at home without the need for a referral to a hospital. This may be a burden on the system	+/-
10 (WHO) Benefits of screening should outweigh potential disadvantages of screening	This is debatable, and one of the key themes of this article.	

CONCLUSION

We conclude that, on the level of the individual, it can be ethically justified to splint deformed baby ears; it allows young children to be perceived as normal without surgery. Associated risks should be assessed relative to other commonly accepted cosmetic interventions in children. Parents have the right to make such a decision for their child. Although this can also be a new burden in a postpartum period already full of medical- and nonmedical choices and responsibilities.

On the level of society, one has to acknowledge that official promotion of ear splinting by the health care system changes our norm in ear shape. Promotion of enhancement increases the pressure of performance and so does the need to embrace hyperparenting. Parents may feel the fear of missing out on the opportunity and the pressure to act.

Making molding part of the official national screening program fails based on WHO criteria, and probably right so, as adding this minor health problem places a burden on the system. Furthermore if ear splinting is pro-actively promoted from within the health care system the message is conveyed that deformed ears are a significant health problem.

Luckily, there are less controversial alternatives to official screening. A reasonable first step is to educate midwifes, maternity nurses, general practitioners, pediatricians and plastic surgeons to recognize deformed ears and offer splints. The flaw being that the knowledge and the resources do not really fit in any ones current daily practice. This is the main reason why this therapy still not made the break-through one would expect. But in the digital age this may very well change. As splints are available for everyone on the internet it is possible that commercial parties want to play a role. Key will be to responsibly educate and facilitate healthcare professionals and parents alike.

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4

CHAPTER 5

Ear piercing techniques and their effect on cartilage, a histologic study.

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ABSTRACT

Background

The popularity of high ear piercing has led to an increased incidence of perichondritis. Damage to the relatively avascular cartilage will make the ear prone to infection. The literature suggests that a piercing gun, mainly used by jewellers to pierce the lobule, may give excessive cartilaginous damage. Therefore some authors favour the piercing needle, as used in piercing studios. But until now, no comparative histological studies have been performed.

Purpose of study

To evaluate the extent of damage to ear cartilage using different piercing techniques.

Methods

Twenty-two fresh human cadaver ears were pierced using two spring loaded piercing guns (Caflon and Blomdahl), one hand force system (Studex) and a piercing needle (16G i.v. catheter). Extent of damage to the perichondrium and cartilage was quantified using a transverse section along the pin tract and compared between the different methods.

Results

The pattern of injury was similar in all techniques, showing perichondrium stripped from the cartilage around the pin tract, with most damage present on the exit site (mean length of 0.43 mm). Cartilage fractures and loose fragments were present over a mean length of 0.21 mm. No significant difference in the amount of injury between the different techniques was observed.

Conclusions

In contradiction with assumptions in the literature, all piercing methods give the same extent of damage to cartilage and perichondrium. Each method is expected to have the same risk for perichondritis, thus in the prevention of post-piercing perichondritis focus should be on other factors such as hygiene and after-care.

INTRODUCTION

High ear piercing has become a popular form of body jewelry since the last decade of the 20th century. Estimates of ear piercing manufacturers are that, at present, about 30% of all ear piercings in Europe involve piercing of the upper, cartilaginous area of the ear. Following this increase in popularity, a series of reports on perichondritis in just-pierced ears, and subsequent ear deformity and reconstruction were published.[1-4] In England and Wales the incidence of auricular perichondritis doubled between 1990 and 1998.[5]

The early features of perichondritis include local heat, erythema and pain, followed by swelling of the infected ear and abscess formation. Despite antibiotic and surgical intervention chondral necrosis occurs, leaving behind a residual deformity of the ear, for which plastic surgical reconstruction is often sought.[1,2] *Staphylococcus aureus* or *Pseudomonas aeruginosa* are mainly cultured from the perichondral abscesses, but infection with *Streptococcus* or *Proteus* species have also been reported.[1-4,6]

Although the minor complication rate in high ear piercing does not exceed the rate of piercing of the lobule of the ear,[7] the outcome after infection can be far worse. High ear piercings were far more susceptible to infection in a case-control study of a large outbreak of *Pseudomonas* infection after piercing (caused by contaminated after-care solution).[4]

This more dramatic course is the result of the unique characteristics of the cartilage. The cartilage is relatively avascular, only nourished by its perichondrium. Trauma by piercing will revascularize it even further. Bacteria, introduced through the piercing pin tract, will find a good medium for infection and can proliferate unchecked by the body's immune system.

It is often suggested that spring-loaded piercing guns, mainly used by jewelers, will cause excessive damage to the cartilage; a relatively blunt stud is forced through skin and cartilage by unloading of a strong spring, thus applying sheer forces to the cartilage with risk of shattering and stripping off of the perichondrium, making the ear prone to infection.[1,3,6,8,9] Professional piercers use disposable intravenous (i.v.) cannula to pierce ears; in their opinion this is a far less traumatic technique.[9]

An alternative technique is a system in which the piercing stud is pushed through the tissue by hand force, therefore applying a more dosed force.

The Dutch Ministry of Health, Welfare and Sport was preparing new regulations for piercing and tattoos, and was considering a ban on spring-loaded piercing guns for high ear piercings based on the present literature. However, the assumptions on tissue trauma through the different piercing methods have never been tested; a study identifying the method of piercing least traumatic to the ear is needed. In this report we have studied the direct effect of different ear-piercing techniques on ear cartilage in a human cadaver study.

MATERIALS AND METHODS

The ears of 22 freshly defrosted un-impregnated cadavers were pierced at room temperature. Left or right ear was used, avoiding the ear with post mortem haemorrhages or oedema. The antihelix of the ears was pierced using four different methods, leaving four piercings per ear. Direction of force was from anterior to posterior in all methods. After piercing, the ears were emerged in 4% formalin for fixation.

Before embedding the tissue in paraffin, the anterior surface was marked with ink. The specimens were anonymously coded and the code was sealed to assure `blind' histological assessment. A series of transversal slides were made parallel through the hole and stained with hematoxylin & eosin.

DIFFERENT PIERCING METHODS

Spring-loaded piercing gun, two types were tested:

A. Traditional open spring-loaded piercing gun (US. Patent 4020848 filed July 25 1973). Using Caflon 1.20 mm diameter studs (Caflon, Aylesbury, Bucks, UK). This model was in use until recently in a local jeweler's store, which specialized in earrings. Stud and clasp are loaded from a sterile cassette, without touching the (nonsterile) gun. Piercing was performed following instructions for use **(Figure 1).**

B. Blomdahl, spring-loaded piercing gun and disposable ear piercing cassettes containing 0.70 mm diameter studs (Blomdahl Medical AB, Halmstad, Sweden). The closed sterile complex of stud, stud holder, clasp and clasp holder is placed on the piercing gun. Piercing was performed following instructions for use **(Figure 2).**

Hand force system

System 75 by Studex. Disposable Cartridge Ear Piercing System and disposable cartridges containing 0.75 mm studs (Studex Inc, Gardena, USA). The closed sterile complex of stud, stud holder, clasp and clasp holder is placed on the push-through instrument. Piercing was performed following instructions for use **(Figure 3).**

Needle

BD Insyte-W IV-catheter 16G 1.7 mm diameter (Becton Dickinson Infusion Therapy Systems Inc., Sandy, Utah, USA). Intravenous catheter used in the University Medical Centre Utrecht, comparable to i.v. catheter used in local piercing studios for ear piercing. Technique as used in local piercing studio: complex of needle and catheter is pierced through the ear at a 90-degree angle, while fixating the ear with forceps with two broad, flat, open tips, leaving a 'window' for the needle. The needle is removed, leaving the catheter in place, and the stud is introduced (1.20 mm stud). With the stud in place, the catheter is removed, and the clasp added to the stud by hand **(Figures 4 and 5).**

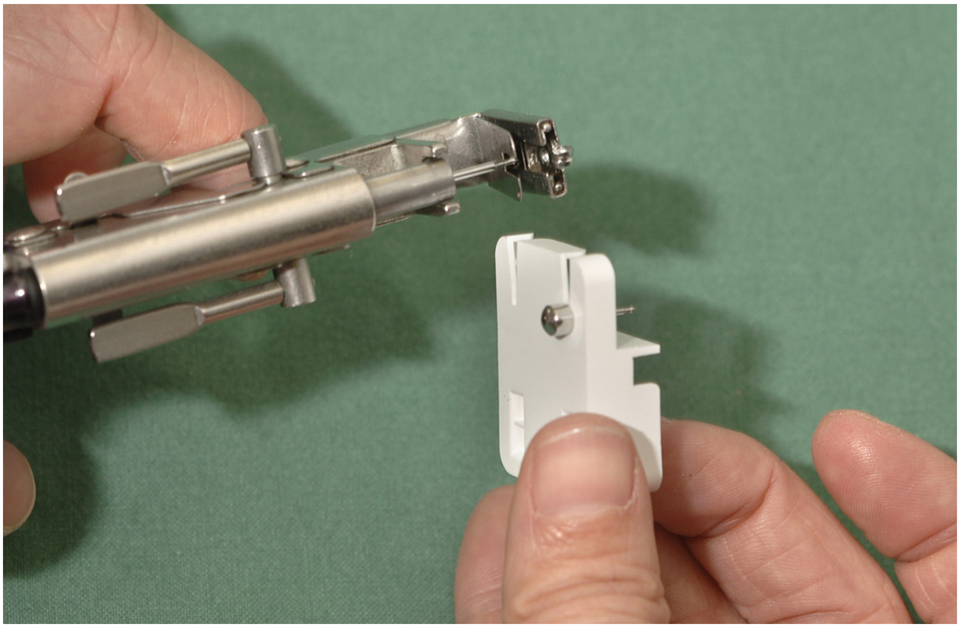


Figure 1. Traditional open spring-loaded piercing gun US. Patent 4020848 + Caflon 1.20 mm diameter studs.

Figure 2. Spring-loaded piercing gun Blomdahl.

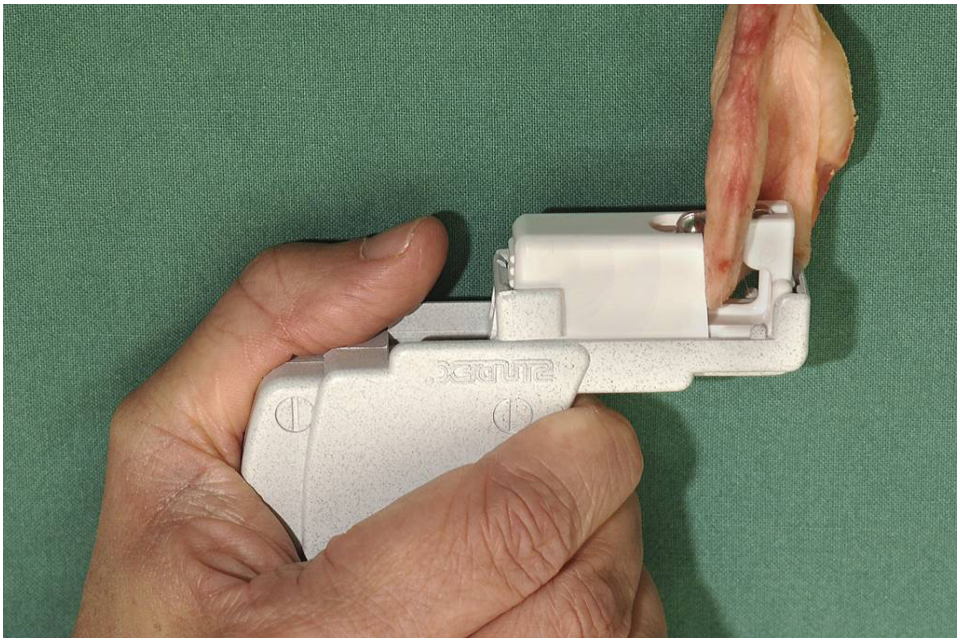


Figure 3. Push through system, Studex.

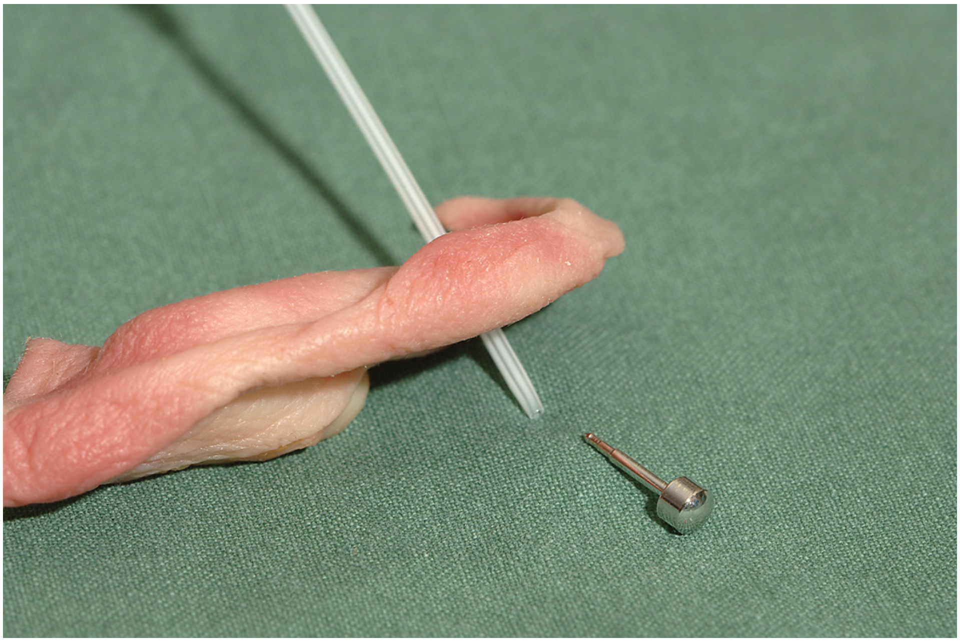


Figure 4. Needle piercing.

Figure 5. Detail of the used piercing studs/needle.

Histology and quantification of tissue damage
With light microscopy (x50 magnification) the transverse section through the pierced hole in the ear shows the auricular cartilage covered by perichondrium and surrounding subcutaneous tissue and anterior and posterior skin. The pin tract is central to this **(Figure 6a, b)**.

For each piercing the slide with the best, largest transection through the pin tract was selected for measurements, a scale in the ocular of the microscope was used to measure the extent of tissue damage (at x50, one scale grade=0.02 mm).

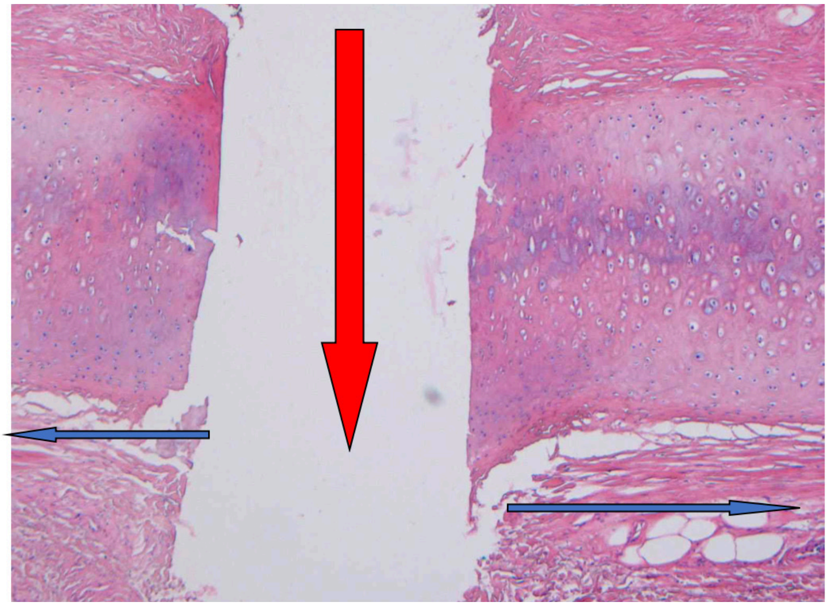
Special attention was paid to borders between cartilage and perichondrium. Along this border the length over which detachment of perichondrium is present was measured on both sides of the pin tract, at both the anterior and posterior border. The sum of these four lengths was taken as a measure of perichondrial damage (further mentioned as total perichondrial damage).

Tears in the cartilage itself were also observed: the maximum distance from the pin tract, at a 90-degree angle at which a tear is found, was measured on both sides of the tract. The sum of these two maximum lengths was taken as a measure of cartilage tears (further mentioned as total chondral tears).

Loose cartilage fragments or cartilage flaps were counted and taken as a measure of chondral shattering. Thickness of both ear and cartilage were measured. Measuring points were beforehand set by a pathologist (J.A. Kummer). Measurements are made in a `blind' fashion as the specimens, beforehand, were anonymously coded and the code was sealed until statistical analysis.

Data were entered in the SPSS 13.0 database. The four groups were compared for each variable using univariate analysis of variance. One-way ANOVA and post hoc multiple comparisons (Bonferroni) were used, correcting for the random effect `ear'.

6a



6b

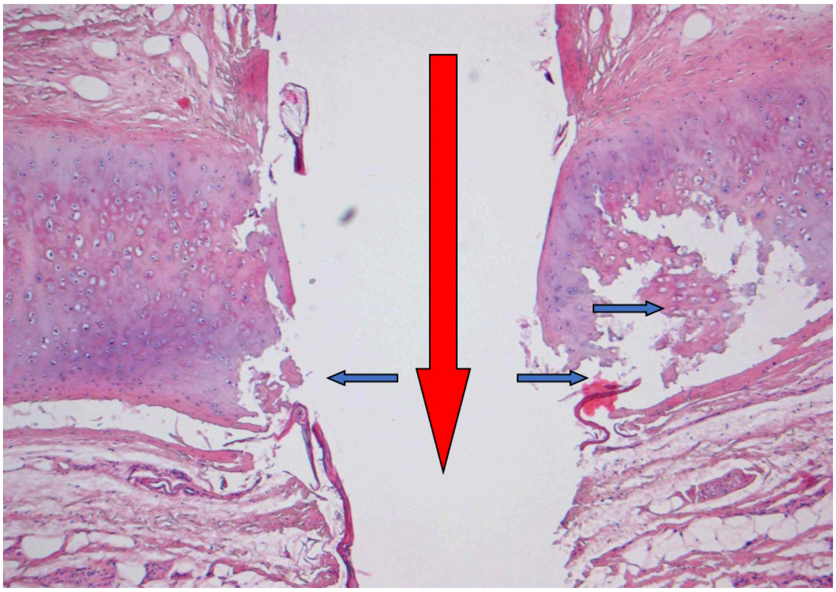


Figure 6a,b.

Example of injury patterns with in (a): mainly perichondrial detachment (small arrows); (b) mainly fragmentation of cartilage (small arrows). Big arrows: direction of piercing; from anterior to posterior (slide through hole, x50, light microscopy, hematoxylin & eosin staining).

RESULTS

Twenty-two ears were pierced with 22 needle piercings, 22 hand force piercings (Studex), 22 Caflon spring-loaded piercing gun piercings and 20 Blomdahl spring-loaded piercing gun piercings (only 20 available).

In nine instances, tissue slides were made beyond the pin tract, thereby failing to include the point of passing through the cartilage. In one ear all four different piercings were lost this way. The other losses were: four extra Blomdahl specimens and one extra hand force piercing (Studex) specimen. This left 21 needle piercings, 20 hand force piercings (Studex), 21 Caflon spring-loaded piercing gun piercings and 15 Blomdahl spring loaded piercing gun piercings available for measuring.

All slides showed excellent histology; the extent of tissue damage due to piercing was easily recognisable and measurable. Thickness of the cartilage at the four different piercing sites along the antihelix was consistent in each ear although thickness of the subcutaneous tissues slightly varied.

Specimens showed a similar pattern of injury at the piercing site. Damage to the epithelium is minimal, occasionally a strip of epithelium is pulled along the pin tract into the subcutaneous tissue. Injury to the subcutaneous tissues is limited to the area directly surrounding the pin tract. At point of entry in the cartilage there is an impression of cartilage and often the perichondrium is torn from the cartilage over a small distance (mean length: 0.26 mm; min 0.00 mm, max 1.50 mm). Most of the cartilage tears and fragments are found in the middle and posterior parts of the cartilage (mean length 0.21 mm; min 0.00 mm, max 2.15 mm). Often the edges of the cartilage along the pin tract are bent to the posterior. At the posterior side, where the pin tract exits the cartilage, the perichondrium is torn off the cartilage over a longer distance (mean 0.43 mm; min 0.00 mm, max 2.00 mm) **(Figure 6a b).**

Measurements and statistics

The four groups were compared for each variable, as mentioned in **Tables 1, 2 and 3**, using univariate analysis of variance. One-way ANOVA and post hoc multiple comparisons (Bonferroni) were used (correcting for the random effect 'ear'). Errors of all three variances were normally distributed. Comparison of one group against the total of measurements (one-way ANOVA), as well as multiple comparisons between the different groups (Bonferroni) did not show any significant difference for the means of total perichondrial damage, total chondral tears or chondral shattering.

Additional measurements

Perichondrial damage on the posterior (exit) site seems more extended than on the anterior site. The percentage of perichondrial damage at the posterior border compared to the total damage is expressed in **Table 4.** This tendency towards posterior damage was tested using the one sample t-test, with 50% as the test value. This tendency was significant for the Caflon springloaded piercings, Studex hand force system and total.

Table 1. Total perichondrial damage.

Measurements	Needle	Blomdahl	Caflon	Studex	Total
Mean. (in mm)	1.36	1.16	1.56	1.34	1.37
SD.	0.66	0.52	0.59	0.82	0.67
Range. (in mm)	0.14 – 2.52	0.46 – 2.14	0.56 – 2.98	0.12 – 3.40	0.14 – 3.40

Total perichondrial damage: sum of lengths over which detachment of perichondrium is present on both sides of the pin tract, anterior and posterior.

Table 2. Chondral tears.

Measurements	Needle	Blomdahl	Caflon	Studex	Total
Mean. (in mm)	0.46	0.36	0.38	0.46	0.42
SD.	0.32	0.29	0.23	0.55	0.37
Range. (in mm)	0.08 – 1.18	0.00 – 1.10	0.06 – 0.96	0.06 – 2.50	0.00 – 2.50

Total chondral tears: sum of max. length on both sides of pin tract in mm.

Table 3. Cartilage fragments.

Measurements	Needle	Blomdahl	Caflon	Studex	Total
Mean. (sum)	3.81	4.19	5.52	4.90	4.63
SD.	4.06	3.58	4.00	3.93	4.17
Range. (sum)	0 – 16	0 – 12	0 – 19	0 – 18	0 – 19

Number of loose cartilage fragments or flaps along the pin tract.

Table 4. Perichondrial damage at posterior border.

Measurements	Needle	Blomdahl	Caflon	Studex	Total
Mean. (%)	62.5	63.3	64.3	70.1	65.1
SD.	20.9	25.0	20.8	22.3	21.8
Range. (%)	15.7 – 88.7	18.2 – 96.2	16.7 – 94.9	21.1 - 100	15.7 -100
P Value*	0.012	0.059	*P*<.001	*P*<.001	*P*<.001

Perichondrial damage at posterior border, percentage of total perichondrial damage.

DISCUSSION

Choosing the least traumatic piercing method could reduce the risk of post-piercing perichondritis. It is often suggested, although never tested, that piercing guns will cause excessive damage to the cartilage. Our human cadaver study of commercial piercing techniques of the upper ear and their direct effect on cartilage evaluated this assumption and provided more clarity on the effects of piercing to the ear cartilage in general.

The direct post-piercing tissue injury pattern, consistent through the slides, shows perichondrium torn from the cartilage and some tears and fragments of the cartilage. Injury to the subcutaneous tissues was limited. Most of the damage, both at perichondrial and cartilage level, is at the side where the piercing stud exits the cartilage. Tissue injury was seen over a relatively small distance; 2.12 mm from the pin tract is the maximum length measured, and the average is much lower.

The extent of the damage is modest, nevertheless the aspect of the tissue injury pattern may be of importance. The perichondrial detachment creates a pocket between the perichondrium and cartilage. This pocket could facilitate the development of a subperichondrial abscess. It is also unfortunate that most of the damage is to the posterior site of the ear, where self-cleaning is less easy to perform. A comparison between the different piercing methods did not show any significant difference in perichondrial damage, total chondral tears or chondral shattering, despite the fact that the design and diameter of the tip of the piercing instrument varied greatly, as well as the force applied to pierce the ear.

This study was not meant to develop the ideal piercing method, but the fact that the needle, having a much larger diameter than the other studs, showed the same amount of damage suggests that the best results can be expected from a sharp piercing instrument with a relatively small diameter. Maybe results of the needle piercings can be improved by removing the (relatively blunt) i.v. catheter, to introduce the stud in the needle instead, although then a larger diameter needle is needed.

Maybe the results of the direct piercing methods (spring loaded and hand force) can be improved by sharpening the tips of the stud.

There does not seem to be an advantage in a dosed force, as used in the hand force system, compared to the spring-loaded guns.

A cadaver study, of course, does not provide the possibility of following the response to injury after piercing. As the direct injury pattern is the same for the different piercing methods, the following events of bleeding, inflammation and healing are expected to be similar. But what might be of importance is the room left between the stud and the pin tract. The needle piercing method makes a larger diameter pin tract for a smaller diameter stud. In the piercing gun and hand force methods the stud directly pierces the ear, leaving no extra space. In these methods secondary pressure necrosis might occur. But in the `loose' needle pin tract there is more room for debris. Both can give an additional risk for secondary infection. Only animal studies at different time-points can study these effects.

In conclusion, what this study does show is that the currently available methods to pierce the upper-ear are comparable with regard to direct tissue damage. Based on this, each method is expected to give the same risk for perichondritis. This means that if we want to reduce the risk of post-piercing perichondritis the focus should be on other risk factors: hygiene during the procedure and in after care. Hygiene is always important, but is vital in piercings through cartilage as the nature of the post-piercing tissue damage, although small, facilitates perichondritis.

Acknowledgements
Funding: Ministry of Health, Welfare and Sport Postbus 20350, 2500EJ Den Haag, The Netherlands. The Ministry, preparing new regulations for piercing and tattoo, considered a ban on spring-loaded piercing guns for high ear piercings based on the present literature. Additional information was requested, resulting in this study.

Products
The Blomdahl spring-loaded piercing gun and disposable ear piercing cassettes and System 75 by Studex Push Through Disposable Cartridge Ear Piercing System and disposable cartridges (Studex Inc., 521W. Rosecrans Ave. Gardena, CA 90248-1514, USA) were kindly provided by: Blomdahl Medical AB, Kristinebergsvägen 18, P.O. Box 7032, SE-300 07 Halmstad, Sweden

Traditional open spring-loaded piercing gun (US Patent 4020848 filed July 25 1973) þ Caflon ear piercings (Caflon, Unit 19, Park Street Industrial Estate, Osier Way, Aylesbury, Bucks HP20 1EB, UK) were kindly provided by the owner of a local jewellery store (specialised in earrings) `Het Oortje' Oudegracht184, 3511NP Utrecht, The Netherlands.

Studio Remi - Piercing & Tattoo art, Utrecht, the Netherlands provided information on

needle piercing, the needle piercing in this study was conducted according to their method.

Role of the sponsors: The sponsoring agencies had no involvement in the design, conduct or write-up of this study.

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CHAPTER 6

T-bar reconstruction of constricted ears and a new classification.

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ABSTRACT

For the correction of constricted ears, many techniques are described in the literature, the majority based on Tanzer's classification of 1975.

The improvements in ear reconstruction published by Brent, Nagata, Firmin and Park make better outcomes possible.

It is therefore that a new classification for constricted ears is proposed, together with an alternative technique for correction of group IIA and IIB deformities, using a T-strut of costal cartilage to reconstruct the underdeveloped or missing superior crus of the antihelix.

INTRODUCTION

Constricted ears form a group of auricular anomalies of the upper third of the ear, whereby it seems that the rim of the ear has been tightened as if by a purse string. It is characterised by four features; lidding, decreased vertical height of the ear, protrusion and low ear position.[1] In the past, it has also been referred to as 'lop ear' and 'cup ear'.[2] In 1975, Tanzer classified constricted ears in three groups and two subgroups **(Table 1)**.[1]

This classification is still in use today and there are many proposed reconstruction techniques for this according to Tanzer, 'curious' group of auricular deformities, none of them however superior.[3] Group I, where only the helix is involved, can in most cases simply be treated by excision of the excess of skin and subcutaneous fatty tissue when there is only some broadening or limited cartilage collapse.[1] In the latter, trimming of the helical rim cartilage is necessary. When the helical rim cartilage is slightly deformed, reinforcement can be done by a conchal cartilage graft[4] or a costal cartilage strip from the first or second floating rib.[5]

When both the helix and scapha are involved, Tanzer differs between group IIA and IIB. The whole plastic surgical bag of tricks was emptied for this group; Banner flaps,[1,2,6] tumbling cartilage flap or D flap,1 V-Y[2,7] or Z advancement of the root of helix,[8] expanding the cartilage by splitting it into interdigitating leaves,[1,2,6,9] conchal cartilage grafts[1,4,10] and addition of local skin flaps.[1,2,11] All techniques are aiming to elongate the upper pole. A mastoid hitch, whereby the refashioned upper neohelix is sutured to the mastoid fascia, is often used as an adjunct to these procedures to maintain helical elevation and prevent recurrence.[6,8]

Since Brent described the four-staged ear reconstruction technique in 1980,[12,13] and Nagata changed this into a twostep technique in 1993,[14] a remarkable improvement in outcomes was obtained. With the adjustments of Firmin[15] and the proposed one-stage reconstruction designed by Park,[16] even more satisfactory results can be achieved. Because of these developments, groups IIB and III of Tanzer in our opinion need to be placed in a different context and regarded as concha-type microtia and corrected accordingly. All the proposed correction techniques for Tanzer type IIB, so nicely enumerated by Tanzer[1] and Cosman,[2] will hardly ever lead to acceptable results in shape and size compared to the normal developed side. With a one- or a two-stage reconstruction technique, as used in microtia cases, using costal cartilage to rebuild the upper part of the constricted ear, very natural results can be obtained in experienced hands.[12-16]

We would like to share a simple one-stage technique for group II of Tanzer and propose a new classification of the constricted ear deformities.

Table 1. Tanzer classification of constricted ears.

Tanzer group I	helical collapse only	
IIa	deficiency of scapha, superior crus, and fossa triangularis create collapse of upper helix, resulting in loss of vertical height, lidding and protrusion	IIa: no supplemental skin needed to expand the auricular margin
IIb		IIb: no antihelical crura, considerable height reduction. supplemental skin necessary to expand the auricular margin
III	attachment of anterior helix close to the lobule, the auricle is pouch-like and the ear is usually low-set.	

METHODS

When faced with lidding of the helix, a distinction must be made between those cases were manually the helical rim can be forced into a normal shape and those cases were this is prevented by collapse and adherence of the cartilage. In fact, what is lacking is the superior crus of the antihelix to support the helical rim. The missing superior crus can be reconstructed by a T-shaped costal cartilage strut. The approach is through an anterior skin incision inside the helical rim and mobilisation of the skin in the scaphal region until the upper part of the antihelix is fully exposed. The anterior access is convenient and the resulting scar is well hidden inside the helical rim. The length of the graft can be chosen in such a way that the helical rim is raised and the height of the ear equalises the non-deformed side and varies between patients. It is carved out of one solid block of costal cartilage; therefore, the fifth rib is used as the floating rib does not have sufficient width **(Figure 1).**

The horizontal part of the T supports the helical rim and prevents sagging. It has to be thinned to 1.5 mm in order not to be visible. Part of the fifth rib is harvested trough a 2-3-cm inframammary incision. In women, this leads to a hardly conspicuous scar. In cases where the lidding can be corrected manually, no cartilage excision needs to be done while in case of adherence, a half-moon-shape excision of the deformed scapha is necessary in order to mobilise the helical rim and move it into a more cranial position. The T-shaped cartilage strut is fixed to the helical rim with two Ethicon® nylon 6/0 sutures and with a second pair of sutures at the transition of the antihelix and inferior crus. The skin around the cartilage of the helical rim needs to be mobilised on both sides to make fixation of the horizontal part of the T-bar with sutures possible **(Figure 2).**

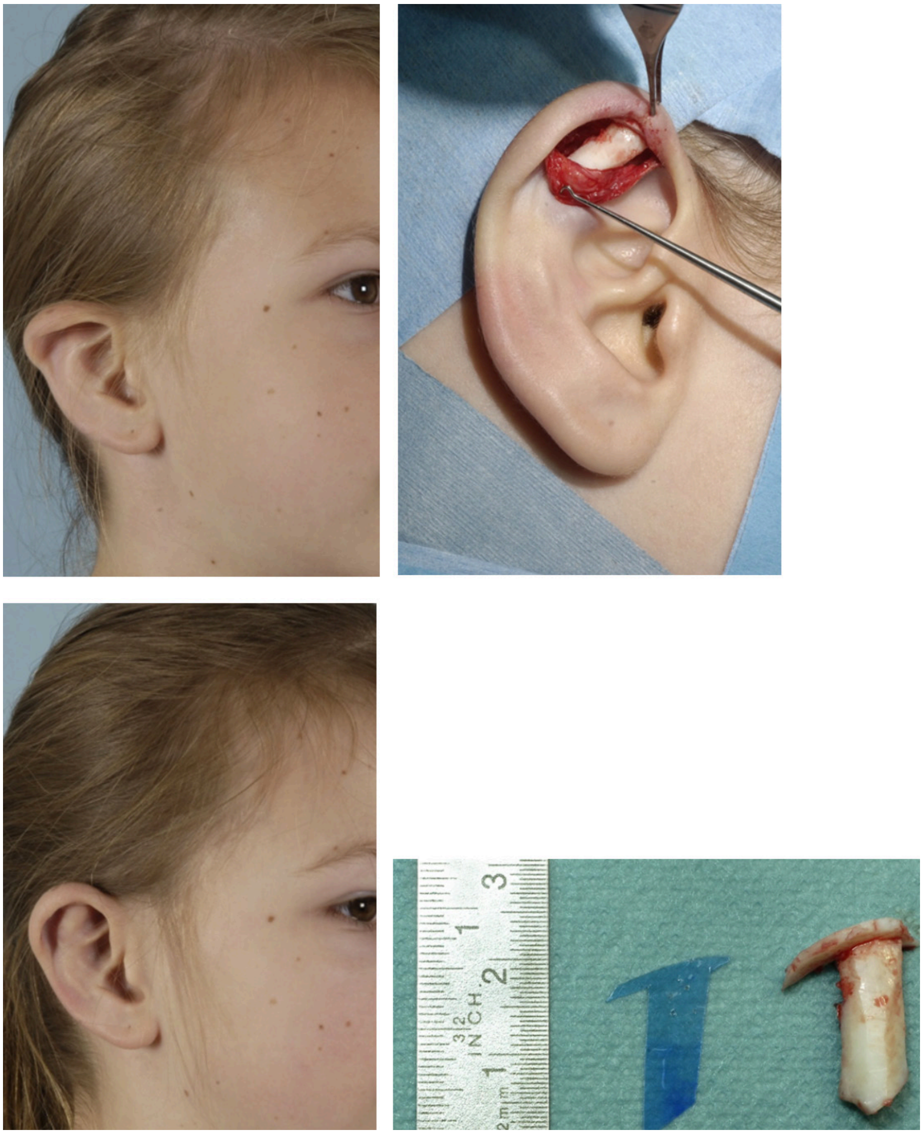

Figure 1. T-shaped cartilage strut for gr. II of Tanzer constricted ear, case 1.

Figure 2. T-shaped cartilage strut for gr. II of Tanzer constricted ear, case 2, two weeks postoperative.

PATIENTS AND RESULTS

A total of nine ears (eight patients, four male patients) were operated by the senior author **(MK, Table 2).** The mean age was 19.5 years (range, 12-36 years). Follow-up period was 3-28 months (mean 16 months). The main problem encountered was the transition between the strut base and the inferior crus in the second and third case of this series. This problem was corrected by refixation of the costal cartilage to the antihelical rim in a more anterior position under local anaesthesia. In one patient, the sutures were removed because the Ethicon® 6/0 nylon sutures were visible through the skin. In two patients, the upper part of the ear was slightly protruding compared to the non-operated side (2 and 4 mm), which could easily be corrected, but the two patients did not request adjuvant surgery. All patients were satisfied with the outcome of the operation because of the general form, the upright position of the upper pole of the ear and the restoration of symmetry. There were no infections or haematomas. The scar was hidden within the helical rim and hardly visible. Donorsite morbidity was neglectable.

Table 2. Results of T-strut correction of constricted ears.

♂/♀	Age	Side	Result	Complication	Secondary correction	Follow up in months
♀	18	R	Excellent	No	No	9
♀	23	R	Slightly broad T-strut	No	T-strut narrowed	3
♂	36	R	Excellent	No	No	9
♂	13	L	Excellent	No	No	28
♀	13	R	Ear slightly protruding	No	No	21
♂	12	L+R	Ear slightly protruding	No	No	20
♀	20	R	Visible transition strut-crus	No	Refixation strut	23
♀	21	R	Visible transition strut-crus	No	Refixation strut	22

DISCUSSION

Because of the developments in ear reconstruction techniques, Tanzer's classification[1] should be shifted towards a new classification **(Table 3)** based on the present operative options.

Group I can be kept as originally described by Tanzer in 1975. The classification of group IIA and IIB should however be changed.

We propose to include in group II only the deformities of helix and scapha. In the new classification, group IIA are those cases which are manually redressable, while group IIB is deformed and adherent but otherwise reshapable by excising the scaphal cartilage deformity. All other deformities of the upper pole of the external ear with the absence of the upper part of the antihelix and antihelical crura and reduction of the height of the ear must be classified and treated as concha-type microtia and thus reconstructed by a full costal cartilage frame. By removing the deformed upper pole, a skin pocket can be obtained large enough to accommodate a new cartilage frame of the same size as the normal side.

6

The T-shaped strut for the correction of IIA and IIB deformities leaves only a small donor scar and gives hardly any postoperative inconvenience. In the eight patients (nine ears) operated with this technique, no recurrence of the deformity has occurred. Only minor irregularities between strut ant antihelix had to be corrected under local anaesthesia. This was only seen in the first patients operated on and can be prevented by a proper shaping of the base of the costal cartilage strut in such way that it fits snugly to and is in level with the antihelix.

As stated in earlier publications, many deformities in group II can in fact be prevented by splinting within the first weeks after birth.[17] For late cases, the T-shaped cartilage strut is a straightforward technique with limited donor-site morbidity.

Table 3. Kon classification of constricted ears.

group I	**helical collapse only**	
IIa	Deformities of helix and scapha.	IIa: manually redressable
IIb		IIb: deformed and adherent but otherwise reshapable by excising the scaphal cartilage deformity
All other deformities of the upper pole of the external ear with absence of the upper part of the antihelix and antihelical crura and reduction of the height of the ear must be classified and treated as concha type microtia		

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CHAPTER 7

Surgical Correction of the ``Sunken Ear'': An Auricular Positional Change after Canal Wall Down Mastoidectomy

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INTRODUCTION

Cholesteatoma is a destructive lesion of the middle ear, clinically characterized by otalgia, otorrhea, and hearing loss. Cholesteatoma is a relatively common condition, with an incidence of 3 to 6 cases per 100,000 children and 9 per 100,000 adults per year. If left untreated, cholesteatoma can cause potentially life-threatening intracranial complications.[1] Therefore, surgical removal is indicated once the diagnosis is made, and mastoidectomy is a common surgical procedure for the treatment of cholesteatoma. When a canal wall down mastoidectomy is performed, the resulting mastoid bowl can cause chronic otorrhea, dizziness, and the need for frequent cleaning.[2] A lesser-known complication of mastoidectomy is a positional change of the external ear, resulting in an aesthetically unsatisfactory appearance. Due to a decreased projection of the mastoid, the position of the ear migrates to an asymmetrical flat position. For this complication, we propose the name ``sunken ear.''

To correct the asymmetrical auricular position, an effective reconstructive surgical intervention is presented. To our knowledge, this is the first description of a technique to correct the sunken ear deformity.

MATERIALS AND METHODS

We retrospectively reviewed the charts of all patients who underwent surgical correction of the sunken ear deformity between 2003 and 2013 in our hospital. All patients developed the deformity after canal wall down mastoidectomy was performed for cholesteatoma.

Ethical Considerations

The Medical Research Involving Human Subjects Act did not apply to this study; therefore, official approval of this study by the University Medical Center Utrecht was not required under the act.

Surgical Procedure

A vertical incision of 3 cm is made in the postauricular sulcus of the affected ear, and the skin is mobilized. A pocket is created between concha and remaining mastoid. Meanwhile, costal cartilage is harvested from the first floating rib of the right hemithorax. A 4-cm piece of cartilage with perichondrium is excised and divided in 2. The separate pieces are fixed together with Vicryl 3.0 and carved into a wedge. The thickness depends on the amount of ear protrusion required and the form of the underlying remaining mastoid structure. The cartilage block is placed in the space between concha and mastoid and fixed with Vicryl 3.0 sutures to the concha cartilage. The skin of the postauricular sulcus is closed with Vicryl Rapide 4.0 sutures. At the donor area, the rectus muscle, fascia, and subcutaneous tissue are approximated, and the skin of the thorax is closed. A small dressing is placed over the operated ear. The patient is treated with oral Augmentin for 5 days.

RESULTS

A total of 9 young adult male patients (aged 13-26 years) were operated. All were >1 year postmastoidectomy. The direct postoperative courses were uneventful. All patients were discharged the next day. During follow-up after 3 months, 8 patients had a near to full symmetrical position of both ears. One patient had to be re-operated because of dislocation of the cartilage block. It moved to a more postantihelical, instead of postconchal, position due to inadequate fixation. This led to less protrusion of the auricle. By simple adjustment and refixation of the cartilage block behind the concha, the problem was solved. Eventually, all patients were satisfied with the results. The pre- and postoperative images of 2 random patients and the costal cartilage wedge are shown in **Figures 1-6.**

Figure 1. Preoperative ``sunken ear'' deformity of the left ear. The space between the skull and helix of the left ear was 0.1 cm.

Figure 2. Situation 6 months postoperative. The space between the skull and helix of the left ear was 1.8 cm.

Figure 3. Preoperative ``sunken ear´´ deformity of the right ear. The space between the skull and helix of the right ear was 0.2 cm

Figure 4. Situation 6 months postoperative. The space between the skull and helix of the right ear was 1.7 cm.

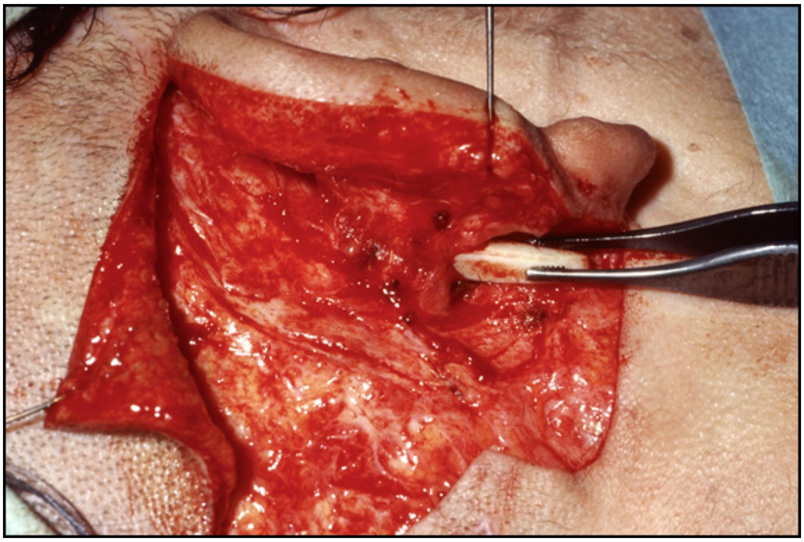

Figure 5. Insertion of costal cartilage graft behind the auricle in a second stage microtia operation. In correction of the sunken ear deformity, only a vertical incision of three centimeters is made in the post-auricular sulcus and space is created between concha and remaining mastoid without extensive mobilization of the skin as shown in the picture. Thereafter the cartilage is fixed to the concha with 3x0 vicryl sutures and the skin incision is closed.

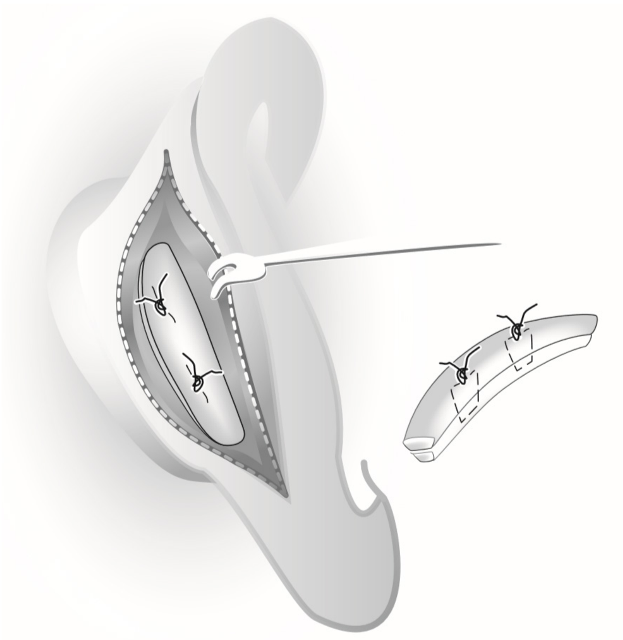

Figure 6. Placement of multilayered costal cartilage block. One side rests on remnants of mastoid; the other side is fixed to the concha. Height of block depends on required projection. (Made by Janssen I. ©UMC Utrecht.)

DISCUSSION

In this article, we describe the asymmetrical auricular position of the ear as a cosmetic complication after surgical treatment for cholesteatoma. It can occur relatively shortly after mastoidectomy, and it results in an aesthetically unsatisfactory appearance that can have a negative effect on patients' self-esteem and quality of life, especially at a young age. We named this deformity ``sunken ear.''

Very little information in the literature is available on auricular positional changes after mastoidectomy. Ali published on acquired low-set ears as a complication after mastoidectomy.[3,4] He reported the inferior displaced ear position after tympanomastoidectomy in 7 patients.[3] However, these outcomes were based on subjective measurements, and follow-up was not clearly described. Therefore, Hong et al started a prospective study to objectify the possible cosmetic complications after mastoidectomy. At 12-month follow-up after canal wall up mastoidectomy, no significant changes of the auricular position were observed in 19 patients.[4] The patients described in this report developed an asymmetrical flat position of the operated ear shortly after mastoidectomy. Perhaps Hong and colleagues used a technique in which the mastoid tip was left in place. Radical mastoidectomy, wherein the mastoid tip is removed, may lead to inward migration of the auricle, causing the sunken ear deformity. Therefore, it seems obvious that this deformity might depend on the chosen surgical technique. Techniques in which the mastoid cavity is obliterated with, for example, temporal fascia may also provide a better base for the external ear, although there is the potential for delayed detection of recidivism or residual disease.[2]

The thick costal cartilage is ideal to provide the necessary 10- to 15-mm base, something that concha cartilage or fascia cannot provide. In case of a second look, the wedge can be easily lifted en-bloc with the external ear or temporary removed. The first floating rib is our first choice in all autologous ear reconstructions. Rib harvest has a potential risk for pneumothorax or chronic pain, but this complication is seldom seen. The rib harvest incision leaves a 4-cm visible scar. In summary, we report here our cases of sunken ear deformities as a complication following mastoidectomy. A successful and relatively simple surgical procedure is available. This technique is very similar to the one used in second-stage ear reconstruction.[5]

7

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CHAPTER 8

Partial ear necrosis due to recluse spider bite.

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PARTIAL EAR NECROSIS DUE TO RECLUSE SPIDER BITE

Bites by spiders of the genus Loxosceles cause symptoms ranging from minor localized effects to severe skin necrosis and systemic reactions including renal failure and in some cases even death. Loxosceles spiders are found in temperate and tropical regions of America, Africa, and Europe.[1]

Loxosceles species are known as recluse spiders, violin spiders, fiddle back spiders, and brown spiders and can be identified by a violin pattern on their dorsal surface.[1] Most cases regarding spider bites are described in the United States. However, bites by the Mediterranean recluse, causing necrosis of the skin, are also described.[2,3] Loxosceles spiders are nocturnal and active when warm. They are found in dry dark places. Most bites happen at night when the spider gets trapped between the sheets and skin of sleeping people. Patients are often unaware of the painless spider bite. Cutaneous symptoms are the 'red, white and blue sign' caused by vasodilatation, ischemia and necrosis.[1,5]

To our knowledge, this is the first case that describes skin and ear cartilage necrosis after a spider bite. A 22-year-old healthy woman was referred to our department, with a partial defect of the helical rim and antihelix of the middle third of her left ear. During her summer holiday in Italy she was woken one night because of pain in her left ear. Throughout the following day the ear became swollen, with a central small vesicle, by the end of the day the oedema had spread to the left half of her face. A General Practitioner prescribed an antihistamine, with no effect. Two days after the incident she was referred to a hospital with oedema of face and left ear, considerable pain and a rash over her body. A high dose of antihistamine appeared to have effect, but the ear remained extremely painful and showed a red, white and blue discoloration **(Figure 1).**

Necrosis of the middle third of the ear was evident from day 12. Back home she attended our outpatient clinic. Based on the patient's history and the clinical signs we diagnosed a bite of the Mediterranean recluse. A partial ear reconstruction was performed. Using a template from the right ear, a framework was made from costal cartilage during the first surgery. The cartilage framework was fixated to the ear remnants with nylon 6.0 and covered with a retro-auricular skin flap. Five months later the external ear was mobilized and a full thickness skin graft was used to close the posterior side of the ear **(Figure 2).**

The diagnosis of Mediterranean recluse bite is based on the typical history of pain in combination with erythema, cyanosis and a central vesicle after a painless bite several hours earlier.[1]

Figure 1. Red-white-blue discoloration day seven leading to through and through necrosis of middle third of the ear on day 21.

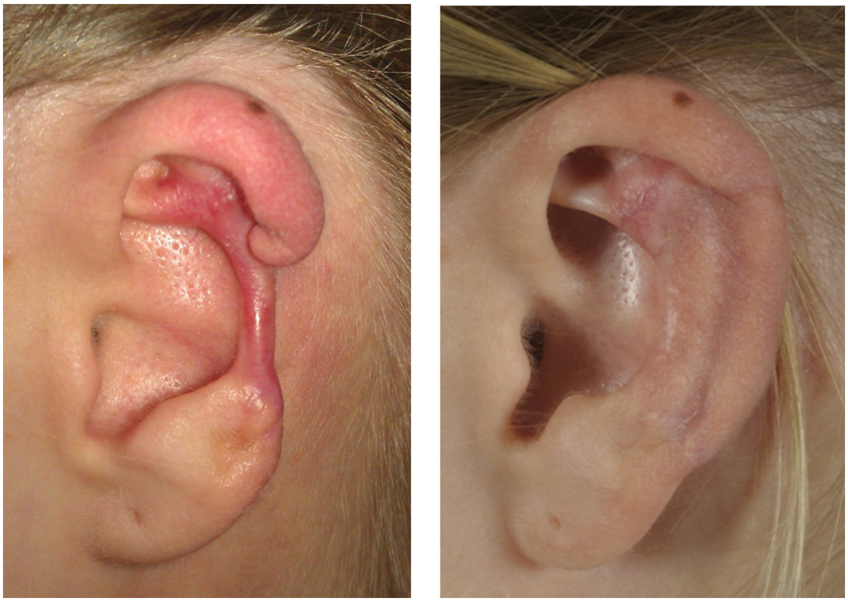

Figure 2. Middle third defect and ear after reconstruction with costal cartilage.

The first 24 h the lesion becomes oedematous and the typical discoloration appears, through erythema, ischemia and thrombosis. Central necrosis reaches its maximum after one to six weeks. Subcutaneous fat necrosis leaves a depressed scar.[1,5]In this case it could be that the venom of the spider had affected the patient's perichondrium and cartilage of the ear, or that the perichondrium and the cartilage were destroyed due to exposure secondary to skin necrosis.

Necrosis is caused by cytotoxic and proteolytic components of the species-specific venoms.[4] The primary cytotoxic component has now been identified as phospholipase D, but the venom is a complex mixture of toxins including alkaline phosphatase, hyaluronidase, metalloproteases, and insecticidal peptides[1,4]

The exact pathogenesis is not completely clear but the toxins activate signalling pathways in different cells causing an inflammatory response, platelet aggregation, and increased blood vessel permeability.[1,4,5] The optimal treatment of a recluse spider bite is controversial and various treatment options have been considered including corticosteroids, antibiotics, excision, antihistamines, colchicine, hyperbaric therapy and anti-venoms.[1,5]

In the past a leukocyte inhibitor, such as Dapsone (diamino-diphenyl sulfone) has been proposed. However, there are risks in using Dapsone and there is no sufficient scientific proof of its effectiveness.[5]

When a recluse spider bite is suspected treatment includes rest, ice compresses and elevation to minimize inflammation and spread of venom. In addition analgesia and tetanus prophylaxis should be given, and antibiotic treatment when needed. Any patient with evidence of systemic loxoscelism should be hospitalized. Laboratory evaluation in cases of expanding dermonecrosis and loxoscelism should screen for evidence of haemolysis, and intravascular coagulation.[1,5]

Early excision of bite lesions and intralesional injection of corticosteroids are contraindicated and could increase the necrosis. At a later stage excision of eschars and covering of the defects with split or full thickness skin grafts or, as in our case, reconstruction of the ear with costal cartilage is necessary.[5]

Faced with patients who develop the described symptoms in Mediterranean areas, one has to keep the Mediterranean recluse spider bite in mind.

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CHAPTER 9

Discussion, conclusion and future perspectives

CHAPTER 1

Background

Odd-shaped ears, whether congenital or acquired, may not be a disease from a biomedical point of view. However, if ears are "different", people still seek help to change their ears to the more average shape.

Congenital auricular anomalies are categorized either as malformational or deformational. Malformations are the result of true abnormal embryologic development, often as part of a syndrome affecting the brachial arches.[1]

A more common group of abnormal ear shapes are considered ear deformations. They have a normal chondro-cutaneous component. The ear bends towards the normal shape by digital pressure. In that light they do not directly seem to be the result of abnormal morphogenesis. External pressure or a different course of the seven intrinsic and four extrinsic muscles is often proposed as the cause of deformed ears.[2,3] Weerda on the other hand classified deformed ears as a Grade I dysplasia.[1] Several distinct shapes exist, protruding ears and some types of constricted ears are common examples.

CHAPTER 2

Ear Splints, literature

In newborn babies, with their malleable cartilage, there is a small window of opportunity to reshape deformed ears using a splint and possibly avoid surgery. Permanent correction can be achieved by "forcing" the ear into the desired position by splinting for several weeks.[4]

Since the first publications from Japan in the late 1980s, many authors demonstrated that by splinting ears permanent correction can be achieved[3,4,5].

But, there are still many unanswered questions surrounding this intervention. At first, it is unclear whether all deformed newborn ears should be splinted; some ear deformities spontaneously resolve during the first months after birth.[4] Lop ears especially tend to straighten out as the cartilage gets stiffer. This could obviously augment the good results seen in the literature with regards to the treatment of lop ears with splints.[6-10]

Based on literature it seems safe to say that protruding ears do not self-correct. Although Matsuo showed that most auricular shape deformities spontaneously resolve in the first year of life, he observed more protruding ears with age.[4] In the few control studies on splinting protruding ears, no spontaneous improvements were observed in the 'control ear'.[11,12]

Splinting can be performed in many ways, provided that the ear is kept in the desired shape. Parents can be taught to replace the adhesive tapes when necessary. This easy, noninvasive technique is not only intended for plastic surgeons but essentially available for other medical practitioners or physician assistants. Gault [6] offers splints to parents through a web shop (EarBuddies™ - www.earbuddies.co.uk), although a simple silicone tube with metal core, as suggested by Porter and Tan in Plastic & Reconstructive Surgery in 2005, will also suffice.[13]

The presumed working mechanism behind ear splinting assumes pliable cartilage caused by the high maternal plasma estrogen levels in the newborn. These levels drop quickly after birth with a drop in pliability of the cartilage as well.[14-18] If the ear is forced in the right position during this transition period, the shape can be permanently changed. The literature seems to support this theory; if splints are applied within 48 hours after birth, two weeks of splinting seems to suffice.[8,11] For older children the relation between patient age and the time needed to splint remains unclear.[9,10,12, 19-22]

It is disputable until what age splinting therapy can reasonably be offered, considering the expected result, time and effort that needs to be invested. Opinions vary from 'newborn only' [7,10,11,21-23] until well up to three[8,24] or six months of age.[4,25] A more rigid fixation than only a splint and tape seems to allow correction in much older children.[12,19,20] Many experts found that after a certain age, splinting becomes unsuccessful and advise against it. It is unfortunate that there is no agreement about this maximum age and that their personal experiences were never clarified by patient data.

There is no comprehensive evidence on the length of time needed for adequate splinting. This pleads for a study that focuses on the time needed to splint in relation to age. However, it might even be more effective to focus on the relation between the ease with which the auricle can be manually folded to the desired shape, the splinting time needed and the ultimate chance of success,[19,20,26] making age or the nature of the deformity less important. But there is no instrument that quantifies cartilage stiffness in vivo.

The desired outcome; a normal looking ear, is easy to imagine, but hard to capture in measurements. In the case of prominent ears, some form of measurement is possible. In adults or older children, the normal mastoid-helical distance is 15-21 mm.[27,28] The normal distance in newborns has never been defined. In surgical correction, outcome can be scored according to an objective list, for example, the list of goals in otoplasty for protruding ears by McDowell and Wright.[27,28] This cannot be applied to ear splinting, but an adjusted scale may be considered.

Conclusion

The non-operative treatment of auricular ear deformities is an elegant technique that should be practiced on a much wider scale than is done today. More awareness is needed, as well as prospective studies addressing the relation between patient age, degree of deformity, stiffness of the cartilage, the time needed to splint and the treatment outcome.

In recent years only the study by Doft[29] (early referral service), and Byrd [30.](presenting the Earwell® device) were valuable additions. They both treated newborns only.

CHAPTER 3

Splinting Dutch baby ears

In this chapter we describe our prospective study on nonsurgical correction of protruding ears that tries to answer the main questions that are absent in the current literature:

- Until what age can splinting be reasonably offered?
- What is the duration needed to splint in relation to patient age?
- Are there differences in results and duration of treatment related to the nature of the auricular deformity?
- Is it possible to quantify prominent ears?

We treated the protruding ears of 132 babies using a splint in the scaphal hollow in combination with tape (EarBuddies™). Treatment continued until the desired shape persisted. Results were judged from pictures and mastoid-helical distance was measured. In 132 babies, 209 ears were treated. Twenty-four patients had no follow-up, 27 stopped therapy because of skin irritation and fixation problems. In the remaining patients, results were good in 28%, fair in 36%, poor in 36%. Efficacy deteriorates with age; with fair or good results in 66.7% if therapy started before the sixth week. Older children needed to be splinted longer. The antihelical fold was easier corrected than a deep concha (correction in 69.8% versus 26.8%).

Table 1. Results in relation to the age at the start of splinting therapy.

	Outcome of splinting therapy				
Age at start therapy	Good	Fair	Poor	Not completed	Total
0 through 6 weeks	12 (30.8%)	14 (35.9%)	7 (17.9%)	6 (15.4%)	39
7 through 12 weeks	9 (19.6%)	10 (21.7%)	14 (30.4%)	13 (28.3%)	46
> 13 weeks	2 (8.7%)	5 (21.7%)	8 (34.8%)	8 (34.8%)	23

Like in the literature we relied on empirical judgement on photography, categorizing outcomes from poor to excellent. An objective measurement was seeked but not found in the change in mastoid-helical rim distance. Although there is a significant difference on group level, for the individual child this measurement gave no indication of a possible successful outcome. Only a small decline in distance was measured before and after treatment even if a clearly good result was found. The head of a baby grows much in its first year of life, and the mastoid-helical rim distance seems to grow with it as well.
When compared to the literature the results for our patients as a group are unsatisfactory.

However, splinting is not common in the Netherlands and we had a large proportion of babies that presented late. Our best results were seen in babies up to six weeks of age, with a fair or good result in 66.7% of them. The success rate in children beyond that age becomes unacceptably low. This study subsequently demonstrates the importance of starting splinting soon after birth. Several other authors state that only newborns should be treated[7,10,11,21-23] and mentioned poor results in older babies. This anecdotal information is now supported with our study.

No control group was added to this study as based on literature it seems safe to say that protruding ears do not self-correct[11,12].

Although our study demonstrates a clear relation between age and the time needed to splint for permanent correction, it is still not possible to exactly predict how long splints should be worn by an individual, and whether greater persistence in wearing splints beyond the suggested period would have improved outcome in our study.

It is likely that the stiffness of the cartilage is an important factor determining the end result. In our population sample, the floppier anti-helical fold was far easier corrected than the stiffer concha (correction in 69.8% versus 26.8%). A similar observation was made by Byrd.[30] Patients with poor outcomes often had a conchal crus . A more rigid splint, like Byrds Earwell® device, Yotsuyanagi's rigid splint[19,20.] and Sorribes Auri method®[12] may be better suited to correct the stiffer concha.

Conclusion

Specific recommendations can now be made to parents based on this study. When considering ear splints for protruding ears a reasonable chance of success can be offered to parents of children up to six weeks of age. It is favorable if the deformity is mainly due to a flat antihelix. Time needed to splint depends on age, but we cannot predict the time needed to splint for the individual, which can be up to ten weeks in a six-week-old.

As early referral is vital for success, we posed the question if ear splinting should be aggressively marketed. In **chapter 4** this was discussed in an ethical debate.

CHAPTER 4

If it ain't broke don't fix it?

On the level of the individual, it is ethically justified to splint deformed baby ears; it allows young children to be perceived as normal without surgery. Associated risks should be assessed relative to other commonly accepted cosmetic interventions in children. Parents have the right to make such a decision for their child [31]. Although this can also be a new burden in a postpartum period already full of medical- and nonmedical choices and responsibilities.

On the level of society, one has to acknowledge that official promotion of ear splinting by the health care system changes our norm in ear shape. Promotion of enhancement[32-38] increases the pressure of performance and so does the need to embrace hyperparenting.[39] Parents may feel the fear of missing out on the opportunity and the pressure to act.

Making molding part of the official national screening program fails based on WHO criteria,[40,41] and probably rightly so, as adding this minor health problem places a burden on the system. Furthermore, if ear splinting is pro-actively promoted from within the health care system the message is conveyed that deformed ears are a significant health problem.

Future perspectives for ear splinting

Official screening may not be the option, but it is reasonable to educate midwifes, maternity nurses, general practitioners, pediatricians and plastic surgeons to recognize deformed ears and offer splinting. The flaw being that the knowledge and the resources do not really fit in any one's current daily practice. This is the main reason why this therapy still not made the break-through one would expect. But in the digital age this may very well change. As splints are available for everyone on the internet, it is possible that commercial parties want to play a role. Key will be to responsibly educate and facilitate healthcare professionals and parents alike.

Splinting Stahl's ears; an exception for a special anomaly

The Stahl's ear, as mentioned in **chapter 1**, has an anti-helical crus perpendicular to the helical rim and abnormal kinks of the helix. It is sometimes called a Spock ear, in reference to the Star Trek character.

This deformity is rather difficult to correct surgically, in contrast to the correction of the more common protruding ears. But as the additional fold and absent helix completely correct as forced in the preferred shape by splinting in the first weeks of life[4.], the advice for splinting therapy of this particular deformity in newborns should therefore be more compelling.

Follow up

Approximately eight years after splinting, an information letter, informed consent form and questionnaire was sent to the parents of the children that fully completed treatment or did not fully complete the therapy because of complications (108 in total). Besides answering the questionnaire, parents were asked to measure the widest mastoid-helical distance using the provided ruler. Furthermore, parents were asked to send three photos of their child from a front, side-, and rear view in which the ears have to be visible. The questionnaires and photos were evaluated by the plastic surgeon and three independent observers. The photos were compared with previous photo series shorty after splinting therapy and one-year post-therapy as described in **chapter 3.**

Questionnaire

1. Were you satisfied about splinting therapy?
2. How did you experience splinting therapy?
3. Did complications occur during/after splinting therapy? Skin irritation, fixation problems?
4. Are ears still prominent at the moment?
5. Do you consider- or already have surgical correction performed?
6. Would you recommend splinting therapy to someone else?
7. What is the widest mastoid-helical distance by using the ruler?
8. Could you send us three photos of your child from a frontal, side- and rear view.

This project was approved by the Medical Ethical Board of the University Medical Centre, Utrecht, the Netherlands.

A total of 106 questionnaires were posted, five addresses were missing. Unfortunately only 32 questionnaires were returned (response rate:30%). Based on this low response rate we were not able to draw conclusions about long term results of splinting in our patient population.

CHAPTER 5

Ear Piercing

The popularity of high ear piercing has led to an increased incidence of perichondritis. Damage to the relatively avascular cartilage makes the ear prone to infection. In literature it was often suggested, although never tested, that a piercing gun, mainly used by jewelers to pierce the lobule, may give excessive cartilaginous damage. Therefore, some authors favor hollow needle piercing, as used in piercing studios. But comparative histological studies were never performed[42-46].

Our human cadaver study of commercial piercing techniques of the upper ear and their direct effect on cartilage evaluated this assumption and provided more clarity on the effects of piercing to the ear cartilage in general.

The direct post-piercing tissue injury pattern shows perichondrium torn from the cartilage with some tears and fragments. Injury to the subcutaneous tissues was limited. Most of the damage, both at perichondrial and cartilage level, is at the site where the piercing stud exits. Tissue injury was seen over a relatively small distance.

The extent of the damage is modest, nevertheless the aspect of the tissue injury pattern may be of importance. The perichondrial detachment creates a pocket between the perichondrium and cartilage. This pocket could facilitate the development of a subperichondrial abscess.

A comparison between the different piercing methods did not show any significant difference in perichondrial damage, total chondral tears or chondral shattering, despite the fact that the design and diameter of the tip of the piercing instrument varied greatly, as well as the force applied to pierce the ear.

A cadaver study, of course, does not provide the possibility of following the response to injury after piercing. As the direct injury pattern is the same for the different piercing methods, the following events of bleeding, inflammation and healing are expected to be similar. But what might be of importance is the room left between the stud and the pin tract. The needle piercing method makes a larger diameter pin tract for a smaller diameter stud. In the piercing gun and hand force methods the stud directly pierces the ear, leaving no extra space. In these methods secondary pressure necrosis might occur. But in the `loose' needle pin tract there is more room for debris. Both can give an additional risk for secondary infection. Only animal studies at different time-points can study these effects.

Ear piercing, conclusions

Our human cadaver study of commercial piercing techniques of the upper ear and their direct effect on cartilage showed that the usual methods to pierce the upper-ear are comparable with regard to direct tissue damage. Based on this, each method is expected to give the same risk for perichondritis. This is in contrast to assumptions made in earlier literature.

Future perspectives for ear piercing

If we want to reduce the risk of post-piercing perichondritis the focus should be on other risk factors than technique: hygiene during the procedure and in after care. Hygiene is always important but is vital in piercings through cartilage as the nature of the post-piercing tissue damage, although small, facilitates perichondritis.

To prevent post piercing perichondritis only piercing of ear parts without cartilage, like the lobule, should be advocated, though global fashion trends cannot be altered easily.

CHAPTER 6

Constricted ears

This chapter covers an auricular anomaly that can be seen as an ear deformation when subtile or as a malformation when severe.[1,2] The constricted ear lacks the superior crus of the antihelix to support the helical rim and looks as if the rim of the ear has been tightened as if by a purse string. It is characterized by four features; lidding, decreased vertical height of the ear, protrusion and low ear position. In the past, it has also been referred to as `lop ear' and `cup ear'.[47,48]

In 1975, Tanzer classified constricted ears in three groups and two subgroups (Table 1).[47] This classification is still in use today and there are many proposed reconstruction techniques for this according to Tanzer, `curious' group of auricular deformities, none of them however superior.[1]

Because of the developments in ear reconstruction techniques,[49-53] Tanzer's classification[47] should be reclassified (Table 2) based on the present operative options. Group I can be kept as originally described by Tanzer in 1975. The classification of group IIA and IIB should however be changed. We propose to include in group II only the deformities of helix and scapha. In the new classification, group IIA are those cases which are manually redressable, while group IIB is deformed and adherent but otherwise reshapable by excising the scaphal cartilage deformity.

All other deformities of the upper pole of the external ear with the absence of the upper part of the antihelix and antihelical crura and reduction of the height of the ear must be classified and treated as concha-type microtia and thus reconstructed by a full costal cartilage frame.

The group IIA and IIB deformities can be corrected by removing the deformed upper pole through an incision in the scapha and adding a T-shaped rib cartilage strut into the created upper pole skin pocket. Leaving only a small donor scar and hardly any postoperative inconvenience.

Table 2. Proposed new classification of constricted ears.

I	**Helical collapse only**	
II a II b	Deficiency of scapha, superior crus, and fossa triangularis create collapse of upper helix, resulting in loss of vertical height, lidding and protrusion	IIa:*manually redressable* IIb: *deformed and adherent but otherwise reshapable by excising the scaphal cartilage deformity*
III	*All other deformities of the upper pole of the external ear with absence of the upper part of the antihelix and antihelical crura and reduction of the height of the ear must be classified and treated as concha type microtia*	

Future perspectives for constricted ears

As stated in **chapter 2,** many deformities in group II can in fact be prevented by splinting within the first weeks after birth. For late cases, the T-shaped costal cartilage strut is a straightforward technique with limited donor-site morbidity.

Reconstruction of acquired ear deformations using rib cartilage

Costal cartilage is an ideal autologous material suitable for plastic surgeons to create spare ear-parts. It can be used to create a cartilage frame in partial or total ear reconstruction,[49-53] or as a strut to support the helical rim in a constricted ear as shown in **chapter 6.** The first floating rib is first choice in all autologous partial ear reconstructions. Although rib harvest has a potential risk for pneumothorax or chronic pain, this complication is seldom seen. The rib harvest incision leaves only a 2- 4 centimeter visible scar.

CHAPTER 7

The sunken ear

In **chapter 7** a block of costal cartilage it is used to form a base for the iatrogenic sunken ear. During a radical mastoidectomy, the mastoid tip is removed. This may lead to inward migration of the auricle, causing the "sunken ear" deformity. Therefore, it seems obvious that this deformity might depend on the chosen surgical technique. [54-57]

Techniques in which the mastoid cavity is obliterated with, for example, temporal fascia may also provide a better base for the external ear, although there is the potential for delayed detection of residual disease.[55]

The thick costal cartilage is ideal to provide the necessary 10 to15 millimeter base, something that concha cartilage or fascia cannot provide. In case of a second look, the cartilage wedge can be easily lifted en bloc with the external ear or temporary removed. The technique used here is very similar to the one used in the second-stage of total ear reconstruction.[52]

CHAPTER 8

Spider bite

In **chapter 8** costal cartilage is used to reconstruct a helical crus of an ear deformed as a result of a Mediterranean recluse spider bite (genus Loxosceles).

The diagnosis of Mediterranean recluse bite was based on the typical history of pain in combination with erythema, cyanosis and a central vesicle after a painless bite several hours earlier.[58,59,60] The first 24 hours the lesion becomes edematous and the typical discoloration appears, through erythema, ischaemia and thrombosis. Central necrosis reaches its maximum after one to six weeks. In the described case it could be that the venom of the spider had affected the patient's perichondrium and cartilage of the ear, or that the perichondrium and the cartilage were destroyed due to exposure secondary to skin necrosis.

Necrosis is caused by cytotoxic and proteolytic components of the species-specific venoms. The primary cytotoxic component has now been identified as phospholipase D, but the venom is a complex mixture of toxins including alkaline phosphatase, hyaluronidase, metalloproteases, and insecticidal peptides.[58,61] The exact pathogenesis is not completely clear, but the toxins activate an inflammatory response, platelet aggregation, and increased capillary permeability. The optimal treatment of a recluse spider bite is controversial and various treatment options have been considered including corticosteroids, antibiotics, excision, antihistamines, colchicine, hyperbaric therapy and anti-venoms.[58,62] In the past a leukocyte inhibitor, such as Dapsone (diamino-diphenyl sulfone) has been proposed. However, there are risks in using Dapsone and there is no sufficient scientific proof of its effectiveness.[62]

When a recluse spider bite is suspected treatment includes rest, cold compresses and elevation to minimize inflammation and spread of venom. In addition, analgesia and tetanus prophylaxis should be given, and antibiotic treatment when needed. Any patient with evidence of systemic loxoscelism should be hospitalized. Laboratory evaluation in cases of expanding dermonecrosis and loxoscelism should screen for evidence of hemolysis, and intravascular coagulation.[58,62] Early excision of bite lesions and intralesional injection of corticosteroids are contraindicated and could increase the necrosis. At a later stage, excision of eschars and covering of the defects with split or full thickness skin grafts or, as in this case, reconstruction of the ear with costal cartilage can be performed.

Future perspectives for reconstructions using cartilage.

The reconstruction of an ear frame using costal cartilage, gouges, steel wires and a template is a true form of art any plastic surgery resident can easily fall in love with. Unfortunately, only a few will master this skill later in their professional life due to the limited number of congenital and acquired ear deformities, the need for centralization of ear reconstruction surgery in centers and the long learning curve.

In the past allografts using silastic or porous polyethylene in ear reconstruction proved to be inferior, although in recent years good results are achieved with Medpore®. The developments in 3D printing and bio-engineering are promising and might make the use of foreign materials or costal cartilage superfluous. However, the advantages of biocompatibility, long term stability, immune-compatibility and the ability to grow with the patient still have to be researched.[63]

For the lay public the step toward 3D printing of ears seems close, due to the strong images this research creates in the media. The picture of a naked mouse with a bovine cartilage ear frame on its back, published in 1997, is an icon that still is remembered.[64] But until now the different tissue engineered cartilage constructs were limited by inflammation, calcification, fibrosis, mechanical instability, antigenicity, degradation and foreign body reaction[63]. Especially the form changes due to external pressure of the skin envelope need to be addressed and solved.

Still, if research continues, there will be a long-lasting tissue engineered solution available and in the future, a 3D printed ear, layer by layer assembled with living cells, will become the state of art.

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CHAPTER 10

Summary

SUMMARY OF THIS THESIS

Ear splints

From a functional point of view, our external ears are no more than an ornamental addition to our heads. Though they assist a little bit in catching the direction of sounds and somewhat in thermoregulation, their main role is a social one. Ears are never considered an especially beautiful feature like large breasts, full lips or spotless skin, but if they are different they are noticed, and may be a reason for ridicule. They carry our glasses and people adorn them with jewellery. They are part of what humans do.

Having deformed ears is no disease from a biomedical point of view. But it can nevertheless be a burden for which plastic surgeons are consulted

Ears can be malformed as result of abnormal morphogenesis but far more often abnormal ear shapes are considered ear deformations. They have a normal chondro-cutaneous component and the ear bends towards the normal shape by digital pressure. Protruding ears are a good example. One in twenty people have protruding ears. Surgical correction is a common plastic surgical procedure which in the Netherlands is generally covered by health insurance for children. The operation can be performed from the age of five.

Figure 1. A baby with a prominent ear with an absent antihelical fold.

In new born babies there is a small window of opportunity to reshape ears using a splint and possibly avoid surgery. Since the first publications from Japan in the late 1980s, many authors demonstrated that permanent correction can be achieved by "forcing" the ear into the desired position by splinting for several weeks.

It is assumed that it is the high level maternal estrogens at birth that make ear cartilage especially pliable. These levels quickly drop after birth, subsequently making cartilage less pliable and moldable.

The external ear anomalies suitable for splinting have in common that no skin or cartilage is absent. Splinting can be performed in many ways, provided that the ear is permanently kept in the desired shape without distorting it (Figure 2). An appealing technique in which the ear shape can be permanently altered without surgery.

The literature on ear splints is often anecdotal, focusing on the technique and effectivity, but as shown in **chapter 2,** some practical questions remain due to the lack of large systematic studies.

We searched for the answers to the following practical questions.

1. Should all deformed newborn ears be splinted? Some ear deformities spontaneously resolve during the first months after birth, protruding ears on the other hand get more common with age.
2. Which method? Splinting can be performed in many ways, most consist of a splint in the scaphal hollow fixated with tape. This method is not reserved for doctors; splints can be purchased though a web shop (Earbuddies™).
3. Until what age can splinting be reasonably offered? Opinions vary from new-borns only until well up to six months of age.
4. How long should therapy be continued? This seems to depend on age at the start of the treatment.

Figure 2a, b, c. Ear splinting for a protruding ear.

Chapter 3

To answer especially the last two questions that were absent in the current literature:

- Until what age can splinting be reasonably offered?
- What is the duration needed to splint in relation to patient age?

We splinted the protruding ears of 132 babies using EarBuddies™ up until six months of age at the start of the treatment. Treatment continued until the desired shape persisted or had to stop due to skin irritation or fixation problems. Our study showed a reasonable chance of success (two out of three children with a good or fair result judged from photo's) if the child was not older than six weeks at the start of the treatment.

Efficacy quickly deteriorates in older children. It is harder to keep the tape in place in an active baby and persistence is needed. Sooner or later skin irritation forces parents to stop.

Table 1. Results in relation to the age at the start of splinting therapy

Age at start therapy	Good	Fair	Poor	Not completed	Total
0 through 6 weeks	12 (30.8%)	14 (35.9%)	7 (17.9%)	6 (15.4%)	39
7 through 12 weeks	9 (19.6%)	10 (21.7%)	14 (30.4%)	13 (28.3%)	46
> 13 weeks	2 (8.7%)	5 (21.7%)	8 (34.8%)	8 (34.8%)	23

The floppier anti-helical fold was far easier corrected than the stiffer concha (correction in 69.8% versus 26.8%). There is a clear relation between age and the time needed to splint for permanent correction but it is not possible to exactly predict how long splints should be worn by an individual. Still some guidance is possible; for a six-week old baby ten weeks of splinting is needed on average, for a newborn two weeks is often enough. As early referral is vital for success, we posed the question if ear splinting should be aggressively marketed. In **chapter 4** this was discussed in an ethical debate.

Ethical discussion, chapter 4

On the level of the individual, it is ethically justified to splint deformed baby ears; it allows young children to be perceived as normal without surgery. Associated risks should be assessed relative to other commonly accepted cosmetic interventions in children. Parents have the right to make such a decision for their child. Although this can also be a new burden in a postpartum period already full of medical- and nonmedical choices and responsibilities.

On the level of society, one has to acknowledge that official promotion of ear splinting by the health care system changes our norm in ear shape. Promotion of enhancement increases the pressure of performance and so does the need to embrace hyperparenting. Parents may feel the fear of missing out on the opportunity and the pressure to act.

Making molding part of the official national screening program fails based on WHO criteria, and probably rightly so, as adding this minor health problem places a burden on the system. Furthermore, if ear splinting is pro-actively promoted from within the health care system the message is conveyed that deformed ears are a significant health problem.

Conclusion

Ear splinting is an attractive method to correct deformed baby ears but only until the age of six weeks. The earlier the better, as splinting time needed depends on age.

Official screening may not be the option, but it is reasonable to educate midwifes, maternity nurses, general practitioners, pediatricians and plastic surgeons to recognize deformed ears and offer splinting. The flaw being that the knowledge and the resources do not really fit in any one's current daily practice. This is the main reason why this therapy still not made the break-through one would expect. But in the digital age this may very well change. As splints are available for everyone on the internet, it is possible that commercial parties want to play a role. Key will be to responsibly educate and facilitate healthcare professionals and parents alike.

De high ear-piercing, chapter 5

The popularity of high ear piercing has led to an increased incidence of perichondritis. Damage to the relatively avascular cartilage makes the ear prone to infection. In literature it was often suggested, although never tested, that a piercing gun, mainly used by jewelers to pierce the lobule, may give excessive cartilaginous damage. Therefore, some authors favor hollow needle piercing, as used in piercing studios. But comparative histological studies were never performed.

Figure 3. deformed ear after perichondritis (left) **Figure 4.** piercing gun (right).

Our human cadaver study of commercial piercing techniques of the upper ear and their direct effect on cartilage evaluated this assumption and provided more clarity on the effects of piercing to the ear cartilage in general.

The direct post-piercing tissue injury pattern shows perichondrium torn from the cartilage with some tears and fragments. Injury to the subcutaneous tissues was limited. Most of the damage, both at perichondrial and cartilage level, is at the site where the piercing stud exits. Tissue injury was seen over a relatively small distance.

A comparison of the different piercing methods did not reveal any difference in the extent of damage. The amount of damage was modest.

Conclusion
Each piercing method is expected to give the same risk for perichondritis. This is in contrast to assumptions made in earlier literature. To prevent post piercing perichondritis only piercing of ear parts without cartilage, like the lobule, should be advocated, though global fashion trends cannot be altered easily.

Classification and treatment of lop-ear, chapter 6
In lop ears, also referred to as constricted ears or cup ears, the upper part of the ear is drooping due to a lack of support. Normally the superior crus of the antihelical fold serves as a pillar. The deformity varies from subtle and manually redressable to severe, in which the ear is low-set, protruding and small. All these varieties are summarized in the classification according to Tanzer from 1975.

Because of the developments in ear reconstruction the more severe variants are now better off treated as concha-type microtia and thus reconstructed by a full costal cartilage frame.

The group IIA and IIB deformities can be corrected by removing the deformed upper pole through an incision in the scapha and adding a T-shaped rib cartilage strut into the created upper pole skin pocket. Leaving only a small donor scar and hardly any postoperative inconvenience.

Tanzer's classification should therefore be reclassified (Table 2). Group I can be kept as originally described, the classification of group IIA and IIB should however be changed.

We propose to include in group II only the deformities of helix and scapha. In the new classification, group IIA are those cases which are manually redressable, while group IIB is deformed and adherent but otherwise reshapable by excising the scaphal cartilage deformity.

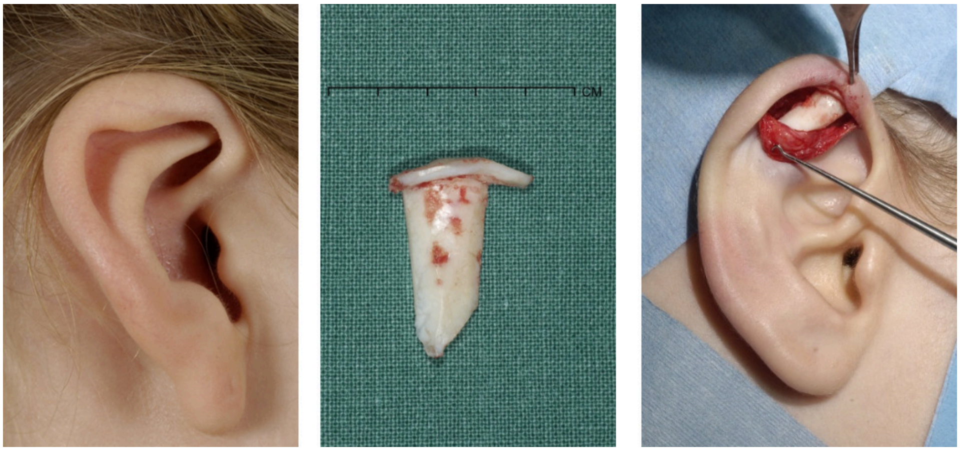


Figure 4 a, b, c. Correction of a type IIb lop-ear with a T-shaped rib cartilage strut.

With these new techniques available we propose a reclassification in which all severe grade III deformities are seen as a concha type microtia and not as a lop-ear. The less severe group (II) can be divided in manually redressable and redressable by excision of the upper pole cartilage

Table 2. Proposed new classification of constricted ears

I	Helical collapse only	
II a II b	Deficiency of scapha, superior crus, and fossa triangularis create collapse of upper helix, resulting in loss of vertical height, lidding and protrusion	IIa:*manually redressable* IIb: *deformed and adherent but otherwise reshapable by excising the scaphal cartilage deformity*
III	*All other deformities of the upper pole of the external ear with absence of the upper part of the antihelix and antihelical crura and reduction of the height of the ear must be classified and treated as concha type microtia*	

Conclusion

As stated in **chapter 2,** many deformities in group II can in fact be prevented by splinting within the first weeks after birth. For late cases, the T-shaped costal cartilage strut is a straightforward technique with limited donor-site morbidity.

Reconstruction of acquired ear deformations using rib cartilage

Costal cartilage is an ideal autologous material suitable for plastic surgeons to create spare ear-parts. Examples are given in **chapter 6,** with the T-shaped strut to support the helical rim in a lop-ear, and in **chapter 7**, where a sunken ear deformity after resection of cholesteatoma is corrected, and in **chapter 8** where part of the ear is replaced after necrosis due to a spider bite. (Mediterranean recluse spider).

The first floating rib is first choice in all autologous partial ear reconstructions. Although rib harvest has a potential risk for pneumothorax or chronic pain, this complication is seldom seen. The rib harvest incision leaves only a 2- 4 centimeter visible scar.

Conclusion

In the near future there will be a long-lasting tissue engineered 3D printed ear available. But the right composition of living and non-living components is still studied. For now, rib cartilage remains the gold standard.

CHAPTER 11

Nederlandse samenvatting

NEDERLANDSE SAMENVATTING

Oorspalkjes

Vanuit een functioneel oogpunt zijn oorschelpen niet meer dan ornamenten aan ons hoofd. Oren helpen een beetje met het opvangen van geluid en het kwijtraken van warmte, maar hebben bij mensen vooral een sociale rol. Oren worden nooit gezien als mooi, zoals volle lippen of grote ogen, maar als ze anders zijn dan valt dat op en worden er grappen over gemaakt. Oren dragen brillen en mensen versieren ze met sieraden, ze zijn een onderdeel van de menselijke interactie.

Het hebben van afwijkende oorschelpen is geen ziekte, maar mensen kunnen het wel als een last ervaren en zoeken geregeld hulp van een plastisch chirurg om normale oren te krijgen.

Soms is een oor in aanleg afwijkend, maar vaker zijn huid en kraakbeen normaal maar alleen vervormd, bijvoorbeeld door een ander verloop van de spieren rondom het oor, en kan het oor met de vingers in de gewenste vorm worden geplooid. Afstaande oren zijn een goed voorbeeld van zo'n oor-deformatie. Een op de twintig mensen heeft afstaande oren. De operatie hiervan is een gangbare plastisch chirurgische ingreep, die voor kinderen meestal wordt vergoed door de zorgverzekeraar en vanaf de leeftijd van 5-6 jaar kan worden uitgevoerd.

Afbeelding 1. Een baby met een afstaand oor met een ontbrekende antihelixplooi

De oren van pasgeborenen hebben de unieke eigenschap dat ze vlak na de geboorte, onder de invloed van de oestrogenen van de moeder, heel slap en plooibaar zijn. In de weken na de geboorte ebt dit effect weg en wordt het kraakbeen in de oren stugger. Als in deze fase een oor in een gewenste vorm gebracht wordt met een spalkje, en daar een tijd wordt gehouden, kan de vorm van het oor worden veranderd. Een aantrekkelijke techniek waarbij zonder operatie de vorm van een oor kan worden verbeterd.

In de jaren 80 werd voor het eerst vanuit Japan over deze vorm van oor correctie gepubliceerd. Hierin wordt de werking, veelal anekdotisch, aangetoond, maar blijven ook vragen onbeantwoord. Vooral ook omdat grote studies ontbreken zoals bleek uit onze literatuurstudie in **hoofdstuk 2**.

Op basis van de bekende literatuur bleek dat er weinig tot geen structureel onderzoek is gedaan. De literatuur had vooral betrekking op casuïstiek. Op basis van deze literatuur zochten wij het antwoord op de volgende praktische vragen:

1. moeten alle gedeformeerde babyoren gespalkt?
   Sommige afwijkingen verdwijnen spontaan. Wel is uit de literatuur duidelijk dat vooral afstaande oren nooit vanzelf weggaan.
2. Welke methode?
   Spalken kan met veel verschillende methoden, de meeste bestaan uit een spalkje in de plooi van het oor en tape. Dit is geen voor dokters voorbehouden handeling. Via een webshop is voor ouders bijvoorbeeld de Earbuddies™ spalk te koop.
3. Tot welke leeftijd kan dit?
   De opinies variëren van alleen pasgeboren tot zeker de leeftijd van zes maanden.
4. Hoe lang moet er gespalkt worden?
   Het lijkt erop dat dit afhankelijk is van de leeftijd van het kind bij de start van de therapie.

Afbeelding 2a, b, c. Oorspalkjes voor een afstaand oor.

Hoofdstuk 3

In het UMC-Utrecht spalkten wij 132 baby's met afstaande oren met Earbuddies™ tot de leeftijd van een half jaar bij de start van de behandeling. Vooral om een antwoord te krijgen op de vragen:

- Tot welke leeftijd is spalktherapie redelijkerwijs effectief?
- Wat is de spalkduur ten opzichte van de leeftijd?

Spalkjes werden continue gedragen en eventueel door ouders opnieuw aangelegd totdat duidelijk was dat de vorm permanent was bereikt of stoppen noodzakelijk was. Onze studie liet zien dat er een redelijke kans op succes was (twee van de drie kinderen hadden een goed tot redelijk resultaat gebaseerd op foto's) als het kind bij de start van de behandeling niet ouder was dan zes weken.

Bij kinderen ouder dan zes weken nam het effect al snel af. Het is bij oudere baby's lastiger om de tape op zijn plek te houden en het spalken moet ook langer worden volhouden. Vroeg of laat wordt dan gestopt omdat de huid geïrriteerd raakt.

Tabel 1. Resultaten in relatie tot leeftijd bij de start van de spalk therapie.

Leeftijd bij start spalken	Goed	Redelijk	Slecht	Niet afgemaakt	Totaal
0 tot 6 weken	12 (30.8%)	14 (35.9%)	7 (17.9%)	6 (15.4%)	39
7 tot 12 weken	9 (19.6%)	10 (21.7%)	14 (30.4%)	13 (28.3%)	46
> 13 weken	2 (8.7%)	5 (21.7%)	8 (34.8%)	8 (34.8%)	23

Een afwezige plooi in het oor is makkelijker te corrigeren dan een diepe kom van het oor (correctie in 69.8% versus 26.8%). De duur van de behandeling tot dat de permanente vervorming is bereikt hangt af van de leeftijd, maar het is voor het individu niet goed te voorspellen hoe lang het spalken precies moet worden volgehouden. Toch is enige richttijd wel te geven: voor een zes-weken oude baby is gemiddeld tien weken nodig, voor een pasgeborene kan twee weken genoeg zijn.

Bovenstaande leidt tot de conclusie dat er zo vroeg mogelijk met spalken moet worden begonnen, en dat helaas veel kinderen te laat worden verwezen. Dit is op te lossen door alle (bijna)ouders actief op de mogelijkheid van spalken te wijzen. Dat heeft echter consequenties.

Ethische discussie, hoofdstuk 4

Voor het individu is het ethisch volledig verantwoord oren te spalken. Zonder chirurgie kun je de vorm normaliseren en de risico's zijn vergelijkbaar of kleiner dan gangbare behandelingen bij kinderen. Ouders kunnen deze beslissing nemen voor hun kind, de keus hiervoor kan ook niet worden uitgesteld tot het kind oud genoeg is om zelf te beslissen. Hoewel het voor ouders weer een extra belasting is in een tijd die al vol zit met allerhande informatie en beslissingen die gevraagd en ongevraagd over verse ouders wordt uitgestort.

Voor de samenleving ligt het wat gecompliceerder. Actieve promotie van oor spalkjes brengt ook de gedachte naar voren dat afstaande oren niet de bedoeling zijn. Nogmaals, afstaande oren zijn geen ziekte en de correctie van afstaande oren is niet een "behandeling" maar een "verbetering". Het aansturen op verbetering jaagt ouders op tot hyper-ouderschap en zet ouders voor het blok; "nu of nooit, anders gaat de kans voorbij.

Het is verleidelijk om bij de nationale gehoortest ook naar de oor vorm te kijken en dan de ouders op de mogelijkheden wijzen. De World Health Organisation (WHO) heeft criteria opgesteld voor screeningsprogramma's. Een screening op afstaande oren voldoet niet aan deze criteria, met name omdat bij afstaande oren geen sprake van ziekte is.

Conclusie

Het spalken van oren is een aantrekkelijke manier om gedeformeerde babyoren te behandelen maar slechts tot de leeftijd van zes weken. Hoe eerder gespalkt, hoe beter, ook omdat de spalkduur afhankelijk is van de leeftijd.

Officiële screening is een brug te ver, maar een te verantwoorden alternatief is om verloskundigen, huisartsen en consultatiebureauartsen en verpleegkundigen voor te lichten over deze mogelijkheid en dan zelf te laten spalken of te verwijzen. Dit wordt nog niet massaal gedaan, vooral omdat het bij niemand in de dagelijkse praktijk past.

Dit is ook de belangrijkste reden waarom gedeformeerde babyoren in Nederland niet veel vaker worden gespalkt. Maar internet kan dit makkelijk veranderen. Mochten commerciële partijen in dit gat willen duiken dan willen wij ze hierin oproepen om gewetensvol ouders voor te lichten en niet te veel op het nu of nooit gevoel te spelen.

De hoge oor-piercing, hoofdstuk 5

In de afgelopen twintig jaar werd de hoge oor-piercing, door het kraakbenige deel van het oor, populair. Helaas geeft zo'n piercing soms een ernstige ontsteking met verlies van oor-kraakbeen en misvorming. Oor-kraakbeen is slecht doorbloed en in het laagje tussen kraakbeen en het de voedende laag van het kraakbeen (het perichondrium) kan een infectie zich makkelijk verspreiden.

Afbeelding 3. Gedeformeerd oor na perichondritis (links) **Afbeelding 4.** Oorbel pistool (rechts)

In de literatuur over dit onderwerp werd meerdere malen gesuggereerd dat een oorbelpistool, eigenlijk bedoeld om de oorlel te piercen, te veel verbrokkeling geeft van het kraakbeen wat infectie vergemakkelijkt. Een naaldpiercing, zoals in tattooshops wordt gebruikt, zou beter zijn. Alleen was deze aanname nooit getest.

Op snijzaal werden oren gepiercet met verschillende gangbare piercingmethoden en de naaldmethode. Er werd onder de microscoop gekeken naar de mate van schade.

De meeste schade bleek aan de uittredeplaats van de piercing te zitten, met het perichondrium van het kraakbeen afgestript.

Een vergelijking tussen de verschillende methoden gaf geen verschil in de mate van schade, schade aan kraakbeen of het laagje eromheen. De hoeveelheid schade bleek ook beperkt.

Conclusie

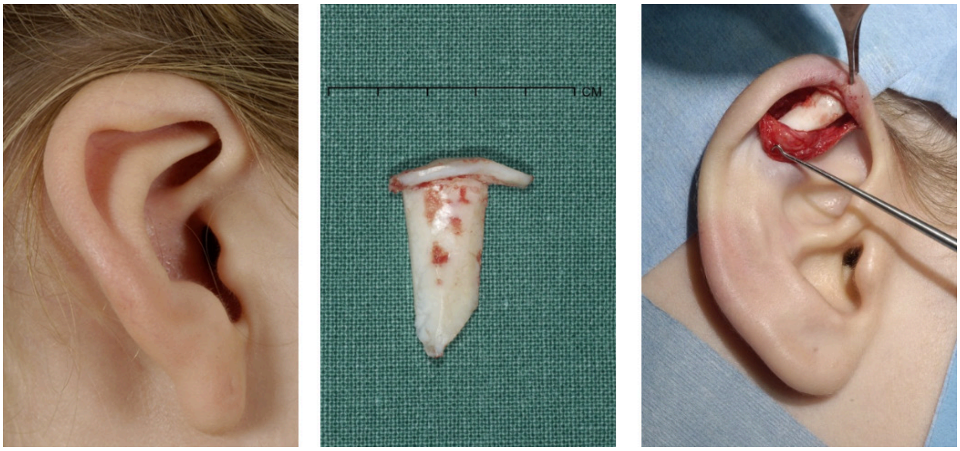
Al met al lijkt het qua weefselschade dus niet uit te maken hoe het oor gepiercet wordt en kan de preventie van oorinfecties na hoge oor piercing beter gericht worden op hygiëne. Ook kun je mensen erop wijzen dat het veiliger is alleen de oorlel te piercen, al is het lastig om modetrends te veranderen.

Classificatie en behandeling van het lop-oor, hoofdstuk 6

Bij lop-oren, ook wel *constricted ears* genoemd, hangt de bovenzijde van het oor door een gebrek aan steun. Normaal houdt de bovenste vouw in het kraakbeen (de antihelix) het oor omhoog. De afwijking kan variëren van subtiel, waarbij het oor met de vingers in de gewenste vorm kan worden gebracht tot een oor dat laag staat, afstaat en verkleind is. Al deze varianten zijn opgenomen in de classificatie van Tanzer uit 1975.

Tegenwoordig kunnen de ernstigere varianten van het lop-oor beter behandeld worden met dezelfde technieken als bij een aanlegstoornis van een oor, dus met een volledige vervanging van het kraakbeen door een nieuw frame gemaakt uit ribkraakbeen.

Voor die gevallen waarbij de afwijking te corrigeren valt door het losmaken van alleen de bovenzijde van het oor kan een T-vormige steun van ribkraakbeen worden ingebracht.



Afbeelding 4 a, b, c. Correctie van een type IIb lop-oor met een T-vormige ribkraakbeensteun

Met deze nieuwe technieken voorhanden stellen we voor de bestaande Tanzer-classificatie aan te passen waarbij alle ernstige graad III afwijkingen gezien worden als een concha-type microtie en niet als een lop-oor. De minder ernstige groep (graad II) kan opgedeeld worden in oren die met de hand nog vervormbaar zijn en die, waarbij dat alleen kan door een deel van het kraakbeen in het bovenste deel van het oor weg te halen.

Voorgestelde nieuwe classificatie constricted ear:

<table>
<tr><th>I</th><th colspan="2">Alleen overhang van de helixrand</th></tr>
<tr><td rowspan="2">II a
II b</td><td rowspan="2">Hangen van de bovenzijde van het oor door verlies van steun door ontbreken van de bovenste vouw in het oor</td><td>IIa: manueel te hervormen</td></tr>
<tr><td>IIb: gedeformeerd en adherent. Maar wel te hervormen door een deel van het kraakbeen te verwijderen</td></tr>
<tr><td>III</td><td colspan="2">Alle andere varianten waarbij de bovenzijde van het oor overhangt met verlies van hoogte van het oor en afwezigheid van de antihelixplooien in het oor moeten geclassificeerd worden als een concha-type microtie</td></tr>
</table>

Conclusie

Veel van de groep II afwijkingen kunnen bij pasgeborenen nog worden gecorrigeerd door spalken. Op latere leeftijd is de T-vormige ribkraakbeensteun een goede optie.

Reconstructie van verworven oor afwijkingen met rib kraakbeen.

Ribkraakbeen is een nuttige bron voor het maken van nieuwe kraakbenige oor-onderdelen. Voorbeelden daarvan worden gegeven in **hoofdstuk 6** met de T-vormige ribkraakbeensteun voor een lop-oor. In **hoofdstuk 7**, waar de oorschelp is ingevallen na het operatief verwijderen van een cholesteatoom en in **hoofdstuk 8** waar een deel van het oor wordt vervangen na gedeeltelijke necrose van het oor als gevolg van een spinnenbeet (Mediterranean recluse spider).

De eerste zwevende rib is hierbij eerste keus. Complicaties als het openen van het longvlies (een pneumothorax) evenals chronische pijn zijn mogelijk, maar ook heel zeldzaam. Om de eerste zwevende rib te oogsten moet een 2-4 cm incisie worden gemaakt wat een klein litteken achterlaat.

Conclusie

In de nabije toekomst zullen kraakbeenonderdelen op maat uit de 3D-printer komen. Maar naar de juiste samenstelling van levende en niet levende componenten wordt nog gezocht. Tot die tijd blijft ribkraakbeen de gouden standaard.

CHAPTER 12

Curriculum Vitae

CURRICULUM VITAE

Marieke van Wijk 15-05-1976

Geboren in Groningen

VWO Zernike College Haren

Geneeskunde 1994 Rijks Universiteit Groningen

Plastische Chirurgie UMC Utrecht / Nieuwegein

Sinds 2012 werkzaam als plastisch chirurg
In Isala Zwolle / Meppel

Getrouwd met Oswald van Dam, moeder van Matthijs, Ella en Pieter.

CHAPTER 13

Dankwoord

DANKWOORD

Het proefschrift dat u in handen heeft is niet volgens een vooropgezet plan ontstaan maar langzaam gegroeid;

het begon in 2008 met de vraag van het ministerie van VWS aan Professor Kon als deskundige of oorbelpistolen verboden moesten worden voor piercings door het kraakbeen. In de literatuur werd dit gesuggereerd. Als AGNIO mocht ik het uitzoeken in het lab van **Professor Bleys** en met hulp van patholoog **Alain Kummer**. Dank! Ik hoop dat er tussen de grote onderzoekslijnen in UMC's altijd plek blijft voor het zo ad hoc, low tech, uitzoeken van ideeën.

Een opleidingsassistent plastische chirurgie doet ook onderzoek; **Corstiaan Breugem** kwam vers uit Canada met enthousiasme voor oorspalken. Dit was de aanleiding voor de literatuurstudie in hoofdstuk 2.

De geconstateerde lacunes in de literatuur waren een uitnodiging voor onze eigen prospectieve studie. **Corstiaan**, dank voor alle input en hulp om dingen concreet te maken.

Mijn grote dank gaat uit naar mijn toenmalige collega assistenten die met mij de oorspalkjes hebben geplakt en de ins en outs hiervan hebben moeten vertellen aan de kersverse ouders die met grote kinderwagens en veel vragen het WKZ binnenkwamen De observatie dat het informed consent bij oorspalkjes meer vergt dan bij ernstige aangeboren afwijkingen liet al zien dat een ethisch artikel zeker welkom was.

Dank **Eveline Corten, Miriam de With, Sven Bruekers, Eline van Amerongen, Paul van Minnen, Dalibor Vasilic, Wies Maarsse en Emma Paes.**
Hiermee stond het fundament van het onderzoek, kon het niet tot een promotie leiden? Het is de verdienste van **Professor Kon** geweest dit beeld te schetsen en te blijven vragen; ja zeggen en doorgaan was op een of andere manier altijd de weg van de minste weerstand.

Tussen mijn fijne tijd bij de **plastische chirurgie in Nieuwegein**, de geboorte van **Matthijs, Ella en Pieter** en de verhuizing naar Zwolle door werden nog drie artikelen toegevoegd. Zwangerschapsverlof blijkt een goed moment om met de handen vrij de laatste hand aan artikelen te leggen. Dank aan **Claire van Hövell tot Westerflier en Irene Holtslag** als medeauteurs.

Toch miste er iets voordat ik met opgeheven hoofd in dat prachtige academiegebouw kon gaan staan; Een ethische beschouwing van onze aanbeveling om iedereen zo vroeg mogelijk in te lichten over de mogelijkheid van oorspalken heeft meer diepgang gebracht. dankzij **Annelien Bredenoord en Roel Wouters** is het verhaal nu compleet.

Last but not least dank aan mijn **ouders, zus, schoonouders, -familie en vrienden** die altijd geïnteresseerd zijn geweest. dank **Oswald** voor je steun, het doorgronden van Word, en je vanzelfsprekende vooronderstelling dat dit proefschrift er eens ging komen; die oren horen al zo lang je mij kent bij mijn to-do-lijstjes.

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Speciale dank aan de weledelzeergeleerde **Eveline Corten** en **Annet van Rijssen** die de rol van paranimf op zich willen nemen; Ik bewonder jullie beider slimheid, energie, daadkracht en het vermogen een goed collega te zijn.