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REVIEW

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

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Summary *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 practised on a wider scale than is done today. Hopefully this article will challenge authors to perform prospective studies

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specifically addressing the relation between patient age, degree of deformity, stiffness of the cartilage, the time needed to splint and the treatment outcome.

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 summarise 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 focussed 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

Table 1 Various ear-splinting materials and methods used

First author	Year	Splint material	Splinting method
Matsuo[3,6]	1984	Aluwax® + tape + bandage. Protruding ear: bandage only.	A
	1990	Cryptotia: dynamic splint	
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. 2 weeks after 1 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 4–6 weeks
Oroz[15]	1995	First: dental compound + Steri-strip®. later: steel wire in silicon tube+ steri-strip® + cap	B 2–3 weeks, followed by cap 1 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 +1 week or more continued
Smith[26]	2005	Wax + Medpore® tape	B 1 month
Lindford[27]	2007	Wire in 6F silastic tube + adhesive skin closure strips	A

A Ear splinted 24 h per day until permanent correction occurred.
B Ear splinted 24 h per day fixed period.

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]

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.

Table 2 Overview literature on non-surgical correction of congenital deformities of the auricle.

First author, year	*N.*	Age at start	Splint time	Deformities	Results	R	Complications	Outcome score by	Follow-up	Comments
Matsuo[3,6],1984, 1990	?	0 − >6M	<1W: Few W At 6M: Few M	? Lop ear ? Stahl's 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's 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's 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's 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's ears 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's 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's 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's 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's ear 3 Prominent 3 Shell 8 Other	27 Good 11 Fair 9 Poor 9 Poor 9 Poor	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's 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's 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's ear	23 Good 5 Fair 8 Gave up	No	No	Author	2–6M	Retro spective
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

(*continued on next page*)

Table 2 (*continued*)

First author, year	*N.*	Age at start	Splint time	Deformities	Results	R	Complications	Outcome score by	Follow-up	Comments
Yotsuyanagi[23], 2004	275	0—9Y	?	128 Cryptotia 39 Stahl's 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's 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's 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			Gave up
		Good	Fair	Poor	
Muraoka[7], 1985	4 Stahl's ear	4			
	2 Cup ear		2		
	1 Cryptotia	1			
	1 Rim kink	1			
	1 Prominent	1			
Brown[11], 1986	2 Lop ear	2			
	1 Cup ear	1			
	1 Stahl's ear	1			
	1 Prominent		1		
Tan/Gault[13], 1994	4 Stahl's ears	4			
	2 Lop ear	2			
	2 Shell		1		
	2 Rim kink		2		
	2 Prominent	1	1		
Oroz[15], 1995	16 Prominent	12	4		
	14 Lop ear	14			
	9 cup ear		9		
	8 Lobe evertion	5	3		
	6 Stahl's ear	6			
Tan[16], 1997	21 Lop ear	21			
	8 Prominent	6		2	
	2 Stahl's ear	2			
	1 Invert concha	1			
Yotsuyanagi[18], 1998	26 Cryptotia	16	6	2	2
	5 Lop ear	2	1	1	1
	5 Stahl's 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		
	24 Prominent	20	4		
	20 Constricted	17	3		
	20 Stahl's ear	18	2		
Sorribes[21], 2002	56 Prominent	15	23	6	
Schonauer[24] 2003	10 Helix contour	6	2		2
	10 Prominent	4	3		3
	9 Constricted	8	1		
	7 Stahl's ear	5	2		
Yotsuyanagi[23], 2004	128 Cryptotia	105			
	39 Stahl's ear	29			
	26 Prominent	14	good or fair		
	24 Lop ear	13			
	13 shell ear	8			
	45 Other	28			
Smith[26], 2005	41 Lop ear	41			
	13 Stahl's ear	13	good or fair		
	12 Prominent	8			
	2 Cryptotia	0			
Lindford[27], 2007	2 Constricted	2			
	2 Prominent	2			
	1 Stahl's ear	1			
Schonauer[25], 2008	Compressed ear				
	28 Vertical	25	3		
	18 Horizontal	13	4	1	
	10 Focal	8	2		

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.

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] and Sorribes[21] mention the highest recurrence rate as 12% and 7%, respectively; however, they both treated older children.

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's ear
1D	TG	1.4	g	Lop ear
1D	TG	2	g	Stahl's 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's ear
3D	Li	4	g	Prominent
3D	Li	4.3	g	Constricted
3D	TM	6	g	Lop ear
3D	TM	7	g	Stahl's ear
3D	TM	9	g	Prominent
3D	TM	12	g	Prominent
3D	TM	24	g	Prominent
4D	Br	3	g	Stahl's 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's 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's ear
5M	Mu	13	g	Prominent
2Y	Mu	13	g	Stahl's ear
2Y	Mu	17	g	Rim kink
3Y	Mu	17	f	Cup ear
3Y	Mu	17	f	Cup ear
3Y	Mu	26	g	Cryptotia
4Y	Mu	17	g	Stahl's ear
5Y	Mu	21	g	Stahl's ear
5Y	Mu	26	g	Stahl's 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].

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]

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

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

Deformity	At birth	1- month old	1- 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%

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 standardised 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 — 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.[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 practised on a much wider scale than is done today. Unfortunately, it is 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.

References

1. Limandjaja GC, Breugem CC, Kon M. et al. Complications of Otoplasty: a literature review. (accepted in J Plast Reconstr Aesthet Surg).
2. Kurozumi N, Ono S, Ishida H. Nonsurgical correction of a congenital lop ear deformity by splinting with Reston Foam. *Br J Plast Surg* 1982;**35**:181—2.
3. Matsuo K, Hirose T, Tomono T, et al. Nonsurgical correction of auricular deformities in the early neonate: a preliminary report. *Plast Reconstr Surg* 1984;**73**:38—50.
4. Nakajima T, Yoshimura Y, Kami T. Surgical and conservative repair of Stahl's ear. *Aesth Plast Surg* 1984;**8**:101—7.
5. Matsuo K, Hirose T. A splint for non-surgical correction of cryptotia. *Eur J Plast Surg* 1989;**12**:186—7.
6. Matsuo K, Hayshi R, Kiyono M, et al. Nonsurgical correction of congenital auricular deformities*Reconstructive Surgery for Deformities of the Ear. Clin Plast Surg* 1990;**17**:383—95.
7. Muraoka M, Nakai Y, Ohashi Y, et al. Tape attachment therapy for correction of congenital malformations of the auricle: clinical and experimental studies. *Laryngoscope* 1985;**95**:167—76.
8. Hunter AGW, Yotsuyanagi T. The external ear: more attention to detail may aid syndrome diagnosis and contribute answers to embryological questions. *Am J Med Genet* 2005;**135A**:237—50.
9. Weerda H. Classification of congenital deformities of the auricle. *Facial Plast Surg* 1988;**5**:385—8.
10. Porter CJ, Tan ST. Congenital auricular anomalies: topographic anatomy, embryology, classification and treatment strategies. *Plast Reconstr Surg* 2005;**115**:1701—12.
11. Brown FE, Colen LB, Addante RR, et al. Correction of congenital auricular deformities by splinting in the neonatal period. *Pediatrics* 1986;**78**:406—11.
12. Brenal-Sprekelsen M, Krummel FJ. Die konservatieve korrektur angeborener formanomalien der ohrmuschel. *Laryngo-Rhino-Otol* 1990;**69**:581—5.
13. Tan ST, Shibu M, Gault DT. A splint for correction of congenital ear deformities. *Br J Plast Surg* 1994;**47**:575—8.

14. Merlob P, Eshel Y, Mor N. Splinting therapy for congenital auricular deformities with the use of soft material. *J Perinatol* 1995; **15**:293—6.
15. Oroz J, Pelay MJ, Colás M, et al. Congenital anomalies of the auricle: correction using external splints. *Eur J Plast Surg* 1995;**18**:288—92.
16. Tan ST, Abramson DL, MacDonald DM, et al. Molding therapy for infants with deformational auricular anomalies. *Ann Plast Surg* 1997;**38**:263—8.
17. Tan S, Wright A, Hemphill A, et al. Correction of deformational auricular anomalies by molding - results of a fast-track service. *N Z Med J* 2003;**116**:584—91.
18. Yotsuyanagi T, Yokoi K, Urushidate S, et al. Nonsurgical correction of congenital auricular deformities in children older than early Neonates. *Plast Reconstr Surg* 1998;**101**:907—14.
19. Furnas DW. Nonsurgical treatment of auricular deformities in neonates and infants. *Pediatr Ann* 1999;**28**:387—90.
20. Ullmann Y, Blazer S, Ramon Y, et al. Early nonsurgical correction of congenital auricular deformities. + Discussion by Yotsuyanagi T. *Plast Reconstr Surg* 2002;**109**:907—15.
21. Sorribes MM, Tos M. Nonsurgical treatment of prominent ears with the Auri Method. *Arch Otolaryngol Head Neck Surg* 2002;**128**:1369—76.
22. Yotsuyanagi T, Yokoi K, Sawada Y. Nonsurgical treatment of various auricular deformities. *Clin Plast Surg* 2002;**29**: 327—32.
23. Yotsuyanagi T. Nonsurgical correction of congenital auricular deformities in children older than early neonates. Follow up. *Plast Reconstr Surg* 2004;**114**:190—1.
24. Schonauer F, Fera G, La Rusca I, et al. Splintage for correction of congenital ear deformities. *Eur J Plast Surg* 2003;**26**: 290—3.
25. Schonauer F, La Rusca I, Molea G. Non-surgical correction of deformational auricular anomalies. J Plast Reconstr Aesthet Surg. doi:10.1016/j.bjps.2007.11.072 , in press.
26. Smith WG, Toye JW, Reid A, et al. Nonsurgical correction of congenital ear abnormalities in the newborn: case series. *Peadiatr Child Health* 2005;**10**:327—31.
27. Lindford AJ, Hettiaratchy S, Schonauer F. Postpartum splinting of ear deformities. *BMJ* 2007;**334**:366—8.
28. Dancey A. Acrylic ear splints for treatment of cryptotia. Letter to the editor. *Plast Reconstr Surg* 2005;**115**:2150—1.
29. Tan ST, Gault DT. When do ears become prominent? *Br J Plast Surg* 1994;**47**:573—4.
30. Fry H, Robertson WV. Interlocked stresses in cartilage. *Nature* 1967;**215**:53.
31. Schiff M, Burn HF. The effect of intravenous estrogens on ground substance. *Arch. Otolaryngol* 1961;**73**:43.
32. Uzuka M, Nakajima K, Ohta S, et al. Induction of hyaluronic acid synthetase by estrogen in the mouse skin. *Biochim Biophys Acta* 1981;**673**:387.
33. Tulchinsky D, Hobel CJ, Yeager E, et al. Plasma estrone, estradiol, estriol, progesterone, and 17-hydroxyprogesterone in human pregnancy. Normal pregnancy. *Am J Obstet Gynecol* 1972;**112**:1095—100.
34. Kenny FM, Angsusingha K, Stinson D, et al. Unconjugated estrogens in the perinatal period. *Pediatr Res* 1973;**7**:826—31.
35. Trotter A, Maier L, Grill HJ, et al. Effects of postnatal estradiol and progesterone replacement in extremely preterm infants. *J Clin Endocrinol Metab* 1999;**84**:4531—5.
36. McDowell AJ. Goals in otoplasty for protruding ears. *Plast Reconstr Surg* 1968;**41**:17—27.
37. Wright WK. Otoplasty goals and principles. *Arch Otolaryngol* 1970;**92**:568—72.

CLINICAL TIP

An infrared forehead thermometer for flap monitoring

In our institution, temperature monitoring of free tissue transfers with skin island is done by using an infrared forehead thermometer (Oriental Inspiration, Ltd, HK SAR China,) to monitor temperature difference between the skin flap (big arrow) and adjacent normal skin (small arrow). If the difference between the two was >2 °C, immediate measures to relieve constrictive dressings are done. If this difference persists for two consecutive hours, the surgeon will be called in for re-evaluation. We have been using this technique of flap monitoring in more than fifteen free tissue transfers with accompanying skin island. The decision to call the attending surgeon was also simplified since instructions were given that if the difference was >2 °C, immediate referral should be done. We recommend the use of this infrared forehead thermometer device as an added armamentarium to the clinical parameters of flap monitoring especially when sophisticated monitoring devices are not available.

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