

Prospective Study

Dorsal Root Ganglion Stimulation (DRGS) for the Treatment of Chronic Neuropathic Pain: A Single-Center Study with Long-Term Prospective Results in 62 Cases

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Background: Dorsal root ganglion stimulation (DRGS) treats discrete, localized areas of neuropathic pain. But there are no long-term results available so far.

Objectives: We studied the long-term outcome of DRGS used in the treatment of chronic neuropathic pain.

Study Design: A prospective, longitudinal single center investigation.

Setting: Academic medical center in Germany.

Methods: Patients (age >18 years) with chronic neuropathic pain in the hands, back, legs, knees and feet were prospectively examined. After a successful test-trial (duration of 3-14 days, pain decrease > 50%), a permanent generator was implanted. The patients were re-examined after 1 year, 2 years and 3 years. We used the Visual Analogue Scale (VAS), the Pain Disability Index (PDI), the Pain Catastrophizing Scale (PCS), the Brief Pain Inventory (BPI), and, the Beck Depression Inventory (BDI) for our assessments.

Results: We included 62 consecutive patients (27 females, 35 males, mean age 56.8 years, with an age range from 28 to 82 years, 62/51 to permanent conversion) during the time period from March 2012 until March 2016. Fifty-one patients had a successful test-trial and a generator was implanted subsequently. Results after 3 years: the VAS dropped from Mdn = 8 to Mdn = 4 ($P = 0.0001$). The PDI decreased from Mdn = 45 to Mdn = 23 ($P = 0.003$). The PCS decreased from Mdn = 34 to Mdn = 21 ($P = 0.001$). The BPI dropped from Mdn = 73 to Mdn = 30 ($P = 0.003$). The BDI decreased from Mdn = 36 to Mdn = 21 ($P = 0.010$). Fourteen patients showed complications (27.4%).

Limitations: This study is limited by the small number of patients in the single groups of the different pain locations.

Conclusion: DRGS may be an effective long-term method of treating discrete, localized areas of chronic neuropathic pain. We would recommend DRGS for the treatment of chronic neuropathic pain in such areas.

Key words: Knee pain, foot pain, hand pain, groin pain, neuromodulation, dorsal root ganglion stimulation, chronic neuropathic pain, paresthesia mapping

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Chronic neuropathic pain is a severe and disabling pain condition (1,2). Conservative treatment modalities and pain therapy according to the WHO pain scale prove to be insufficient

in many instances. Spinal cord stimulation (SCS) has been shown to effectively decrease neuropathic pain. However, there are problems involved with SCS such as paresthesias in the non-painful areas as well as

postural changes due to the stimulation (3,4). Also, discrete and well-localized pain regions such as in the groin, the knees, the feet or the hands are difficult to treat with SCS.

Here, SCS often cannot provide sufficient stimulation coverage, and, when successful, it is then at the expense of large pain-free areas involved in the additional stimulation (5). Paresthesia free systems are also limited as they might deliver excess energy with no mechanisms to control its dispersion. There is also restricted information on success in this focal pain population. This would include Burst DR, high frequency and other novel waveforms.

The advent of dorsal root ganglion stimulation (DRGS) has, therefore, been welcomed as a novel treatment of chronic neuropathic pain. Small areas of pain can now be stimulated precisely, without involving the other dermatomes (6). The application of the stimulation energy is direct and focused on the dorsal root ganglion (DRG) without diffusing through the spinal cord fluid as it often happens during SCS. Another advantage is the fact that the first neuron is being stimulated directly. This offers additional possibilities for better pain control. Therefore, DRGS appears to be a very valuable improvement. The armamentarium of neuromodulative techniques used in the treatment of chronic pain has been substantially strengthened by means of DRGS (7-9). In this study we prospectively examined a single center long-term survey of 62 cases treated using DRGS for neuropathic pain. It was our goal to establish long-term results over a time period of up to 3 years.

METHODS

Patients undergoing DRGS for the treatment of chronic pain were prospectively analyzed. The study was authorized by the local Ethic Committee. This is a single center study.

Inclusion Criteria

- Age > 18 years
- Chronic neuropathic pain in a localized area involving 1-2 but not more than 3 dermatomes such as a knee, a foot, a hand, a leg, the chest and the back.
- The pain had to be confirmed by a clinically detectable sensory loss, hyperalgesia or allodynia, within an anatomic concordant area of a nerve or a root dermatome. The Budapest criteria were fulfilled in the diagnosis of complex regional pain syndrome (CRPS) type II. One symptom in 3 of 4 categories

(sensory, vasomotor, sudomotor/edema, motoric/trophic) had to be fulfilled. Most cases showed sensory, vasomotor and trophic changes.

- Failure of pain treatment having used numerous medications, having had interventions or having even been hospitalized.
- There was no further indication for another surgical intervention in the area of the painful region (e.g., knee, foot or back)

Exclusion Criteria

- Age < 18 years
- Previous spinal surgery at the level of the intended implantation of the DRG leads
- Presence of cardiac pacemakers, vascular access catheters, other SCS or peripheral nerve stimulators. These included actively implanted and previously attempted and failed stimulators.
- Psychiatric disorders

Pre-operative Assessment

Most of the patients who were referred to us came from our own hospital or from other pain clinics. History was taken and a clinical examination was performed. Chronic neuropathic pain had to be clearly diagnosed. Further surgical intervention in the painful area was no longer a recommendation.

It was most important to clearly identify the dermatomes that innervate the painful area in each patient when planning the use of DRGS. The first step comprised of a thorough clinical examination identifying the painful area and corresponding regions of allodynia or hyperpathy. If there was a doubt regarding possible nerve roots innervating the painful region, a nerve root infiltration was performed. In such cases 1 mL of a local anesthetic agent (Ropivacaine 0.2%) was infiltrated on the nerve root under x-ray control. If the pain subsided after such an infiltration, then this nerve root was also involved in the pain transmission. A lead would also have to be placed on this DRG as well. Such preoperative local anesthetic diagnostic nerve root blocks are important prior to surgery in order to clearly identify the involved nerve roots. Nerve root infiltrations can be performed on a prior day or the same day as the DRG trial implantation. Infiltrations on a prior day provide more time to evaluate the patient. Infiltrations on the same day have the advantage that the patient does not need an additional appointment; however, sometimes it seems to be difficult to schedule everything on one day in a suitable sequence. There-

fore, we prefer to perform the infiltrations on a prior day.

In all of our patients who received a transforaminal injection first, the pain returned after the effect of the injection faded away. We do not think that a case can be made to see if prolonged pain relief is achieved by a transforaminal injection first since the pain pathway would be interrupted and central desensitization may be achieved.

We currently operate on most of our patients under sedation analgesia and perform an intraoperative testing in order to ensure the correct positioning of the electrodes.

Sedation analgesia has the advantage that an intraoperative testing can ensure a definite correct position of the electrode. As soon as an electrode has been positioned on the dorsal root ganglion, an intraoperative x-ray is performed in order to confirm the correct position of the electrode in the middle of the foramen. Then, we perform a paresthesia testing and ask the patient in which area the tingling sensation is felt and whether the painful area is fully covered by paresthesia. We perform a motor inducement only if it remains unclear whether the probe might be located ventrally. Additionally, prior to the surgery, we perform antero-postero and lateral x-rays of the lumbar spine in order to visualize the bony structures, especially the foramina of the targeted levels.

If there might be signs of spinal stenosis on plain x-rays, we performed a CT scan of the area where the electrodes are supposed to be placed in order to rule out possible spinal generators of the pain and to ensure wide enough foramina.

The patient undergoes a trial phase of 3 to 14 days. If the pain is reduced by more than 50%, a permanent generator is implanted. We usually implant the generator in the gluteal area under a local or under a general anesthesia depending on the patient's preference.

Postoperative Outcome Assessment

The patients were re-examined at our outpatient department after 12 months and then annually thereafter. The primary outcome was assessed using the Visual Analog Scale (VAS). We evaluated the secondary outcome utilizing the Pain Disability Index (PDI), the Pain Catastrophizing Scale (PCS), the Brief Pain Inventory (BPI), the Beck Depression Inventory (BDI), pain medication and the general satisfaction and well-being of the patient. We also performed a paresthesia mapping on each of the patients. The area of the pain and the

area of the stimulation were mapped at baseline and at each visit thereafter.

Statistical Evaluation

We used a one way non-parametric repeated measures analysis of the variance equivalent (Kruskal-Wallis test), followed by a post hoc analysis with a Tukey-Kramer correction for multiple comparisons for the statistical evaluation. The significance levels were set at $\alpha = 0.05$.

RESULTS

Patients

From March 2012 until March 2016, 62 consecutive patients underwent a trial, 11 dropped out, leaving 51 patients, of which 25 were followed up for 3 years (nearly half of the remaining 51). These patients (27 women, 34 men, with a mean age of 56.8 years, age ranging between 28 to 82 years) were specifically treated for chronic pain at our department using DRGS. The majority of patients presented with knee pain ($n = 30$), but also other localized pain regions were treated, such as pain in the hand or in the foot. Table 1 provides an overview of the different pain regions, which were treated using DRGS. Patients with groin pain are not included in this study and have been separately reported on in the past (10). The main indication for using DRGS in these patients were pain areas, which were well localized and involved 1 or 2 but definitely not more than 3 dermatomes. All of the patients had histories of pain that lasted longer than 6 months. The mean duration of pain was 1.8 years, lasting between 0.3 to 6 years. All patients had undergone extensive pain treatments according to the WHO pain scale. However, 50% of the patients were unable to tolerate the side effects of opioids the antiepileptic drugs. Forty percent of the patients reported that the medication did not provide sufficient pain relief.

Trial Period

All patients underwent a test trial. The trial lasted from 3 to 14 days, with the modal trial period being 7 days. Fifty one patients (82.3%) reported pain relief of more than 50% during the trial and then went for the implantation of a permanent internal pulse generator (IPG). Eleven patients (17.8%) had an insufficient reduction in pain and the stimulation electrodes were removed subsequently (Table 1).

Table 1. Type of pain: negative and positive test-trials.

Type of Pain	n	Negative Test-Trial	Positive Test-Trial
Knee pain	30	3	27
Hand pain	7	1	6
Foot pain	8	2	6
Back pain	6	2	4
Leg pain	9	3	6
Post Zoster pain T11-12	1		1
pAVK leg	1		1
Total	62	11	51

Table 2. Follow up.

	Baseline	1 year	2 years	3 years
Knee	27	25	21	16
Hand	6	4	3	3
Foot	6	4	3	3
Back	4	2	2	
Leg	6	3	2	1
pAVK	1	1	1	1
Postma.	1	1	1	1
Total (n)	51	40	33	25

Forty-nine patients received IPGs implanted into the gluteal region and 2 patients received IPGs in the abdominal area.

Outcome

Twenty-five patients had 3-year follow ups. Thirty-three patients were re-examined after 2 to 3 years (Table 2).

Visual Analogue Scale (VAS)

A one-way nonparametric repeated measures analysis of variance (Kruskal-Wallis test) showed a significant main effect of DRGS on the VAS scores ($H(3) = 105.77, P < 0.0001$). Post hoc analysis with Tukey-Kramer correction for multiple comparisons revealed a significant decrease in VAS scores after 1 year (Mdn = 3; $U(39) = 8.26, P < 0.0001$), after 2 years (Mdn = 4; $U(34) = 7.98, P < 0.0001$) and after 3 years (Mdn = 4; $U(27) = 7.37, P < 0.0001$) of DRGS in comparison to scores prior to (Mdn = 8) DRGS (Fig. 1). The patients had experienced $78.4\% \pm 12\%$ less pain after 1 year on the VAS scale, and, $65.5\% \pm 10\%$, after a 3 year period. After a year, 82.5% ($n = 33/40$) of the implanted patients, and, after 3 years 72% of the implanted patients ($n = 18/25$) reported of more than 50% reduction in pain.

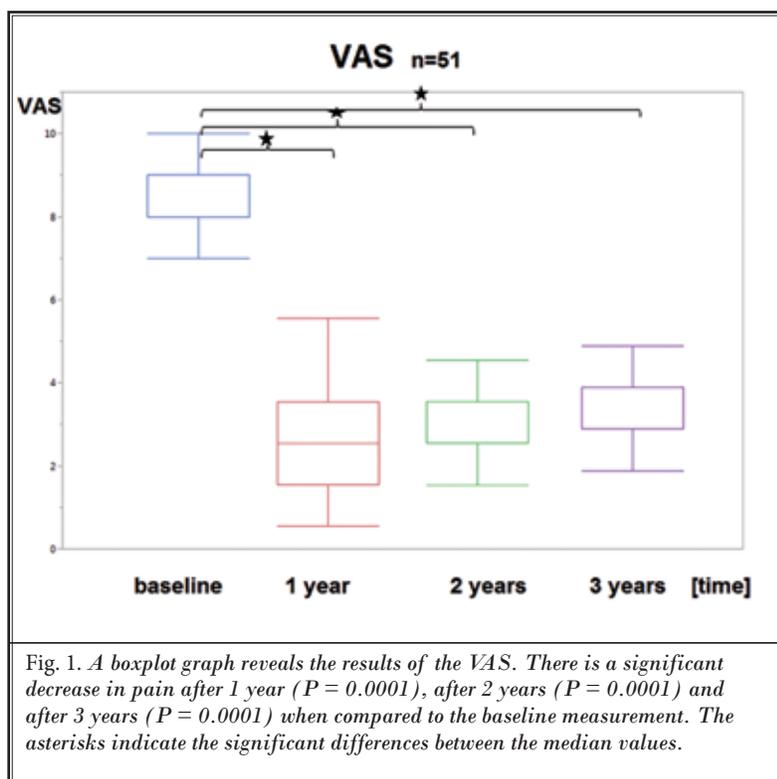


Fig. 1. A boxplot graph reveals the results of the VAS. There is a significant decrease in pain after 1 year ($P = 0.0001$), after 2 years ($P = 0.0001$) and after 3 years ($P = 0.0001$) when compared to the baseline measurement. The asterisks indicate the significant differences between the median values.

Beck Depression Inventory (BDI)

A one-way nonparametric repeated measures analysis of variance (Kruskal-Wallis test) showed a significant main effect of the DRGS on the BDI scores ($H(3) = 61.82, P < 0.0001$). Post hoc analysis with Tukey-Kramer correction for multiple comparisons revealed a significant decrease in BDI scores after 1 year (Mdn = 23; $U(39) = 5.00, P < 0.0001$), after 2 years (Mdn = 17; $U(34) = 6.01, P < 0.0001$) and after 3 years (Mdn = 21; $U(27) = 6.09, P < 0.0001$) of DRGS in comparison to before (Mdn = 36) DRGS. Additionally, BDI scores decreased significantly after 3 years (Mdn = 15; $U(27) = 3.32, P = 0.0009$) of DRGS compared to after 1 year of (Mdn = 23) DRG stimulation (Fig. 2).

Pain Disability Index (PDI)

A one-way nonparametric repeated measures analysis of variance (Kruskal-Wallis test) showed a significant main effect of the DRGS on the PDI

scores ($H(3) = 72.51, P < 0.0001$). Post hoc analysis with Tukey-Kramer correction for multiple comparisons revealed a significant decrease in the PDI scores after 1 year (Mdn = 25; $U(39) = 6.30, P < 0.0001$), after 2 years (Mdn = 23; $U(34) = 6.71, P < 0.0001$) and after 3 years (Mdn = 23; $U(27) = 6.45, P < 0.0001$) of DRGS in comparison to scores prior to (Mdn = 45) DRGS (Fig. 3).

Pain Catastrophizing Scale (PCS)

A one-way nonparametric repeated measures analysis of variance (Kruskal-Wallis test) showed a significant main effect of DRGS on PCS scores ($H(3) = 58.90, P < 0.0001$). Post hoc analysis with Tukey-Kramer correction for multiple comparisons revealed a significant decrease in the PCS scores after 1 year (Mdn = 23; $U(39) = 5.25, P < 0.0001$), after 2 years (Mdn = 17; $U(34) = 6.24, P < 0.0001$) and after 3 years (Mdn = 21; $U(27) = 5.83, P < 0.0001$) of DRGS in comparison to scores prior to (Mdn = 34) DRGS (Fig. 4).

Brief Pain Inventory (BPI)

A one-way nonparametric repeated measures analysis of variance (Kruskal-Wallis test) showed a significant main effect of DRGS on BPI scores ($H(3) = 85.10, P < 0.0001$). Post hoc analysis with Tukey-Kramer

correction for multiple comparisons revealed a significant decrease in BPI scores after 1 year (Mdn = 41.5; $U(39) = 6.52, P < 0.0001$), after 2 years (Mdn = 30; $U(34) = 7.20, P < 0.0001$) and after 3 years (Mdn = 36; $U(27) = 6.85, P < 0.0001$) of DRGS in comparison to scores prior to (Mdn = 73) DRGS (Fig. 5).

Pain Medication

Nine patients (17.6%) did not require previous pain medications anymore after DRGS. Twenty-one patients (41.2%) were able to reduce pain medications by 50%. Six (11.8%) patients reduced pain medications by 25% after the DRGS. Fifteen patients (29.4%) continued with previous pain medications. Thus, in this study, 70.6% of the patients could reduce pain medications after DRGS.

Paresthesia Mapping

Forty-seven patients (92.2%) were examined and their maps were compared. In

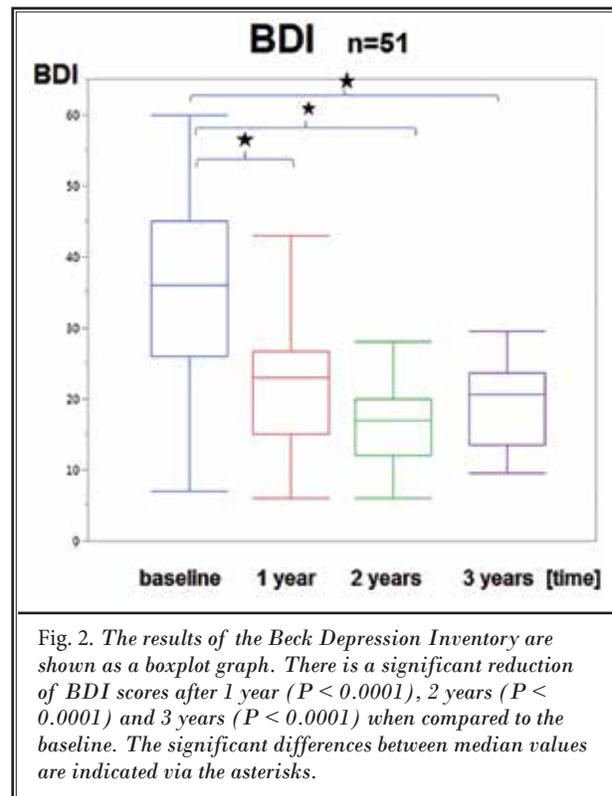


Fig. 2. The results of the Beck Depression Inventory are shown as a boxplot graph. There is a significant reduction of BDI scores after 1 year ($P < 0.0001$), 2 years ($P < 0.0001$) and 3 years ($P < 0.0001$) when compared to the baseline. The significant differences between median values are indicated via the asterisks.

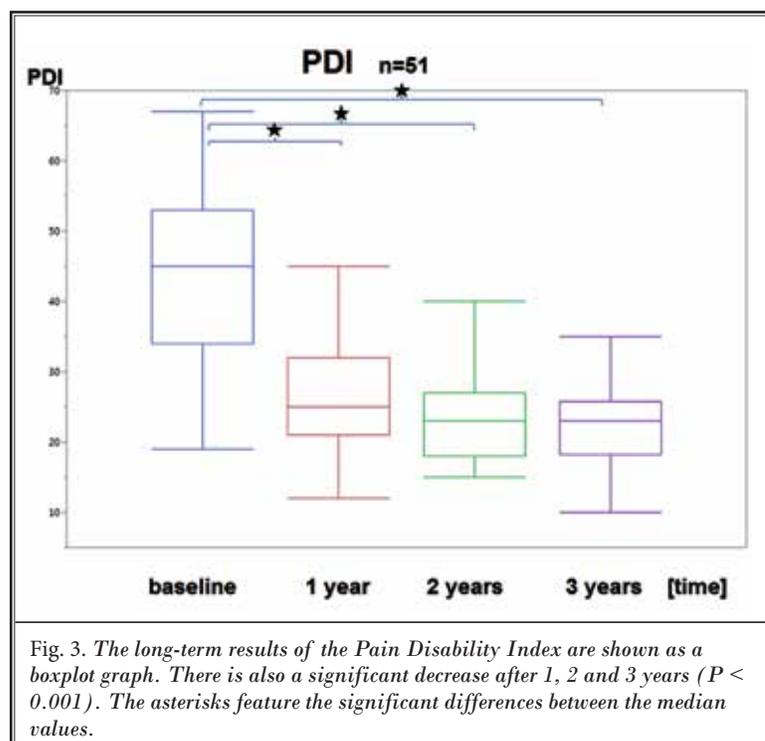


Fig. 3. The long-term results of the Pain Disability Index are shown as a boxplot graph. There is also a significant decrease after 1, 2 and 3 years ($P < 0.001$). The asterisks feature the significant differences between the median values.

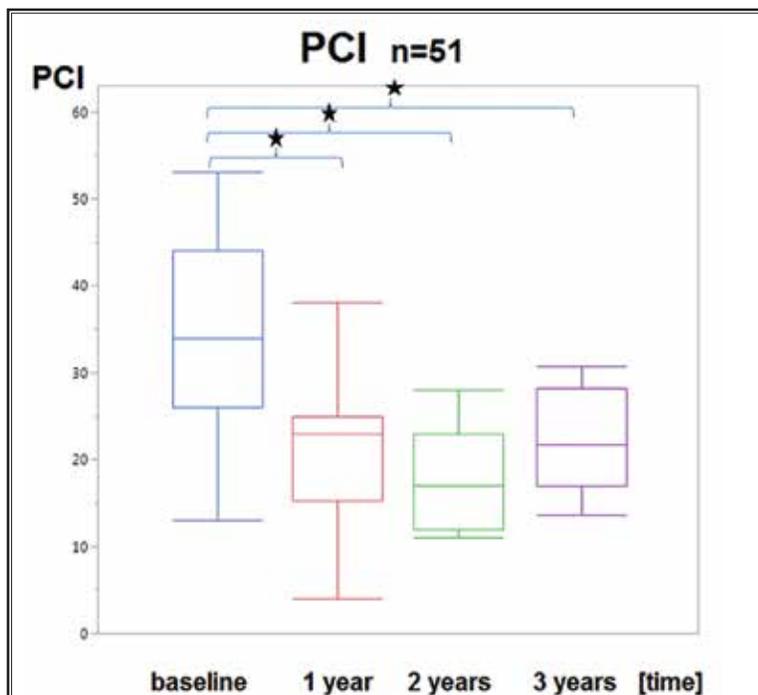


Fig. 4. A boxplot graph represents the results of the Pain Catastrophizing Scale. After 3 years of DRGS there was a substantial drop in the score from an initial median of 34 to a median of 18 ($P = 0.006$). The asterisks reveal the significant differences between the median values.

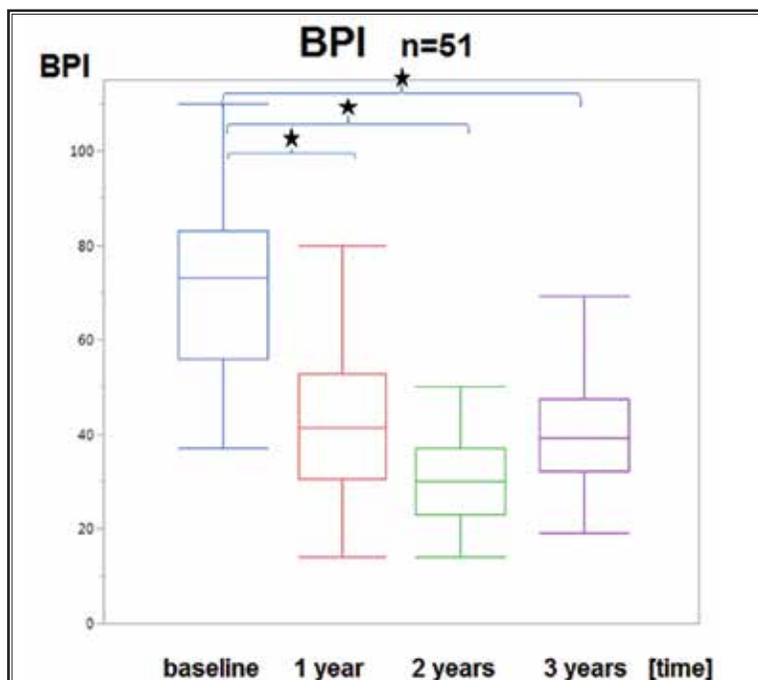


Fig. 5. The results of the Brief Pain Inventory are shown as a boxplot graph. The median value dropped from a baseline of 73 to 30 after 3 years. The asterisks exhibit the significant differences between the median values.

4 of the patients a mapping was not performed. We did not find involvement of any other dermatomes other than those covered by the DRGS electrodes (Fig. 6). Approximately 40% of the patients also reported the effects of postural changes. They described these changes mainly as a moderate decrease or an increase in the perception of the stimulation power in the painful area.

Complications

Fourteen patients showed complications (27.4%): a breakage of the lead ($n = 5$), a dislocation of the electrode ($n = 1$), an infection ($n = 2$), an additional electrode was required ($n = 3$), a relocation of a generator to the abdominal region ($n = 1$) and the explantation of systems ($n = 2$). Two patients with back pain did not benefit from the stimulation on a long-term run and the systems needed to be removed after 8 months and 14 months respectively. The breakage of the lead always occurred at the entry point of the muscle fascia just proximal to the anchor of the lead. As a result of this, we do not anchor the leads anymore. Subsequently, we have not had any further lead breakages. In 2 of the cases with knee pain and in one case with pain in the foot, we needed to implant an additional lead at 6 months, 10 months and at 14 months respectively, after the implantation of the IPG. In these cases, we performed a preoperative local anesthetic diagnostic nerve root block under x-ray control, in order to confirm the necessity of an additional probe.

Discussion

DRGS serves as a highly desirable adjunctive method to the existing mode of SCS, PNS and PNFS (11). Now it is possible to stimulate single nerve roots in a direct and focused manner. The DRG is also regarded as an active component in the generation of neuropathic pain. Electrical stimulation of the DRG may affect neurophysiological mechanisms, which in turn may decrease the pain

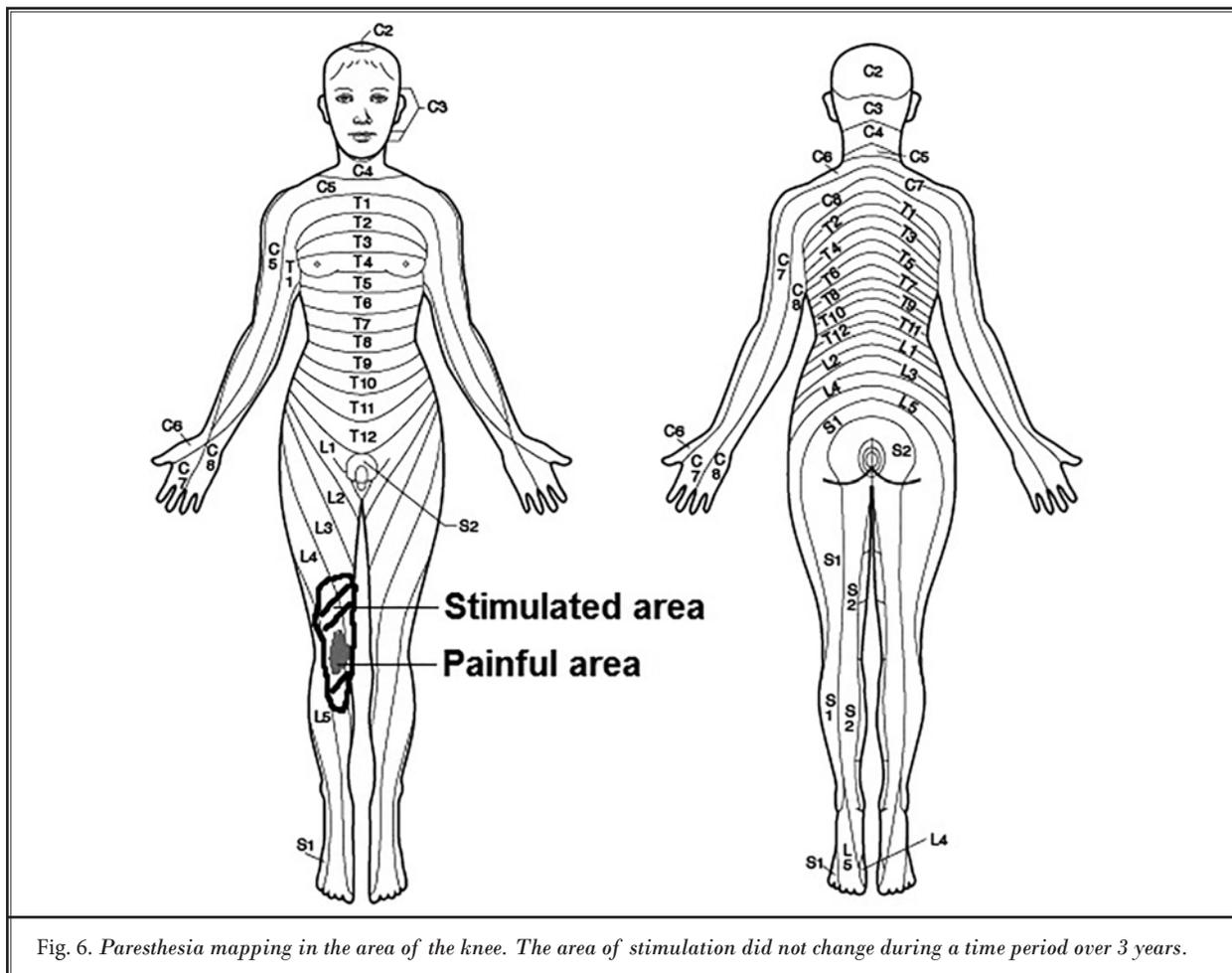


Fig. 6. Paresthesia mapping in the area of the knee. The area of stimulation did not change during a time period over 3 years.

(12-14). Another advantage of DRGS is the possibility of direct stimulation and influence on the first sensory neuron in comparison to stimulation of the fibers of the dorsal columns. Investigations with laser-evoked potentials could reveal that the stimulation of the DRG may restore impaired A-delta pain pathways (15). Some authors have emphasized the fact that the critical role played by the DRG in the induction and maintenance of chronic pain has been largely previously overlooked (3). While the results from a number of small observational studies seem promising, more evidence on the long-term effectiveness and safety of DRGS was demanded (8). DRGS of the spinal cord was regarded as effective as SCS in relieving various neuropathic pain syndromes, including pain due to a failed back surgery syndrome (FBSS), CRPS, and chronic postsurgical pain (9). Furthermore, the DRG was seen as an active participant in the development of neuropathic pain. DRGS

has multiple effects on the abnormal changes that occur within the DRG as a result of a peripheral afferent nerve fiber injury (14). Although the role of the DRG in acute nociception, as well as in the development of chronic pain, seems to evolve more, poor evidence exists with regards to the therapeutic strategies (6). In the ACCURATE study, 152 subjects diagnosed with a complex regional pain syndrome or a causalgia in the lower extremities were treated with DRGS or SCS. The percentage of subjects receiving $\geq 50\%$ pain relief and a successful treatment was greater in the DRG arm (81.2%) than in the SCS arm (55.7%, $P < 0.001$) after 3 months. The results show that DRG stimulation provided a higher rate of success in the treatment with less postural variation in paresthesia intensity, when compared to SCS (16). These studies confirm the safety and efficacy of DRGS. However, there are no DRGS long-term studies available up to date.

Preoperative Assessment

DRGS treats localized pain syndromes effectively. The prerequisite is an exact diagnosis and location of the painful area. The clinical examination may not be fully conclusive in some cases. In these patients, a preoperative local anesthetic diagnostic nerve root block under x-ray control may be beneficial in order to identify the dermatomes, which are responsible for the pain syndrome. We used such additional selective nerve root infiltrations in about 10% of our patients, prior to the implantation of our test-stimulation electrodes. Selective radiofrequency stimulation of the DRG is another method used in order to predict targets for DRGS (17). This is an elegant technique used for the purpose of identifying the nerve roots and associated skin areas, without causing additional neurological impairment, such as temporary sensory deficits. Obviously, neither of these methods can predict the later outcome during the test-stimulation. But, they are an important assistant in order to tailor the surgical approach and select the correct nerve roots prior to the test-trial. Paresthesia mapping also appears to be important, in order to identify the involved dermatomes during the stimulation process (18). We did not find other affected dermatomes except the ones which had been stimulated.

DRGS can be used in the treatment of different pain regions. We want to highlight some of these and discuss them.

Knee Pain

Chronic pain of the knee is common. In Germany, more than 220,000 knee operations were performed annually in the last 3 years. The rate of chronic pain is reported between 10% and 34% (19) after these operations. Most of the pain syndromes are mixed constituting neuropathic and nociceptive pain. With SCS the problem is, that in most of the instances the whole leg will be stimulated, and, paresthesias beyond the painful region are not well tolerated by most of the patients. DRGS, on the other hand, can stimulate the knee region selectively with high energy levels. We have treated 30 patients with knee pain and 27 progressed to the final implantation of a generator. In 14 of the patients, the dermatomes L3 and L4 were involved. One electrode was sufficient for 6 of the patients and 3 electrodes were needed for 4 patients. Sixteen patients continued follow up for up to 3 years, and showed a VAS pain reduction of up to 69% on after 3 years. In a case report, 3 DRG stimulation leads were placed at levels L2, L3, and L4 in a patient with intractable CRPS type I of the knee,

and this resulted in major pain relief (20). A randomized, prospective, observational crossover cohort study was conducted comparing 2 methods of neurostimulation in 12 patients with CRPS confined to the knee only. After finishing the trial period, 10 patients (83.3%) preferred DRG stimulation and 2 (16.7%) preferred SCS stimulation ($P = 0.04$) (21).

Groin Pain

The groin is another discrete area, which is very difficult to treat using SCS (22-24). We believe that chronic neuropathic pain of the groin is a very good indication for the use of DRGS and we have devoted a separate paper specifically to this pain region (10). Thus, patients with groin pain are not included in this study. Data from 29 patients with neuropathic groin pain were reviewed in another study. The average pain reduction was $71.4 \pm 5.6\%$, and 82.6% (19/23) of the patients experienced a > 50% relief in their pain at the last follow-up (25).

Foot Pain

Chronic neuropathic pain of the foot is mostly a result of injuries or operations in that area. Operations of the ankle can result in nerve damage of the sural nerve and cause severe pain syndromes. CRPS Type I and II are also common in this region. The dermatomes involved in the pain are commonly L5 and S1. SCS can reach the foot, but in cases of discrete localized areas, such as the region of the medial or the lateral ankle, DRGS appears to apply the stimulation much more precisely and with more energy. We treated 8 patients with pain of the foot. Six patients, who had neuropathic pain after an ankle operation or after trauma to this region, benefited from the test-stimulation and received an IPG. Three of these 5 patients still experienced more than 50% pain relief (66%, 65% and 63%) at 3-year follow up. Two patients, who were previously operated on for Morton Neuralgia with no postoperative improvement, did not benefit from a test-trial using DRGS.

Hand Pain

Chronic neuropathic pain in the hand affecting only 1, 2 or 3 digits, after an injury or an operation is difficult to treat using SCS. A big problem using SCS on the hand is postural changes in the area of the neck. DRGS can cover the dermatomes of the hand (C6-8) well and can achieve complete stimulation coverage of the hand.

We have treated 7 patients with hand pain, 6 of them had a positive test-trial and 3 of them continued to 3-year follow-up. The average pain relief after 3

Table 3. Location and number of implanted electrodes.

Location	Level	Number of patients	Number of implanted electrodes
Knee (n = 27)	L3	3	3
	L4	3	3
	L3 + 4	17	34
	L2 + L3	2	4
	L3 + 4 + 5	2	6
Hand (n = 6)	C6	1	1
	C7	1	1
	C8	2	2
	C6 + 7	2	4
Foot (n = 6)	L5	1	1
	S1	1	1
	L5 + S1	4	8
Back (n=4)	L1 bilat.	1	2
	L2 bilat.	1	2
	L1 + L2 bilat.	2	8
Leg (n=6)	L4	1	1
	L5	1	1
	S1	1	1
	L4 + 5	3	6
Post Zoster (n=1)	T11 + 12	1	2
pAVK leg (n=1)	L4 + 5	1	2
Total (n)		51	93

years was 68.3%. In 3 of the patients, 1 electrode was sufficient; in 2 patients, 2 electrodes were necessary. During cervical DRGS, we use sedation analgesia in order to monitor neurological function throughout the procedure. To date, only one case showed complications dealing specifically with upper extremity CRPS using DRGS (26).

Back Pain

It has been reported that one of the main pathways of pain originating from the disc, facet joint and sacroiliac joint, is the sympathetic trunk, which is related to the L2 spinal nerve root (27). This has led to the conclusion that DRGS could also be used in order to treat back pain. We treated 4 patients with back pain and implanted electrodes at different levels (Table 3). We found the combined bilateral use of L1 and L2 to be the most effective one. But, the pain relief in a long term run was less than 50% in all instances. Two of the

Table 4. Outcome – VAS (only groups with n ≥ 2 have been considered).

Diagnosis	Baseline		1 year		3 years	
	n	VAS	n	% Improvement	n	% Improvement
Knee	27	8.9	25	78.9	16	69.2
Hand	6	8.7	4	81.2	3	68.3
Foot	6	7.8	4	79.8	3	64.7
Back	4	7.9	2	44.3		
Leg	6	8.4	3	76.2		

patients wanted the system to be explanted. In a study, twelve patients with significant chronic discogenic lower back pain, due to FBSS, were implanted with DRG stimulation systems that had at least one lead placed at the levels of L2 or of L3. More than half of the patients reported a 50% or even a greater pain relief in the lower back, and, the average lower back pain reduction was 45.5% after 1 year. DRG stimulation, at the levels L2-L3, was effective in relieving lower back pain in the studied cases (28).

CRPS

CRPS seems to be one of the key indications for the use of DRGS. Several studies showed good results using DRGS in the treatment of CRPS (21,29). In a study with CRPS and the failure of conventional SCS, DRGS provided sufficient pain relief (30). Eleven patients diagnosed with uni- or bilateral lower-extremity CRPS, were recruited in a prospective case series as part of a larger study involving chronic pain of heterogeneous etiologies. There was a significant reduction in an average self-reported pain of up to 62%, relative to the baseline values. Pain relief persisted throughout a year in most of the patients. Neuromodulation of the DRG was able to provide excellent pain-paresthesia concordance in locations that are typically hard to target with traditional SCS (29). DRGS can also be used to rescue patients who did not benefit from previous SCS for a lower extremity CRPS (31). Table 4 provides an overview with the outcomes based on diagnosis and percentage response.

Complications

In this series DRGS revealed a complication rate of 27.5% (n = 14), a breakage of the probe being common one (9.8%, n = 5). We needed an additional electrode in 3 cases (2 with knee pain, 1 with leg pain). The infection rate was 3.9% (n = 2). An electrode dislocation was rare

(2%, n = 1). These electrodes are very thin and therefore, they may break with time at the point of entry and at the exit points of the muscular fasciae. Stretchable probes will most likely be a major improvement in this regard and may soon be available. The advent of new DRG systems with straight tips have facilitated the procedure of positioning the probe. The use of an S loop in the epidural space has increased the stability of the probe and prevented possible dislocations. New tapered sheaths have improved the navigation of the tip and it is easier to reach the target point. All these improvements are valuable and will contribute to a safer and even more convenient use of this device.

The fact, that we required 3 additional electrodes during the time course emphasizes the need for a proper preoperative assessment with regards to the dermatomes which are involved in the pain syndrome. In case of a doubt, a preoperative local anesthetic di-

agnostic nerve root block should rather be performed, prior to the placement of the lead.

Limitations of the Study

This study on a whole reports on 62 patients who were treated using DRGS. However, the subgroups of the different pain locations such as a hand, a foot, the back or a leg, are small, and, statistical comparisons between these groups do not seem to be appropriate. The study is only a single center study and the overall number of patients is also limited.

CONCLUSION

DRGS may be an effective long-term method of treating discrete, localized areas of chronic neuropathic pain. Therefore, clinicians may utilize DRGs for the treatment of chronic neuropathic pain in such areas, awaiting further literature in carefully selected patients.

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