Tübingen Hip Flexion Orthosis

designed by Prof. Dr. Bernau
Improved Tübingen Hip Flexion Orthosis with the same treatment principle, but better handling and greater comfort.
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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, ensuring 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 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.

Special features of the Tübingen Hip Flexion Orthosis:

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

Ossification of the hip 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 pelvic 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. At the beginning of the third month of life, the acetabulum is fully formed. After that, maturation of the femoral head and acetabulum is more proportionate.

Fig. 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 cartilage-bone interface was added by Matthiessen (1999). Beginning at the ossification centres of the ilium and ischium (light yellow) in the cartilaginous pelvis (light blue), ossification proceeds into the lateral cartilaginous acetabulum towards the acetabular labrum (yellow) and the Y-shaped cartilage (orange arrows).

Fig. 2: Right: Mature type I hip. The femoral head is well covered by the osseous and cartilaginous acetabulum. Left: Highly eccentric Type IV hip. The femoral head has moved completely out of the primary socket cranilaterally and displaced the acetabular roof cartilage caudally. Cranially, it is covered only by the joint capsule and muscle. The osseous acetabular rims are marked by a yellow circle.

Ossification of the cartilaginous acetabulum

A = Foetal period; B = not yet sufficiently ossified hip in the late foetal period; C = good osseous formation in about the 6th week of life; D = normal osseous coverage around the 4th month of life.
Growth curves by Graf and Tschauner and the "exponential range" of optimal hip development

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 describe a range for optimal hip development (yellow zone). This means that shape differentiation and acetabular ossification increase exponentially in the first 6 weeks of life, already slow down by the 12th week, and level off around the 16th week to a 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°).
Practical experience and scientific studies

Over 250,000 Tübingen Hip Flexion Orthoses were used between 1987 and 2010, primarily in German-speaking regions. The orthoses are offered in 3 sizes (Small, Medium, Large).

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 during 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 external rotation 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 fixed abduction offer a significant advantage for quickly normalising the initial pathological finding. According to Matthiessen (1999), from the biomechanical perspective, flexion and abduction are optimally set when the resulting position of the premature acetabulum is aligned at a right angle to the three-dimensional curve of the acetabular growth plate. 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 orthosis treatment**

The standard indication for treatment with the Tübingen Hip Flexion Orthosis 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 centred (Fig. 3).

Aside from this author, several experienced users (Bernau) report that in exceptional circumstances, they have also successfully treated eccentric hips with the Tübingen Hip Flexion Orthosis. These exceptions apply to the start of treatment immediately after birth, when a centred alignment of the femoral head can be achieved by flexion and abduction alone. The physician's competence and the parents' compliance are indispensable. This procedure is recommended only for colleagues who have mastered all the potential complications and can justify their deviation from the recommended “three-phase standard therapy” (Graf) in case of lawsuits for unsuccessful treatment. If, at known high ossification speed, no clear stabilization and increase in ossification occur within 3 weeks, the only alternative is a Fettweis cast. For all infants with eccentric hip joints who are not diagnosed until the 4th or 5th week of life at the U3 screening or later, the Graf "three-phase treatment concept" that corresponds with the patho-anatomical stage of development of the joint is: reposition, retention, and post-maturation.

**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 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 acetabular growth. 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 (Type IIa, after age 2 months pathological ossification delay Type IIb), until the hip is in the Type IIc danger zone. The tension of the hip muscles pushes the femoral head more and more in lateral and cranial direction until the beta angle becomes pathological. The hip is "about to decentre" (Type D). Without further biomechanical therapy, the femoral head will move out of its primary socket (Type III) and become more cranial and lateral, and then displace the cartilaginous acetabular roof caudally until it has formed a Type IV. It then becomes increasingly difficult to reposition the femoral head in the primary 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 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, with strong abduction 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 stimulus for the acetabular growth plate. The development of the three-dimensional curved acetabulum is encouraged mostly by the counter pressure put on it when the femoral head is optimally aligned, i.e. centred. 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 necrosis (= circulatory disorder leading to deformation of the femoral head) when using bandages with a similar principle, but which allow unlimited abduction (e.g. the Hoffmann-Daimler and Pavlik bandages).

Using the Tübingen Hip Flexion 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 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 Orthosis, but not by simply double diapering or spreading the hips. Hip flexion of more than 90° is crucial (Fig. 4).
Initial fitting of the orthosis

Discussion with the parents
The parent’s 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 week 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 II hip lasts an average of 4 to 6 weeks. The much less common eccentric hip joints require a different treatment concept. After repositioning and retention therapy, the Tübingen Hip Flexion Orthosis is used in the postmaturation phase. The time treatment begins is crucial for the length of treatment, as the speed of ossification is greatest in the first 6 weeks (Fig. 3). If treatment is started later, the time that remains until the growth potential tapers off is no longer sufficient to achieve complete maturation. When treatment is begun at age 4-6 weeks, treatment time of 3-4 months is needed 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.
2. 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.

3. 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.
For further information

Additional observations by the physician
It has proven extremely beneficial to have frequent checkups, especially at the beginning. The correct use of the orthosis should be checked, in particular with respect to new questions or uncertainty on the part of parents. 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 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
When normal ultrasound findings are achieved, the orthosis use can be decreased. According to a recommendation of the working group for hip dysplasia (Tönnis), the final examination of treated hips should always include an additional 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 year) 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, one year before they start school (example see Fig. 5), and possibly before the end of the growth period.

Fig. 5: X-ray observation of the progress of hip dysplasia that was treated with the Tübingen Hip Flexion Orthosis in 1988. Today, eccentric joints must go through the repositioning and retention phase (Graf, 2009) which is then followed by post-maturation 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.
Bibliography


Ordering information

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