Journal of Clinical Neuroscience 18 (2011) 1449–1453

Contents lists available at SciVerse ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Clinical Study

CyberKnife stereotactic radiosurgical rhizotomy for refractory trigeminal neuralgia ☆

Chi-Tun Tang [a], Steven D. Chang [b], Kuan-Yin Tseng [a], Ming-Ying Liu [a], Da-Tong Ju [a,*]

[a] Department of Neurological Surgery, National Defense Medical Center/Tri-service General Hospital, No. 325, Sec. 2, Cheng-Kung Road, Nei-hu District, Taipei 11490, Taiwan
[b] Department of Neurosurgery, Stanford University Medical Center, Stanford, CA, USA

ARTICLE INFO

Article history:
Received 10 January 2011
Accepted 9 March 2011

Keywords:
Stereotactic radiosurgery
Trigeminal neuralgia
CyberKnife
Rhizotomy
Dysesthesia

ABSTRACT

Stereotactic radiosurgery (SRS) has been established as an option for the treatment of trigeminal neuralgia (TN). Here, we report our experience of CyberKnife®-based (Accuray, Sunnyvale, CA, USA) stereotactic rhizotomy on medically refractory patients to determine its clinical effectiveness. Between January 2007 and December 2009, 14 selected patients underwent SRS for TN at our CyberKnife Center. Patients were evaluated for pain relief using a visual analog scale (VAS) score, time to reach pain relief (latency), duration of pain control, decrease of pain medication, occurrence of new dysesthesia, and side effects at the 3-month, 6-month, 1-year and 2-year follow-up. A literature analysis revealed that compared with other SRS systems, which can provide a high rate of pain control, CyberKnife® stereotactic rhizotomy yielded an earlier onset of pain relief in our cohort.

1. Introduction

The symptoms of trigeminal neuralgia (TN), first named "tic douloureux" and viewed as a psychiatric disease in the 18th century, are typically abrupt lancinating pain with a shock-like component distributed in one or more trigeminal nerve division. Anticonvulsants are the initial treatment of choice. Surgical interventions, including radiofrequency ablation, chemical rhizotomy, balloon compression and microvascular decompression (MVD), offer long-term results,[1] and radiosurgical rhizotomy was reported in the mid-to-late 1990s to yield comparable pain relief.[2–4] Radiotherapy for treatment of TN was first introduced by Leksell in 1951.[5] Following the pioneering efforts of Colombo et al.,[6] Lutz et al.,[7] and Lunsford. [8] the effectiveness of frame-based stereotactic radiosurgery (SRS) has been established. In one large series, the 50% pain relief latency was reported to be 2 months after Gamma Knife® radiosurgery (Elekta, Stockholm, Sweden).[9] Since then, a new generation of frameless radiosurgical systems has been developed.[10] Excellent response rates (67–93%) and shorter pain relief latencies (7–14 days) have been reported using CyberKnife (Accuray, Sunnyvale, CA, USA) radiosurgery.[11,12] Efficacy has been sustained for as long as 2 years in one early multicenter series.[13]

The purpose of this study was to investigate the safety, efficacy and side effects of CyberKnife treatment for TN and to obtain early onset pain relief, determine the optimal target length and to estimate the duration of the response.

2. Materials and methods

2.1. Patient selection

Between January 2007 and December 2009, 14 patients received CyberKnife stereotactic rhizotomy at the Tri-service General Hospital. All patients presented with characteristic pain that was refractory to prior medical and surgical treatment. Pretreatment MRI and CT scans were performed to detect neurovascular compression, demyelinating disease, or cerebellopontine angle lesions. Patients diagnosed with atypical pain, multiple sclerosis, herpes zoster, dental disease, orbital disease, temporal arteritis and those with follow-up shorter than 6 months were excluded. The cohort included eight women and six men, with a mean age of 67.8 years (range, 32–88 years). The demographic data, TN distribution and treatment parameters are listed in Table 1.

2.2. Treatment planning

Iopamidol-enhanced CT cisternography with 1.25-mm contiguous slices was used to visualize the segment of the trigeminal nerve in the prepontine cistern (Fig. 1). A lumbar puncture was performed to inject 10 mL to 12 mL of contrast material. The trigeminal nerve was readily identified on the planning workstation and a segment of the nerve was marked as the target (mean volume range, 25–71 mm^3). The target included the cisternal segment of the trigeminal nerve extending to the gasserian ganglion

☆ The authors have received no personal financial support or institutional interest in conjunction with the article.

* Corresponding author. Tel.: +886 2 87972 7177; fax: +886 2 8792 7178.
E-mail address: shune86@yahoo.com.tw (D.-T. Ju).

0967-5868/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jocn.2011.03.012

Table 1
Demographic data, trigeminal nerve distribution and treatment parameters for patients who underwent CyberKnife stereotactic radiosurgical rhizotomy for refractory trigeminal neuralgia

Patient no.	Age (years)/ sex	Pain distribution	Previous treatment	Treatment dose (Gy)	Target volume (mm^3)	Length of nerve treated (mm)	Distance from DREZ (mm)
1	57, F	V3	None	66	26	7.1	3
2	32, M	V3	MVD	66	44	6.7	3
3	78, F	V3	None	66	57	6.9	3
4	78, F	V2, V3	Ganglion block and RFL	66	25	7.2	3
5	64, M	V2	None	66	45	5.9	3
6	73, M	V2	MVD	66	59	7.3	3
7	52, M	V1, V2	None	66	71	7.5	3
8	88, M	V3	None	66	76	6.6	3
9	49, M	V1, V2	None	66	51	6.9	3
10	62, F	V2, V3	None	66	71	6.1	3
11	61, F	V3	None	66	79	5.8	3
12	57, F	V2	None	66	47	6.9	3
13	82, F	V3	None	66	52	7.1	3
14	80, F	V1, V2	None	66	38	7	3

DREZ = dorsal root entry zone, MVD = microvascular decompression, RFL = radiofrequency lesioning.

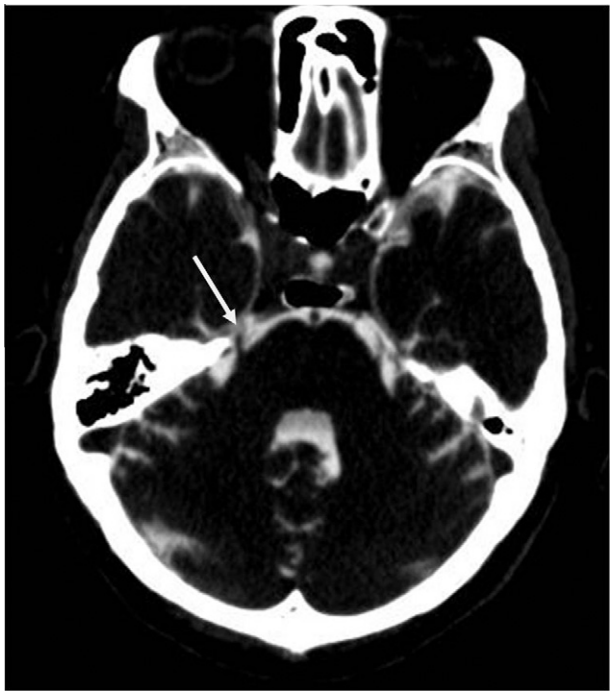

Fig. 1. Axial iopamidol-enhanced CT cisternography showing the segment of the trigeminal nerve in the prepontine cistern (arrow).

in Meckel's cave; the target volume was contoured 3 mm ventral to the brainstem root entry zone. The dose to the brainstem was limited to 30% to 50% of the maximum dose (range, 75–86.5 Gy). To examine dose homogeneity and treatment conformity, we calculated the homogeneity index (HI) and the new conformation index (nCI) during the generation of each treatment plan. The HI described the uniformity of dose within a treated target volume, and the nCI described the degree to which the prescribed isodose volume conformed to the shape and size of the target volume.

2.3. Treatment protocol

Each patient was placed on the treatment couch and immobilized with a previously constructed custom thermoplastic mask. To ensure accurate target acquisition, digitally reconstructed radiographs created from the CT cisternography data were compared with standard orthogonal radiographs taken periodically throughout the treatment.

We treated our patients using the Stanford University Medical Center protocol. Each patient was treated in a single session with the median marginal dose of 66 Gy delivered in 60 minutes to 90 minutes. A 7.5-mm collimator and a non-isocentric treatment plan were used. The dose was prescribed to the 80% isodose line in a conformal fashion to cover an average 6.8-mm nerve span, sparing the proximal 3 mm (Fig. 2). After the registration was confirmed, the treatment was carried out according to the plan.

2.4. Clinical outcomes evaluation

Pain relief, time to pain relief, duration of pain relief, decrease in pain medication, occurrence of new dysesthesia or numbness, and side effects were recorded. The pain intensity was evaluated by using a visual analog scale (VAS) score (range, 0–10) before and after treatment. Pain relief was defined as a minimum improvement of 5 on the VAS scale score. The VAS score was obtained and recorded at the 3-month, 6-month, 12-month, and 24-month follow-up visits.

3. Results

Six patients experienced pain in the mandibular (V3) branch of the trigeminal nerve, three patients in the maxillary (V2) branch, three patients in the ophthalmic (V1) and V2 branches, and two patients in the V2 and V3 branches. All patients had taken pain medication for an average of 2.3 years (range, 11 months–7 years). Two patients had undergone MVD with the initial pain relief lasting at least 2 years. Ipsilateral recurrences in the same distribution were recorded prior to treatment. One patient had recurrent TN after a previous ganglion block and radiofrequency rhizotomy. The pain scores of all 14 patients before treatment were 10.

The treatment target included an average 6.8-mm segment of the trigeminal nerve with a mean volume of 52.9 mm^3 (range, 25–79 mm^3). A 66 Gy dose was prescribed to a mean 80% isodose line, with a mean maximal dose of 80.5 Gy (range, 75–86.5 Gy). The mean new conformation index (nCI) was 2.85 (range, 2.09–4.69) and the homogeneity index (HI) was 1.29 (range, 1.25–1.43). The scatter plots with a correlation analysis of nCI and HI against volume are shown in Fig. 3.

One patient was lost to follow-up after 6 months, having reached a treatment VAS score of 1 at that time. The median follow-up time was 20.4 months (range, 6–32 months). Significant