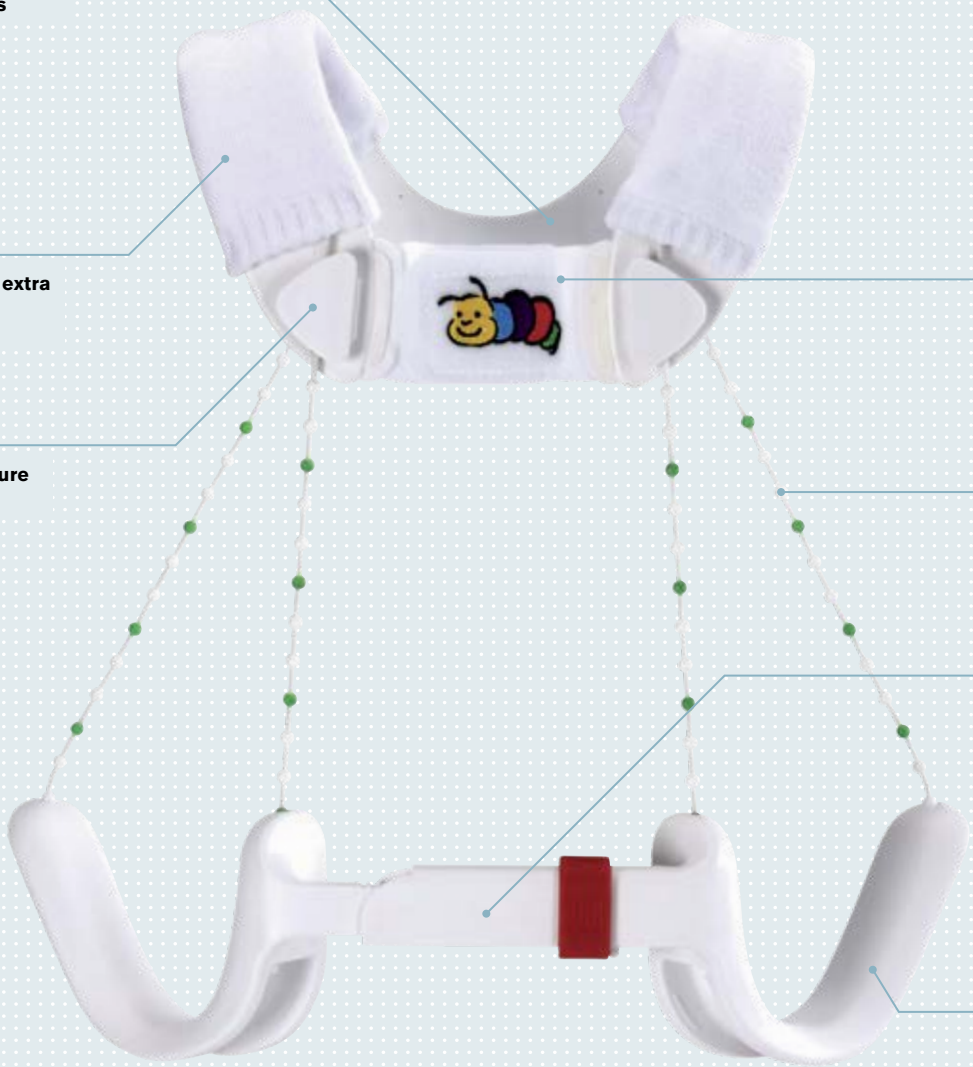
ottobock.

Tübingen hip flexion and abduction orthosis

designed by Prof. Bernau

Information for physicians


Anatomically optimised shoulder harness
Comes with four extra terry cloth pads
Easy-to-use closure mechanism
Hook & loop closure with caterpillar can be completely removed for cleaning.
An extra closure is included.
Coloured beaded cord makes it easier to reproduce the settings
Reproducible spreader bar setting
The orthosis is constructed completely of plastic, making it easy to clean.

Tübingen hip flexion and abduction orthosis

Treating hip development disorders naturally

The well-known pediatric orthopaedic surgeon Bob Salter in Toronto, Canada, proved that children's hip joints mature optimally under the conditions existing in the womb, i.e. in nature. He coined the term "human position" which is equivalent to "natural position". The hips are generally strongly flexed in the womb and only slightly abducted.
For the treatment of hip dysplasia in infants, flexion of the hip joints in excess of 90° with controlled moderate abduction of 30° to 45° is – in addition to beginning treatment immediately after birth – the best prerequisite for rapid maturation of the hip joint with delayed development.

The Tübingen hip flexion and abduction orthosis has proven to be particularly effective for this indication.
The thigh supports are connected to the shoulder harness with two beaded cords to allow for exact hip flexion positioning. The desired degree of abduction is adjustable using a spreader bar with a ratchet that prevents uncontrolled abduction.

Features of the Tübingen hip flexion and abduction orthosis:

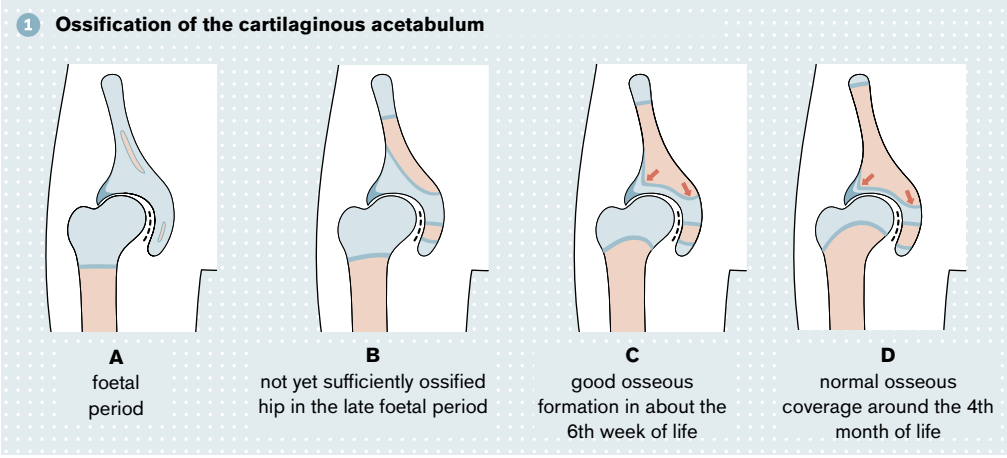
- Proven, sustainable treatment method.
- The high degree of acceptance by parents is due to the fact that it is simple to use, in particular for reproducing the flexion and abduction angle without needing tools.
- The lightweight design allows babies to move around to the permissible extent and does not restrict them any more than necessary.
- The orthosis is waterproof and resistant to salt water.

Medical background

Hip development

Ossification of the hip (Fig. 1) begins in the early foetal period in the cartilaginous pelvis, beginning from the ossification centres of the ilium (cranially), the ischium (dorsally), and the pubis (ventrally). All three growth lines meet at the centre of the acetabulum. First the inner zone of the os ilium, then the outer zone is ossified via the unipolar growth plate moving toward the acetabular labrum. If shear forces act on the growth plate during this sensitive ossification phase (e.g. in breech presentation), ossification of the acetabulum can be disrupted considerably so that delayed ossification requiring treatment may already be present at birth. Prior to birth, flexion contracture is more or less developed; after birth, the newborn extends its legs more frequently and to a greater extent. Only a well ossified acetabulum can withstand these changes in forces. The various stages of ossification can be documented by ultrasound after birth and correspond with the Graf hip classification, the stages of maturation. Starting at the beginning of the third month of life, the structural development of the hyaline-preformed acetabulum is completed by the fourth month of life through increasing endochondral ossification. After that, maturation of the femoral head and acetabulum is more proportionate.

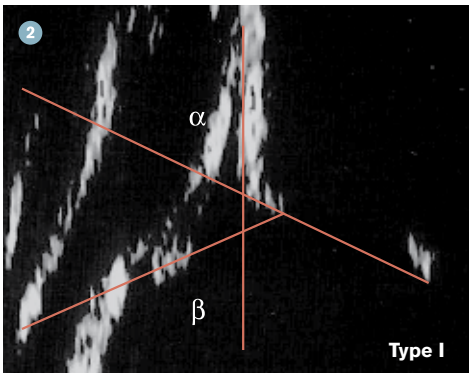
1 Endochondral ossification of the hyaline cartilaginous pre-formed acetabular roof according to Schilt (2004, 1). The course of the growth plates (blue) along the chondro-osseous-border was added by Matthiessen (1999). Beginning at the ossification centres (pink) of the ilium and ischium marked in the cartilaginous pelvis (light blue), ossification proceeds into the lateral cartilaginous acetabulum towards the acetabular labrum (blue) and the triradiate cartilage (red arrows).

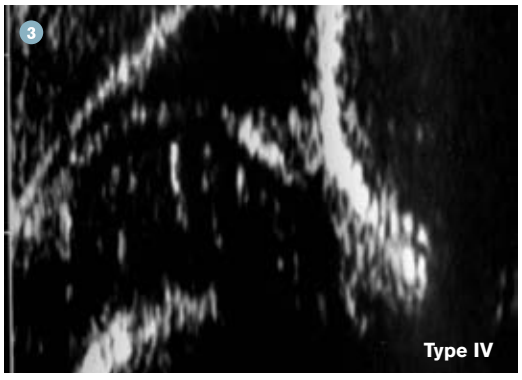


Sonograms of a mature and of a decentred hip joint are shown side by side for visual clarification

2 Mature type I hip. The femoral head is well covered by the bony and cartilaginous acetabular roof.

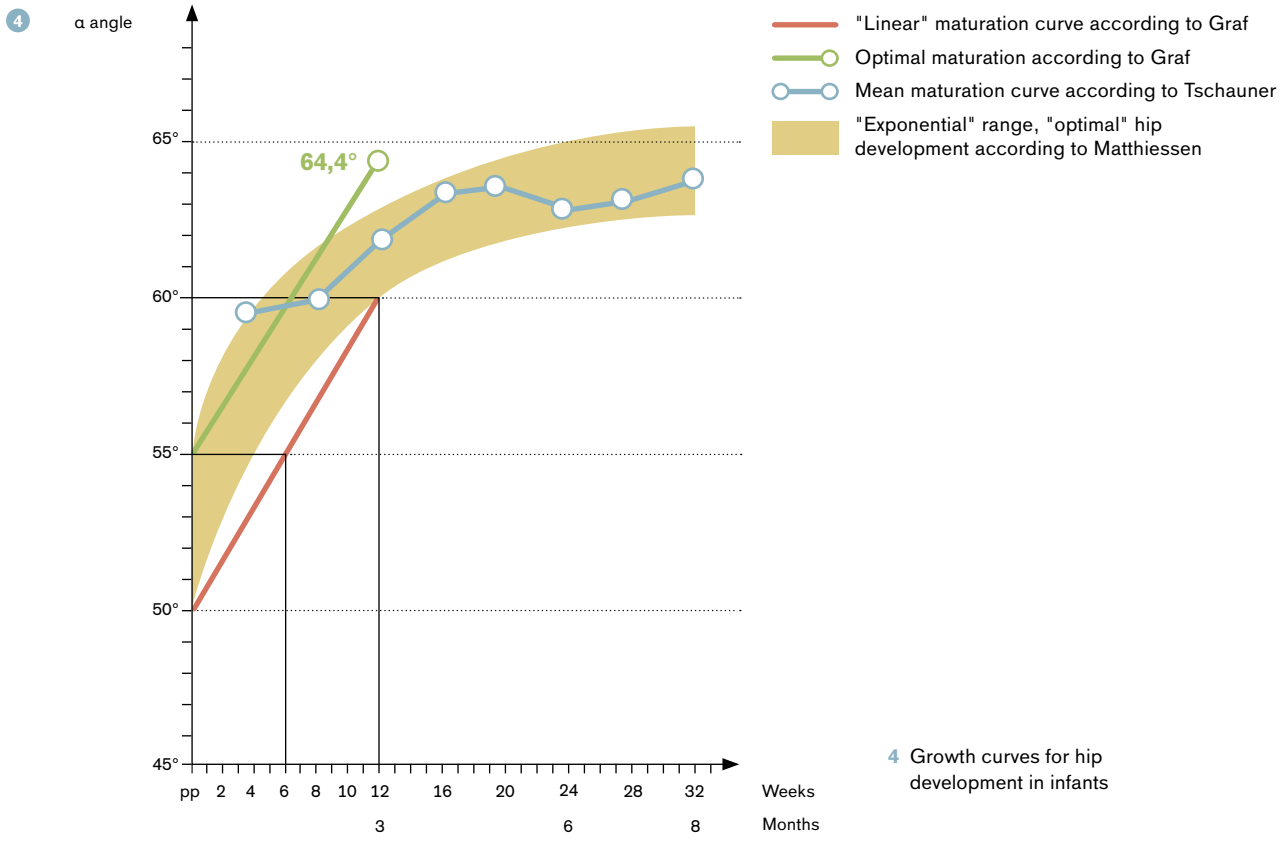
3 Decentred Type IV hip joint. The femoral head has moved completely out of the acetabular roof craniolaterally and displaced the acetabular roof cartilage caudally. Cranially, it is covered only by the joint capsule and muscle. Further ossification of the cartilaginous acetabulum cannot take place due to high shear stresses in the acetabular growth plate.





A decentred joint of this type (Fig. 3) must undergo the repositioning and retention phase in a stable position (e.g. Fettweis plaster cast). Only afterwards can the Tübingen hip flexion and abduction orthosis be used in the secondary ossification phase.

Growth curves by Graf and Tschauner and the "exponential range" of optimal hip development



4 Growth curves for hip development in infants

The progress of ossification can be measured in an ultrasound using the alpha angle described by Graf. This angle identifies the state of development of the hip joint. At birth, this angle must be at least 50°. Assuming a minimum linear ossification process (orange line), according to the Graf ultrasound values, the hip must have reached an alpha angle of at least 60° by the 3rd month. Statistical studies by Tschauner (1990) showed that the mean alpha value for Type I joints was 64.4° in the 3rd month. If we assume a parallel development of the curves (green line), this means that the optimal alpha angle at birth is 55°. Tschauner (1994) identified a maturation curve based on spontaneously matured, untreated hip joints that already had an alpha angle of 59° in the fourth week of life. After analysing the normal hip development of healthy infants, Matthiessen (1999) was able to confirm, supplement, and parameterise Tschauner's maturation curve and to describe a range for optimal hip development (yellow zone). This means that shape differentiation and acetabular development increase exponentially in the first 6 weeks of life, already slow down by the 12th week, and level off around the 16th week to proportional growth of the femoral head and socket.

Therefore, in case of delayed hip development, therapeutic measures should be initiated as soon as possible to utilise the huge ossification potential and achieve rapid maturation of the acetabulum with biomechanical treatment that reproduces Salter's "human position" (more than 90° flexion with moderate abduction of 30° to 45° [optimally, according to Tönnis 1984: 110° flexion, 40° abduction]).

Practical experience
and scientific studies

Over 250,000 Tübingen hip flexion and abduction orthoses were used between 1987 and 2010, primarily in German-speaking regions. The orthoses are offered in 3 sizes (**S**mall, **M**edium, **L**arge).

In aggregate statistics of the working group for hip dysplasia of the German Association of Orthopaedics and Traumatology (DGOT), Tönnis (1999) compiled the treatment outcomes of over 2,300 immature joints over the course of nearly 10 years. More than 20 hospitals and users participated in this study. The analysis showed that the most effective orthoses were those that achieved more than 90° flexion while at the same time preventing the uncontrolled abduction of the thighs (extreme frog-leg, or Lorenz position) using a spreader bar. The aggregate statistics compiled by Tönnis show clearly that in order to achieve rapid centring and make up for the maturation deficit, orthoses that make it possible to achieve greater flexion and limited abduction offer a significant advantage for quickly normalising the initial pathological finding.

According to Matthiessen (1999), flexion and abduction are optimally set from a biomechanical perspective when the resultant force is aligned at a right angle to the three-dimensional curved and flat acetabular growth plate at the chondro-osseus border. Only in this position is the acetabular growth plate optimally stimulated. For this reason, the flexion and abduction settings must be adjusted during the course of treatment to the improved ossification state of the hip joints.

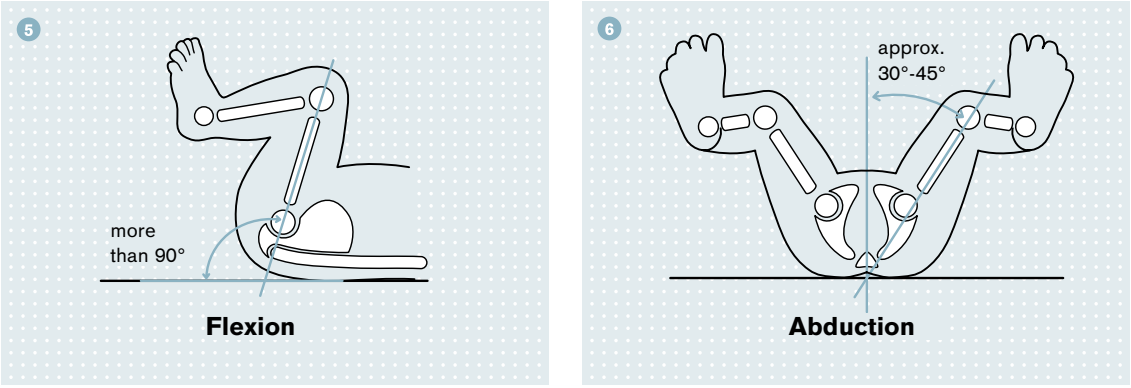
Indication for flexion and abduction orthosis treatment

The standard indication for treatment with the Tübingen hip flexion and abduction orthosis is the secondary ossification phase; that is, hip dysplasia without instability (IIa, IIb, IIc stable on the Graf scale). These are hip development disorders with alpha angles that lie below the "exponential range" of optimal hip development in the diagram by Matthiessen, but which are, however, not yet decentred (Fig. 4).

For all infants with decentred hip joints, the Graf "three-phase treatment concept" that corresponds with the pathoanatomical stage of development of the hip joint is: reposition, retention, and secondary ossification.

Graf stages of hip maturity

The hip joint can be diagnosed in an ultrasound examination according to the Graf stages as age-appropriately matured (Type I) or, if ossification of the cartilaginous acetabulum is inadequate, as developmentally delayed. If ossification progresses too slowly up to the start of the third month for whatever reason and does not reach Type I (see growth charts), the result is a pathologically delayed Type IIb hip. Now at the latest, flexion treatment should be initiated in order to prevent the increasing effects of shear forces acting on the acetabular growth plate. If this is unsuccessful, ossification is reduced up to a complete halt in growth with increasing flattening of the bony socket. The femoral head lateralises and pushes the soft hyaline cartilaginous acetabulum in cranial direction; the alpha angle decreases, until the hip is in the Type IIc critical zone. The tension of the hip muscles pulls the femoral head more and more in lateral and cranial direction until the beta angle becomes pathological from 77 degrees. The hip is "about to decentre" (Type D).



5&6
Diagram of the optimal treatment position

Without further biomechanical therapy, the femoral head will move out of its original socket, glide more and more in cranial and lateral position (Type III), and then displace the cartilagenous acetabular roof caudally until it has formed a Type IV. It then becomes increasingly difficult to reposition the femoral head in the original socket using conservative means. The alpha bone angle describes the ossification state and determines the hip type; the beta cartilage angle describes formation of the cartilaginous acetabulum and regulates fine differentiation.

Conditions for optimal treatment

The preceding explanations of natural and pathological maturation of the hip make it clear that when treating immature hip joints, Salter's "human position", that is the natural position of the legs in the womb, must be copied as far as possible. This is *not* possible with the formerly used abduction pants or similar methods, as they generally do not achieve the necessary hip flexion of 90° and can maintain it even less reliably. The "human position" requires in particular the controlled flexion of the hips, strong abduction is not desired. At the same time, the child's natural kicking movement should be restricted as little as possible, because kicking acts as a natural ossification stimulus for the acetabular growth plate via the femoral head. The ossification of the cartilaginous acetabulum is therefore primarily promoted by the alternating loading (kicking) of the femoral head, which is optimally aligned, i.e. centred, in the hip flexion and abduction orthosis.

Hip flexion should be free, only the harmful extension must be controlled. The baby's legs must be prevented by a bar from falling to the side under their own weight. This undesired strong abduction is exactly what can harm a baby's hip. This is probably one of the main causes of the feared femoral head necroses (= circulatory disorders with femoral head necrosis and resulting deformation of the femoral head with loss of containment) when using bandages which are otherwise essentially similar, but which allow unlimited abduction (e.g. the Hoffmann-Daimler and Pavlik bandages).

Using the Tübingen hip flexion and abduction orthosis, the back is extended due to the flexed hips, so there is no risk of damage to the back. Additionally, spontaneous kicking counteracts the development of a round back. Hip flexion is the normal position at this age and is therefore much easier to achieve. The child must be able to move its back relatively freely to the side during normal and desirable alternating hip movements (kicking).

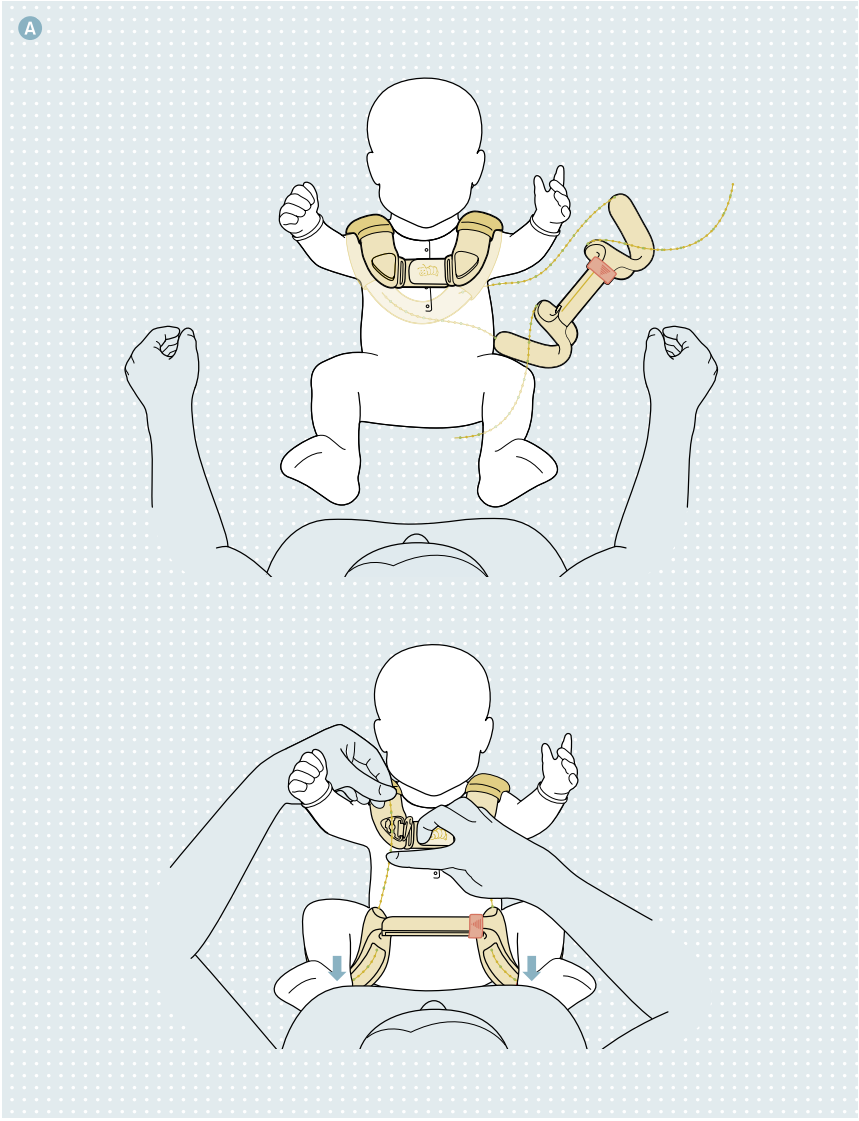
For a Type IIa (-) hip, a joint in which maturation is beginning to be delayed, the treatment goal of safe maturation can thus be most reliably achieved by imitating the natural hip position ("human position") in the womb, as is achieved with the Tübingen hip flexion and abduction orthosis, but not by simply double diapering or spreading the hips. Hip flexion of more than 90° is crucial (Fig. 5 & 6).

Initial fitting of the orthosis

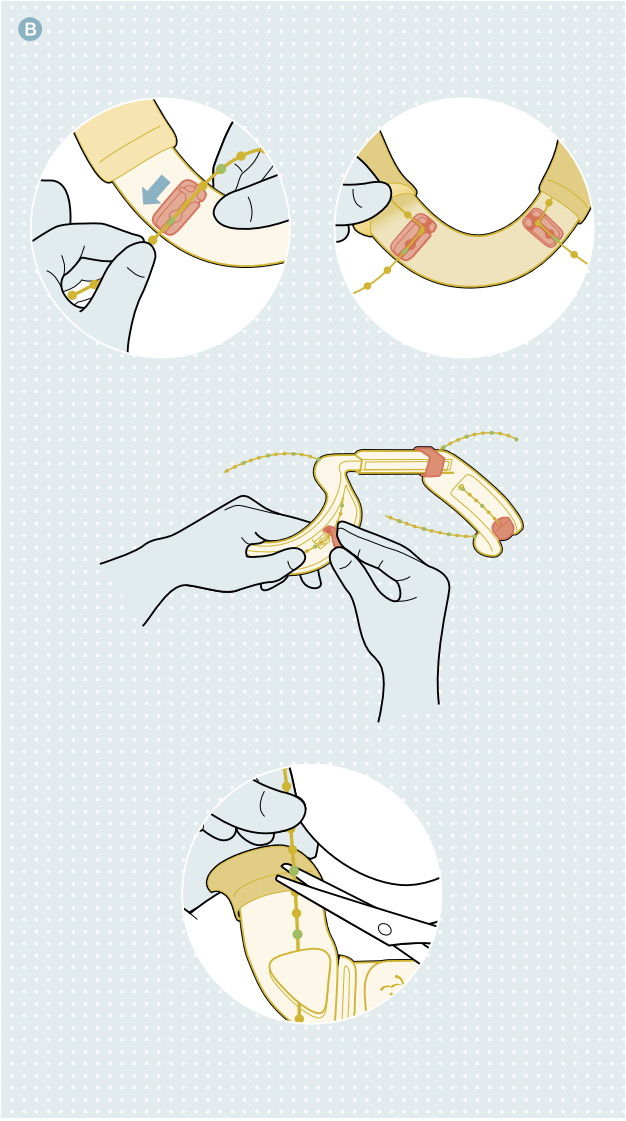
Discussion with the parents
The parents' cooperation is essential for the success of treatment. The physician should always take enough time to explain the orthosis, how it works, and how to put it on. The topic should be discussed with a great deal of sensitivity and potential questions should be anticipated and addressed. For this reason, it is useful to schedule the first follow-up examination after a short time, i.e. within a few days depending on the finding, in order to answer other questions the parents might have.

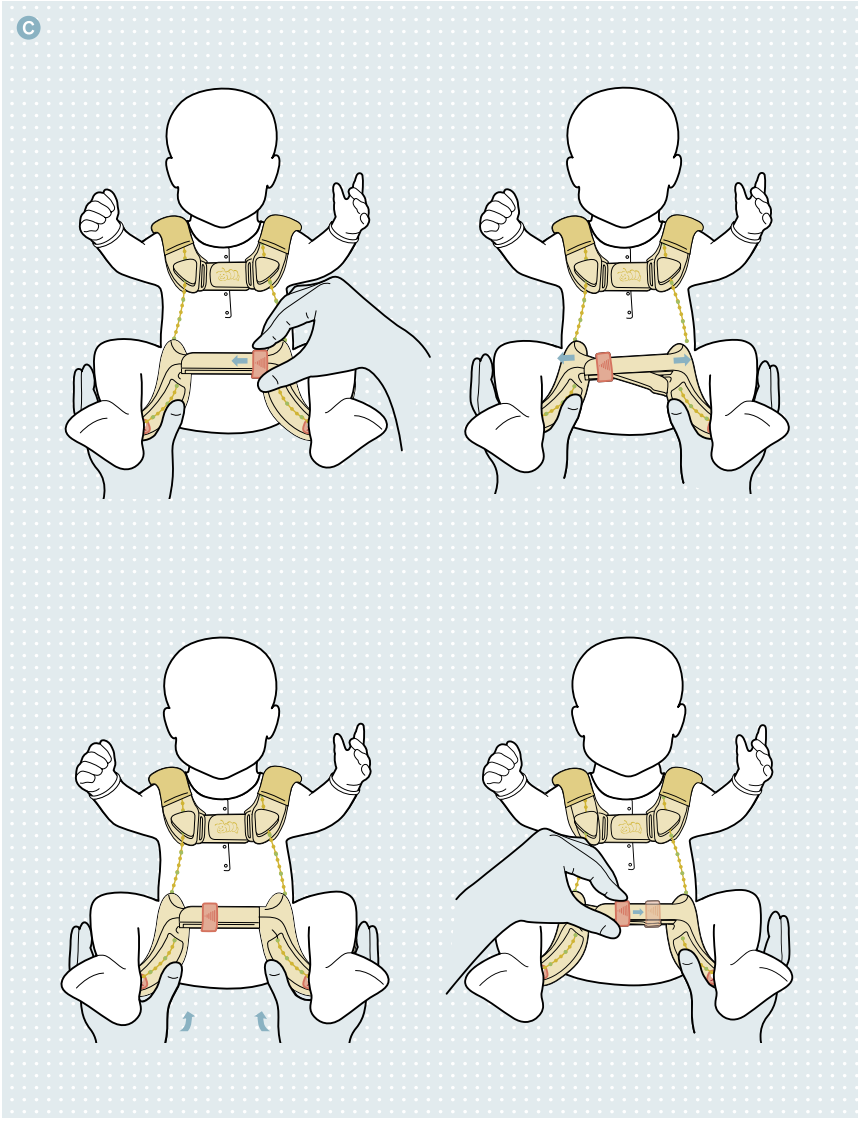
In the beginning, parents especially want to know approximately how long the treatment will take. Even if an exact answer cannot be given for an individual case, parents are quite satisfied to hear that this treatment for a Graf Type IIc hip can last an average of **4 to 6** weeks, depending on when treatment begins (Fig. 4). The much less common decentred hip joints require a different treatment concept. After repositioning and retention therapy with stable centring, the Tübingen hip flexion and abduction orthosis is used in the phase of secondary ossification.

The time treatment begins is crucial for the length of treatment, as the speed of ossification is greatest in the first 6 weeks (Fig. 4).
If treatment is started later, the period that remains until growth potential tapers off is no longer sufficient to achieve complete maturation; this results in "residual dysplasias". When treatment is begun at age 4 to 6 weeks, a treatment time of 3 to 4 months may be required for eccentric hips. Another approximate value is that the treatment time is twice the baby's age. The orthosis should be worn 23 hours a day, i.e. all the time except for diapering and bathing.



A On the changing table, the shoulder harness is first applied from the back, and the hook-and-loop closure is then closed with the caterpillar image facing forward. The child is pulled towards your abdomen so that the legs are flexed by more than 90 degrees at the hips, and so they can also no longer be extended. Then the leg supports are guided underneath the thighs. When the child's feet are supported on your abdomen, the beaded cords can be attached in the white closures without tension.





B The beaded cord can first be lengthened by releasing the reserve cord at the back of the shoulder harness. The length must also be changed accordingly at the red closures on the leg supports. Finally, at the initial fitting, the cord is shortened above the white closures to 3 beads on either side so that the length and thus the setting is clearly indicated to the parents.

C Abduction is adjusted according to age using the spreader bar. It is opened by sliding the slide lock to the left – from the physician's perspective – and adjusted after tilting to the desired width. To close, the slide lock is pushed back to its original position to the far right until it clicks into place.

Further information

Additional observations by the physician
It has proven extremely beneficial to have frequent checkups, especially at the beginning. This allows for the correct use of the orthosis to be checked, and new questions or uncertainty on the part of parents can be addressed. For parents who live further away from the physician, the offer of the physician's permanent availability by phone is very important. However, whenever possible, a first follow-up after a brief period is recommended. If progress is normal, clinical and ultrasound checkups should be conducted at intervals of 4 (to 6) weeks, depending on the child's age. Depending on progress and growth of the infant, the orthosis may need to be readjusted during the course of treatment. The reserve length of the beaded cord is located at the back of the shoulder harness above the red closures on both sides.

Conclusion of treatment
Flexion and abduction orthosis treatment can be concluded after age-appropriate sonographic hip values have been achieved (see growth charts). However, we recommend a checkup 6-8 weeks after treatment has been concluded to exclude any potential new delay in ossification. According to a recommendation of the working group for hip dysplasia (Tönnis), the final examination of treated hips should always include an x-ray of the pelvis, because contrary to earlier reports, deterioration of the hip finding (Matthiessen's "endogenous factor") cannot be completely ruled out even for otherwise healthy children.

For such cases, reliable assessment after the sonography age (about 1 to 1 ½ years) is possible only if a comparison can be made with imaging procedures used later. Further clinical and possibly x-ray checkups are necessary for children treated for hip dysplasia before they start walking at the age of one year, before they start school at around five or six years (femoral antetorsion with valgus deformity), and possibly before the end of the growth period.

7 X-ray observation of the progress of hip dysplasia that was treated with the Tübingen hip flexion and abduction orthosis in 1988. Today, decentred joints must go through the repositioning and retention phase (Graf, 2009) which is then followed by secondary ossification in an orthosis. The diagnosis of a Type D hip was made by ultrasound at the age of 2 months. After only 6 weeks of treatment, the hip improved at the age of 3 months to a Type I hip with an alpha angle of 65°.
The x-ray checkup at age 5 ½ months shows the morphology of this area in the lateral acetabular rim with newly formed mineralised osteoid after very good ossification.
The x-ray checkup before starting school shows very good coverage of the femoral head at the age of 6 years.

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Ordering information

Article number	Size	Age of infant (in months)
28L10=	S	0–1.
28L10=	M	2.–5.
28L10=	L	6.–12.

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