Chapter 9

Summary

Selective dorsal rhizotomy (SDR) is a treatment modality to reduce spasticity which has mainly been evaluated in children who suffer from spastic cerebral palsy (CP). The effect of SDR in paediatric patients who suffer from spasticity due to other etiologies than CP, especially in patients who suffer from progressive spasticity, has not been described previously. Furthermore, the selection of patients for SDR is mainly based on clinical criteria, and other criteria, such as neuroimaging, have not been evaluated in patients undergoing SDR. Although most centers that perform SDR have definite selection criteria, the impact of preoperative clinical findings on outcome has hardly been described. Although there is good evidence that SDR has a positive impact on the reduction of spasticity and the level of functioning in the short term, the long-term effects and adverse events after SDR have only been reported in few studies which were published very recently. The aims of the present thesis were therefore (A) to describe the effects of SDR in patients who suffer from spasticity due to other etiologies than CP, (B) to assess whether neuroimaging studies can help to select patients for SDR, (C) to describe possible relations between the preoperative level of functioning and gait performance after SDR and (D) to describe the long-term effects and adverse events after SDR.

Chapters 1 and 2 comprise the introduction, aims, design and outline of the study.

In **chapter 3** we report the effectiveness of SDR in two patients with progressive spasticity due to neurodegenerative disease. The cases described in chapter 3 showed that spasticity diminished or completely disappeared after SDR, and did not recur. In both patients, caregiving was eased and sitting comfort was improved. However, whereas the spasticity was dramatically and permanently reduced, SDR did not have an influence on other motor disturbances than spasticity, such as ataxia and posture-dependent muscle spasms. We therefore concluded that before deciding to perform SDR in patients who suffer from progressive spasticity due to neurodegenerative disease, other treatment modalities, such as the use of oral antispastic medication or intrathecal baclofen therapy should be considered first. However, when other treatment modalities fail or are contraindicated, SDR could be an alternative to treat spasticity in patients who suffer from spasticity due to progressive neurological disease.

In the study reported in **chapter 4,** we aimed to determine whether there is a relationship between preoperative MRI findings and gross motor function capacities after SDR in patients with bilateral spasticity. We compared the changes in the Gross Motor Function Measure (GMFM) for 19 patients who underwent SDR and for whom preoperative neuroimaging studies were available. The MRIs were classified into three different diagnostic groups: periventricular leucomalacia (PVL, n=10), hydrocephalus (n=2) and normal MRI (n=6). In patients with PVL, the severity of the MRI abnormalities was also scored, using a scoring system which assesses ventricular size, extension of white matter signal intensity, extension of white matter loss, thinning of the corpus callosum, dimensions of subarachnoidal space, evidence of cysts, and presence of gray matter abnormalities. We compared the changes in the GMFM-66 after SDR between patients who presented with evidence of hydrocephalus, patients who showed evidence of PVL and patients who did not show any MRI abnormalities. Additionally, we correlated the severity of the MRI abnormalities in patients with PVL with the changes in the GMFM-66. After a mean follow-up duration of 5 years and 4 months, we observed the best improvement of gross motor function in patients with normal MRI findings. Patients who showed evidence of PVL in the preoperative MRI had intermediate improvements, whereas the two patients who suffered from hydrocephalus showed no improvement in gross motor function. Whereas the severity of the preoperative MRI abnormalities correlated with the preoperative level of gross motor capacity in patients with PVL, there was no correlation between the severity of the preoperative MRI abnormalities and the improvement after SDR. We concluded that MRI of the brain can provide additional information for the selection of patients for SDR, but that the degree of PVL does not provide information about the degree of improvement in gross motor function after SDR.

In **chapter 5** we assessed the reliability and validity of a custom-made software program that is routinely used at the VU Medical Center to assess gait kinematics in patients with spastic CP. The reasons for performing this study were that we wished to assess gait kinematics before and after SDR, and that for most of the patients preoperative gait analysis included only video documentations and EMG measurements, but not 3-dimensional instrumental gait analysis, which is considered to be the gold standard for the assessment of gait kinematics. A group of 17 patients diagnosed with spastic CP was examined. The patients walked on a 10 m walkway and video recordings were made. Additionally, 3-D instrumental gait analysis was carried out. Two investigators measured 6 different sagittal joint/segment angles (shank, ankle, knee, hip, pelvis and trunk) using a custom-made software package (the MoXie Viewer®, www.smalll.nl). The reproducibility of these measurements was assessed by the intraclass correlation coefficient (ICC), the standard error of measurement (SEM) and the smallest detectable difference (SDD). In addition, the agreement between the video screen measurements and 3-Dinstrumental gait analyses was analyzed by Bland-Altman plots and limits of agreement (LoA). The findings on intra-rater reproducibility showed that the ICC ranged from 0.99 in the shank to 0.58 in the trunk, the SEM from 0.81° in the shank to 5.97° in the trunk and the SDD from 1.80o in the shank to 16.55° in the trunk. With regard to the inter-rater reproducibility, the ICC ranged from 0.99 in the shank to 0.48 in the trunk, the SEM from 0.70° in the shank to 6.78° in the trunk and the SDD from 1.95° in the shank to 18.8° in the trunk. The LoA between the video screen measurements and 3-D gait analyses was best for the knee extension in the stance phase (0.4 +/–13.4°) and poorest for the ankle dorsiflexion in swing (12.0 +/–14.6°). We concluded that, when performed by the same observer, the video screen measurements allow relevant changes after an intervention to be detected. With respect to the gait changes after SDR, we therefore decided that these gait changes should be measured by the same observer, and we chose to primarily measure changes in the knee kinematics, due to the poorer intra-rater reproducibility for the ankle, pelvis, hip and trunk and the larger LoA between video screen measurements and 3-D instrumental gait analysis in the ankle.

In **chapter 6** we summarize the results of patients with preserved walking ability who have been treated with SDR at the VU Medical Center, Amsterdam, the Netherlands. A gait analysis was performed for 30 children before SDR and 12 to 24 months postoperatively. The subjects walked on a 10 m walkway at comfortable walking speed, and biplanar video was recorded. We measured the sagittal knee angles according to the method described in chapter 4, and administered the Edinburgh Gait Assessment Scale (EGAS) before and after the SDR. In addition, surface EMG was recorded for the rectus femoris (RF) muscle, the vastus lateralis (VL) muscle, the gastrocnemius medialis (GM) muscle, the tibialis anterior (TA) muscle and the semitendinosus (ST) muscle. We compared the gait performance – as assessed by the EGAS – before and after SDR, and correlated the improvement in the EGAS with the age at SDR, the Gross Motor Function Classification Score before SDR and the total EGAS score before SDR. The kinematic measurements of the knee joint were compared before and after SDR. EMG changes after SDR were assessed qualitatively and a quantitatively – describing the total amount of abnormal EMG activity. The EGAS significantly improved after SDR ($p<0.001$) and there were significant improvements in knee angle kinematics ($p<0.001$). The improvement in terms of EGAS scores was significant in independent ambulators ($p<0.001$) as well as in patients who had walked with assistive devices before SDR ($p=0.002$). Improvements were much more pronounced among the independent ambulators and correlated significantly with the preoperative GMFC score (rho = –0.413, $p=0.001$), but not with the patient's age at the time of SDR or the preoperative EGAS score. With respect to the EMG activity, only slight changes were observed after SDR. We found that the activity of the GM decreased and a late peak appeared in stance, while the activity of the ST increased in stance. Furthermore, the activity of the RF decreased in swing. In conclusion, we found that SDR improved overall gait performance, especially in patients who had walked without assistive devices before SDR. EMG changes were only slight. Better timing of the GM in stance and reduced activity of RF in swing may have increased knee flexion in swing, and reduced hamstring spasticity may have led to postural instability of the hip.

The study reported in **chapter 7** aimed to assess the long-term outcome and adverse events of SDR in children with spastic CP. We performed a systematic search of the medical literature and summarized the results in a systematic review. The studies included in this review reported results of children with CP who underwent SDR with a follow-up period of at least five years. At least 50% of the subjects were diagnosed with CP or the outcome results had to be documented separately for patients diagnosed with CP. Only articles written in English were included in the review. Several databases were screened (MEDLINE, Web of Science, Embase, PEDro, and the Cochrane library) and the studies meeting the inclusion criteria were scored by two reviewers. The studies were graded with respect to their level of evidence and their quality/conduct. In total, we identified 21 studies that met the inclusion criteria; these included 966 patients. On the whole, their strength and the quality of the evidence were very limited. Only three Level III studies provided a tentative conclusion and it could be assumed that the outcomes were attributable to the SDR. All 18 remaining level IV studies did not allow a conclusion with respect to the causation of SDR and the outcomes 5 years or more after SDR. Two level III studies reported outcomes after 10 and 20 years for the ICF domains of body structure and function. Both reported improvements of gait after SDR. One level III study reported outcomes in the ICF domain of activity; it did not find any differences in the activity domain between children undergoing SDR and a control group that was treated with physical therapy alone. There were no studies reporting outcomes in the ICF domain of participation. Various studies with lower levels of evidence reported spinal abnormalities after SDR. In summary, we found that there is moderate evidence that SDR has a positive long-term influence on the ICF domains of body structure and body function, but that there is no evidence that SDR has an effect on the ICF activity and participation domains.

Chapter 8 presents a general discussion. Methodological issues and aspects of the outcome assessments after SDR are discussed in detail. The possibility of SDR as a treatment option for spasticity in patients diagnosed with other disorders than CP is discussed. The chapter also discusses possible relationships between the preoperative level of functioning and the improvement in terms of gross motor function and gait performance after SDR, as well as the value of preoperative neuroimaging and the long-term effects and adverse events of SDR. The chapter concludes by discussing clinical implications and formulating recommendations for future research.