

1.

**Year:** 2006

**Patient number:** 15

**Author:** Aryan, Henry E.; Nakaji, Peter; Lu, Daniel C.; Alksne, John F.

**Reference:** Journal of clinical neuroscience : official journal of the Neurosurgical Society of Australasia, 13, 2, 239-44, 2006

**Title:** Multimodality treatment of trigeminal neuralgia: impact of radiosurgery and high resolution magnetic resonance imaging

**Abstract:** This study was conducted to evaluate the two main surgical modalities, microvascular decompression (MVD) and gamma-knife radiosurgery (GK), the treatment of trigeminal neuralgia (TN) and outline for an algorithm for the selection of these procedures. The authors have identified distinct differences in the two treatment groups and formulated a scale that predicts the outcome and satisfaction of patients who underwent the procedures. This series included 34 TN patients treated in 2000 and 2001 with MVD (19) and GK (15). Patients with TN associated with tumor or multiple sclerosis were excluded. Each patient's age, past medical history, clinical features of pain or pre-operative pain grade, duration of TN, medications, and prior surgical procedures were recorded. Long-term results were assessed by a structured interview by telephone. Clinical outcome was classified as excellent (complete relief without medications and numbness), good (complete relief without medications), fair (> 50% relief or with substantial numbness and weakness), or poor (< 50% relief or treatment failure). Patient self-rated satisfaction score was rated on a scale of 1 (unsatisfied) to 10 (completely satisfied). Statistical analysis was performed by paired t-tests and anova with post-hoc analysis by the Tukey-Kramer method. The median follow-up was 17 months (18 months for MVD and 16 months for GK). The average age of MVD patients was 61 years compared to 74 years for GK patients ( $p = 0.0005$ ). In both groups there was a female majority (68% for MVD and 60% for GK). The latency between first symptom of TN and treatment procedure was 3.0 years for MVD and 3.9 years for GK ( $p > 0.05$ ). There was no significant difference in pain grade between the two groups. The average TN complexity grade was significantly different between the two groups (3.0 for MVD and 5.8 for GK) ( $p < 0.001$ ). Average response to procedure for MVD was 3.4 (good) and 2.4 (fair) for GK ( $p = 0.017$ ). The satisfaction outcome for MVD was 8.7 compared to 6.4 for GK ( $p = 0.02$ ). There was a significant correlation ( $r = -0.818$ ,  $p < 0.001$ ) between TN complexity grade and response. Additionally, a significant correlation between TN complexity grade and patient satisfaction was found ( $r = -0.763$ ,  $p < 0.0001$ ). The data here support the treatment algorithm employed by the senior author (JFA) of this study. The TN complexity grade accurately correlates with the patient's response and satisfaction to the surgical procedure. This complexity grade may be useful for patient counseling when choosing between treatment options.

2.

**Year:** 2006

**Patient number:** 239

**Author:** Balamucki, Christopher J.; Stieber, Volker W.; Ellis, Thomas L.; Tatter, Stephen

B.; Deguzman, Allan F.; McMullen, Kevin P.; Lovato, James; Shaw, Edward G.; Ekstrand, Kenneth E.; Bourland, J. Daniel; Munley, Michael T.; Robbins, Michael; Branch, Charles  
**Reference:** Journal of neurosurgery, 105, 5, 730-5, 2006

**Title:** Does dose rate affect efficacy? The outcomes of 256 gamma knife surgery procedures for trigeminal neuralgia and other types of facial pain as they relate to the half-life of cobalt

**Abstract:**OBJECT: Gamma Knife surgery (GKS) is a treatment option for patients with refractory typical trigeminal neuralgia (TN), TN with atypical features, and atypical types of facial pain. The Gamma Knife's 201 60Co sources decay with a half-life of 5.26 years. The authors examined whether the decrease in dose rate over 4.6 years between Co source replacements affected the control rates of facial pain in patients undergoing GKS. METHODS: The authors collected complete follow-up data on 239 of 326 GKS procedures performed in patients with facial pain. Patients were classified by their type of pain. The isocenter of a 4-mm collimator helmet was targeted at the proximal trigeminal nerve root, and the dose (80-90 Gy) was prescribed at the 100% isodose line. Patients reported the amount of pain control following radiosurgery by answering a standardized questionnaire. Eighty percent of patients experienced greater than 50% pain relief, and 56% of patients experienced complete pain relief after GKS. Neither dose rate nor treatment time was significantly associated with either the control rate or degree of pain relief. A significant association between the type of facial pain and the pain control rate after GKS was observed ( $p < 0.001$ ; Pearson chi-square test). In their statistical analysis, the authors accounted for changes in prescription dose over time to prevent the dose rate from being a confounding variable. There was no observable effect of the dose rate or of the treatment duration within the typical period to source replacement. CONCLUSIONS: Patients with facial pain appear to receive consistent treatment with GKS at any time during the first half-life of the Co sources.

3.

**Year:** 2006

**Patient number:** 61

**Author:** Brisman, Ronald

**Reference:** Stereotactic and Functional Neurosurgery, 85, 2-3, 94-98, 2006

**Title:** Microvascular Decompression vs Gamma Knife Radiosurgery for Typical Trigeminal Neuralgia: Preliminary Findings

**Abstract:**Background: Patients with typical trigeminal neuralgia were treated by one neurosurgeon with either microvascular decompression (MVD) or Gamma Knife radiosurgery (GKRS) and were prospectively evaluated with a uniform protocol. Method: GKRS was done with 75 Gy maximum to the cisternal trigeminal nerve near the pons. MVD was done without cauterizing or cutting the trigeminal nerve. Results: Twenty-four patients were treated with MVD and 61 with GKRS. Complete pain relief (no pain no medicines) occurred at 12 and 18 months in 68 and 68% of patients treated with MVD and 58 and 24% with GKRS ( $p = 0.089$ ), and  $> / = 90\%$  pain relief (with or without medicine) at 12 and 18 months in 90 and 78% with MVD and 75 and 48% with GKRS ( $p = 0.171$ ).

There were no permanent complications. Conclusion: Although many trigeminal neuralgia patients treated with either MVD or GKRS have pain relief, MVD is more likely than GKRS to result in complete pain relief. Copyright (c) 2007 S. Karger AG, Basel.

4.

**Year:** 2006

**Patient number:** 31

**Author:** Erbay, Sami H.; Bhadelia, Rafeeqe A.; O'Callaghan, Mark; Gupta, Punita; Riesenburger, Ron; Krackov, Warren; Polak, Joseph F.

**Reference:** Radiology, 238, 2, 689-92, 2006

**Title:** Nerve Atrophy in Severe Trigeminal Neuralgia: Noninvasive Confirmation at MR Imaging--Initial Experience

**Abstract:** Purpose: To retrospectively evaluate the size of the trigeminal nerve on magnetic resonance (MR) images of patients with unilateral trigeminal neuralgia. Materials and Methods: Institutional review board approval was obtained and informed consent was waived for this HIPAA-compliant study. The sizes of the trigeminal nerves in 31 patients (18 men and 13 women; mean age, 68 years; age range, 44-84 years) with clinically confirmed intractable unilateral trigeminal neuralgia were measured before treatment with gamma knife radiosurgery. Images were analyzed separately by two neuroradiologists who were blinded to the side of the face with symptoms. Coronal projection images were used to determine the diameter and cross-sectional area of the trigeminal nerves at 5 mm from the entry point of the nerve into the pons. Comparisons were made by using a paired t test. Interobserver variability was assessed by using the Pearson correlation coefficient. Results: The mean diameter of the trigeminal nerve on the symptomatic side was significantly smaller than the mean diameter on the asymptomatic side in 30 of 31 patients (2.11 mm +/- 0.40 (standard deviation) and 2.62 mm +/- 0.56,  $P < .001$ , 95% confidence interval: -0.35, -0.67 mm). The mean cross-sectional area on the symptomatic side was significantly smaller than the area on the asymptomatic side in 27 of 31 patients (4.50 mm<sup>2</sup> +/- 1.75 and 6.28 mm<sup>2</sup> +/- 2.19,  $P < .001$ , 95% confidence interval: -2.41, -1.16 mm<sup>2</sup>). Conclusion: The results indicate that trigeminal nerve atrophy can be depicted noninvasively in patients with trigeminal neuralgia. (c) RSNA, 2006.

5.

**Year:** 2006

**Patient number:** 40

**Author:** Erbay, S. H.; Bhadelia, R. A.; Riesenburger, R.; Gupta, P.; O, Callaghan M.; Yun, E.; Oljeski, S.

**Reference:** Neuroradiology, 48, 1, 26-30, 2006

**Title:** Association between neurovascular contact on MRI and response to gamma knife radiosurgery in trigeminal neuralgia

**Abstract:** Treatment with gamma knife radiosurgery (GKRS) provides adequate

short-term pain control in about 70% of the patients with intractable trigeminal neuralgia (TN). The purpose of our study was to evaluate whether the presence of neurovascular contact (NVC) at the root entry zone of the trigeminal nerve on pre-gamma knife MR imaging predicts an increased likelihood of an adequate response to GKRS. We studied 40 consecutive patients who underwent GKRS for treatment of intractable TN. Two neuroradiologists blinded to the side of symptoms analyzed pre-treatment constructive interference in steady state (CISS) images to determine the presence of NVC by consensus. An adequate response was defined as freedom from pain with or without reduced need for medical therapy. Adequate short-term response to GKRS was seen in 29 (72.5%) of 40 patients. NVC was seen in 30 of the 40 patients. Twenty-five (83.3%) of 30 patients with NVC had adequate short-term response to GKRS. Only four (40%) of the 10 patients without NVC had adequate response to GKRS ( $X^2=7.06$ ;  $P<0.01$ ). Patients with NVC were seven times more likely to have an adequate response to GKRS than those without NVC (odds ratio =7.5). The presence of NVC on pre-treatment MR imaging predicts an increased likelihood of an adequate response to GKRS. © Springer-Verlag 2005.

6.

**Year:** 2006

**Patient number:** 77

**Author:** Fountas, Kostas N.; Lee, Gregory P.; Smith, Joseph R.

**Reference:** Stereotactic and functional neurosurgery, 84, 2-3, 88-96, 2006

**Title:** Outcome of patients undergoing gamma knife stereotactic radiosurgery for medically refractory idiopathic trigeminal neuralgia: Medical College of Georgia's experience

**Abstract:** Gamma knife radiosurgery represents an established treatment option for the management of medically refractory trigeminal neuralgia (TN). In our current communication we present our experience in radiosurgically treating patients with idiopathic TN. Over a period of 5 years, 77 patients underwent gamma knife radiosurgery. The patients were divided into 2 groups based on their previous surgical treatment. In the group of patients with no previous surgeries, the initial response rate was 92.4% (48/52 patients), while in the group with previous surgeries it was 84% (21/25 patients). The excellent outcome rates (complete pain relief with no pain medications) at the completion of 1, 2 and 3 years after treatment for the group with no previous surgeries were: 80.8% (42/52 patients), 69.2% (36/52 patients) and 53.8% (28/52 patients), respectively. The respective excellent outcome rates for the group of patients with previous surgeries were: 64% (16/25 patients), 44% (11/25 patients) and 12% (3/25 patients). The good outcome rates at the completion of 1, 2 and 3 years after treatment for the group with no previous surgeries were: 7.7% (4/52 patients), 11.5% (6/52 patients) and 19.2% (10/52 patients). The respective percentages of good outcome for the patients with previous surgery were: 12% (3/25 patients) at 1 year, 16% (4/25 patients) at 2 years and 32% (8/25 patients) at the completion of 3 years after treatment. The most commonly encountered complication in our series was the development of facial numbness. Our findings confirm previous reports that the presence of preceding surgical interventions represents a negative

long-term outcome factor. However, gamma knife radiosurgery constitutes a safe and efficient minimally invasive treatment option for patients with idiopathic TN. Copyright 2006 S. Karger AG, Basel.

7.

**Year:** 2006

**Patient number:** 74

**Author:** Martínez, Moreno N. E.; Martínez, Alvarez R.; Rey, Portolés G.; Gutiérrez, Sárraga J.; Burzaco, Santurtún J.; Bravo, G.

**Reference:** Revista de neurologia, 42, 4, 195-201, 2006

**Title:** Gamma Knife radiosurgery treatment of trigeminal neuralgia and atypical facial pain

**Abstract:**INTRODUCTION: Typical trigeminal neuralgia (TTN) is a condition that is treated initially by pharmacological means and, if this fails, with different surgical techniques. With the advent of radiosurgery a relatively bloodless form of treatment with low toxicity and good results has become available and can be considered for use as the first choice procedure. AIMS: Our aim was to report the findings obtained from treating this pathology using Gamma Knife radiosurgery in order to assess the possibility of using it for patients with neuralgia associated to multiple sclerosis (MS) or who have atypical facial pain (AFP). We also assessed the patients who were re-treated owing to recurrence or persistence. PATIENTS AND METHODS: The sample was made up of 74 patients, including seven cases of lesions in the brain stem at the nerve entry point, 45 cases of associated vascular compression, 15 cases of AFP and eight cases of re-treatment. The median maximum dose was 84 Gy (60.2-120). The mean follow-up time was 23.26 months (1-97.83). RESULTS: Of those with TTN, 76.2% of subjects had no pain at the end of the study (75% in cases of second treatments, 69% in cases of associated vascular compression, 52% of those with prior interventions and 43% with MS), and 33% in the case of AFP. The mean time elapsed before pain disappeared was 4.34 months (0-23.72). Sensitivity was newly affected in 20.3% of patients with TTN or AFP. CONCLUSIONS: Gamma Knife radiosurgery is a first choice therapeutic option for use with patients who have TTN or AFP, as well as in cases of neuralgia associated to MS. It can also be considered for use as re-treatment with a tolerable rate of morbidity.

8.

**Year:** 2006

**Patient number:** 49

**Author:** Massager, Nicolas; Nissim, Ouzi; Murata, Noriko; Devriendt, Daniel; Desmedt, Françoise; Vanderlinden, Bruno; Régis, Jean; Levivier, Marc

**Reference:** International journal of radiation oncology biology physics, 65, 4, 1200-5, 2006

**Title:** Effect of beam channel plugging on the outcome of gamma knife radiosurgery for trigeminal neuralgia

**Abstract:**PURPOSE: We studied the influence of using plugs for brainstem protection

during gamma knife radiosurgery (GKR) of trigeminal neuralgia (TN), with special emphasis on irradiation doses delivered to the trigeminal nerve, pain outcomes, and incidence of trigeminal dysfunction. **METHODS AND MATERIALS:** A GKR procedure for TN using an anterior cisternal target and a maximum dose of 90 Gy was performed in 109 patients. For 49 patients, customized beam channel blocking (plugs) were used to reduce the dose delivered to the brainstem. We measured the mean and integrated radiation doses delivered to the trigeminal nerve and the clinical course of patients treated with and without plugs. **RESULTS:** We found that blocking increases the length of trigeminal nerve exposed to high-dose radiation, resulting in a significantly higher mean dose to the trigeminal nerve. Significantly more of the patients with blocking achieved excellent pain outcomes (84% vs. 62%), but with higher incidences of moderate and bothersome trigeminal nerve dysfunction (37% mild/10% bothersome with plugs vs. 30% mild/2% bothersome without). **CONCLUSIONS:** The use of plugs to protect the brainstem during GKR treatment for TN increases the dose of irradiation delivered to the intracisternal trigeminal nerve root and is associated with an important increase in the incidence of trigeminal nerve dysfunction. Therefore, beam channel blocking should be avoided for 90 Gy-GKR of TN.

9.

**Year:** 2006

**Patient number:** 100

**Author:** Régis, Jean; Metellus, Philippe; Hayashi, Motohiro; Roussel, Philippe; Donnet, Anne; Bille, Turc Françoise

**Reference:** Journal of neurosurgery, 104, 6, 913-24, 2006

**Title:** Prospective controlled trial of gamma knife surgery for essential trigeminal neuralgia

**Abstract:**OBJECT: Stereotactic radiosurgery is an alternative to conventional surgery for the treatment of trigeminal neuralgia. The authors conducted a prospective evaluation of the safety and efficacy of this method in a large series of patients. **METHODS:** A total of 100 patients presenting with trigeminal neuralgia were treated and followed up for a minimum of 12 months. The mean age was 68.2 years; 54 patients were male, and 46 were female. Seven had a history of multiple sclerosis, and 42 had already received conventional surgical treatment for trigeminal neuralgia. The intervention consisted of gamma knife surgery to the retrogasserian cisternal portion of the fifth cranial nerve. The median dose used at the maximum was 85 Gy (range 70-90 Gy). The number and intensity of pain attacks were recorded by the patient from 3 months before radiosurgery to a minimum of 12 months after treatment. Before and a minimum of 12 months after treatment, the patient completed a quality-of-life questionnaire. Neurological examination and quantitative sensory testing to evaluate sensory perception were performed by an independent neurologist over this same time period. At the last visit 83 of 100 patients were reported to be pain free. Fifty-eight of these 83 patients had stopped taking medication during the study. All quality-of-life parameters were improved ( $p < 0.001$ ). Six patients reported facial paresthesia, and four patients reported hypesthesia. These symptoms were classified as mild. None of the complications reported for other

techniques were observed. **CONCLUSIONS:** Radiosurgery is a safe and effective alternative treatment for trigeminal neuralgia and is associated with a particularly low rate of hypesthesia.

10.

**Year:** 2005

**Patient number:** 63

**Author:** Alpert, Tracy E.; Chung, Chung T.; Mitchell, Lisa T.; Hodge, Charles J.; Montgomery, Craig T.; Bogart, Jeffrey A.; Kim, Daniel Y. J.; Bassano, Daniel A.; Hahn, Seung S.

**Reference:** Journal of neurosurgery, 102, 185-8, 2005

**Title:** Gamma knife surgery for trigeminal neuralgia: improved initial response with two isocenters and increasing dose

**Abstract:**OBJECT: The authors sought to evaluate the initial response of trigeminal neuralgia (TN) to gamma knife surgery (GKS) based on the number of shots delivered and radiation dose. **METHODS:** Between September 1998 and September 2003, some 63 patients with TN refractory to medical or surgical management underwent GKS at Upstate Medical University. Ten patients had multiple sclerosis and 25 patients had undergone prior invasive treatment. Gamma knife surgery was delivered to the trigeminal nerve root entry zone in one shot in 27 patients or two shots in 36 patients. The radiation dose was escalated to less than or equal to 80 Gy in 20 patients, 85 Gy in 21 patients, and greater than or equal to 90 Gy in 22 patients. Pain before and after GKS was assessed using the Barrow Neurological Institute Pain Scale and the improvement score was analyzed as a function of dose grouping and number of shots. Sixty patients were available for evaluation, with an initial overall and complete response rate of 90% and 27%, respectively. There was a greater improvement score for patients who were treated with two shots compared with one shot, mean 2.83 compared with 1.72 ( $p < 0.001$ ). There was an increased improvement in score at each dose escalation level: less than or equal to 80 Gy ( $p = 0.017$ ), 85 Gy ( $p < 0.001$ ), and greater than or equal to 90 Gy ( $p < 0.001$ ). Linear regression analysis also indicated that there was a greater response with an increased dose ( $p = 0.021$ ). Patients treated with two shots were more likely to receive a higher dose ( $p < 0.001$ ). There were no severe complications. Five patients developed mild facial numbness. **CONCLUSIONS:** Gamma knife surgery is an effective therapy for TN. Initial response rates appear to correlate with the number of shots and dose.

11.

**Year of Conference:** 2005

**Patient number:**256

**Author:** Balamucki, C.; Ellis, T. L.; deGuzman, A. F.; Tatter, S. B.; Bourland, J. D.; Lovato, J.; Munley, M.; Ekstrand, K.; Shaw, E. G.; Branch, C.; Huang, T. W.; Stieber, V. W.

**Reference:**Conference title: 47th Annual Meeting of the American-Society-for-Therapeutic-Radiology- and-Oncology, October 16 -20, 2005 , Denver, CO, USA, Sponsor: Amer Soc Therapeut Radiol & Oncol., 63, S106-S107, 2005

**Title:** The effect of dose rate on the outcomes of 256 gamma knife radiosurgery procedures for facial pain

12.

**Year:** 2005

**Patient number:** 11

**Author:** Cheng, Jason S.; Sanchez, Mejia Rene O.; Limbo, Mary; Ward, Mariann M.; Barbaro, Nicholas M.

**Reference:** Neurosurgical focus (electronic resource), {Neurosurg-Focus}, 15 May 2005 (epub), vol. 18, no. 5, p. e13, ISSN: 1092-0684.

**Title:** Management of medically refractory trigeminal neuralgia in patients with multiple sclerosis

**Abstract:** OBJECT: Trigeminal neuralgia (TN) is a painful disorder that frequently causes lancinating, electrical shock-like pain in the trigeminal distribution. Common surgical treatments include microvascular decompression (MVD), radiosurgery, and radiofrequency ablation, and complete pain relief is generally achieved with a single treatment in 70 to 85% of cases for all modalities. In a subset of patients with multiple sclerosis (MS), however, the rates of surgical treatment failure and the need for additional procedures are significantly increased compared with those in patients without MS. In this study the authors report their experience with a cohort of 11 patients with TN who also had MS, and assess the efficacy of MVD, gamma knife surgery (GKS), and radiofrequency ablation in achieving complete or partial long-term pain relief. METHODS: Eleven patients with TN and MS who were treated by the senior author (N.B.) at the University of California, San Francisco were included in this study. All patients underwent GKS and/or radiofrequency ablation, and four received MVD. A detailed clinical history and intraoperative findings were recorded for each patient and frequent follow-up evaluations were performed, with a mean follow-up duration of 40.6 months (range 1-96 months). Pain was assessed for each patient by using the Barrow Neurological Institute scale (Scores I-V). CONCLUSIONS: Achieving complete pain relief in patients with TN and MS required significantly more treatments compared with all other patients with TN who did not have MS ( $p = 0.004$ ). Even when compared with a group of 32 patients who had highly refractory TN, the cohort with MS required significantly more treatments ( $p = 0.05$ ). Radiosurgery proved to be an effective procedure and resulted in fewer retreatments and longer pain-free intervals compared with MVD or radiofrequency ablation.

13.

**Year:** 2005

**Patient number:** 73

**Author:** Drzymala, Robert E.; Malyapa, Robert S.; Dowling, Joshua L.; Rich, Keith M.; Simpson, Joseph R.; Mansur, David B.

**Reference:** Stereotactic and functional neurosurgery, {Stereotact-Funct-Neurosurg }, 2005 (epub: 03 Oct 2005), vol. 83, no. 4, p. 148-52, ISSN: 1011-6125.

**Title:** Gamma knife radiosurgery for trigeminal neuralgia: the Washington University initial experience

**Abstract:** Seventy-three patients were evaluated for the changes in pain relief, numbness and paresthesias after Gamma Knife radiosurgery to a maximum dose of 76-87 Gy for trigeminal neuralgia. Patients experienced pain relief as follows: 59% attained complete pain relief without prior surgery (33% with prior surgery); 25% achieved > or = 50% pain reduction (28% with prior surgery); 11% of surgery patients obtained minor pain relief, and 16% of patients without surgery had no relief (28% with prior surgery). Level of pain decreased rapidly within 6 weeks after radiosurgery. Numbness/paresthesias developed slowly over the first 12-15 months. Bothersome levels were experienced by 15% of the patients without prior surgery (22% with prior surgery). Comparison of the occurrence of numbness/paresthesias, with respect to prior surgery, was not statistically significant. Only 2% of all patients had persistently bothersome side effects. In conclusion, radiosurgery is an effective treatment of trigeminal neuralgia, especially for those patients not having prior surgery. Copyright 2005 S. Karger AG, Basel.

14.

**Year:** 2005

**Patient number:** 73

**Author:** Drzymala, Robert E.; Malyapa, Robert S.; Dowling, Joshua L.; Rich, Keith M.; Simpson, Joseph R.; Mansur, David B.

**Reference:** Stereotactic and functional neurosurgery, 83, 4, 148-52, 2005

**Title:** Gamma knife radiosurgery for trigeminal neuralgia: the Washington University initial experience

**Abstract:** Seventy-three patients were evaluated for the changes in pain relief, numbness and paresthesias after Gamma Knife radiosurgery to a maximum dose of 76-87 Gy for trigeminal neuralgia. Patients experienced pain relief as follows: 59% attained complete pain relief without prior surgery (33% with prior surgery); 25% achieved > or = 50% pain reduction (28% with prior surgery); 11% of surgery patients obtained minor pain relief, and 16% of patients without surgery had no relief (28% with prior surgery). Level of pain decreased rapidly within 6 weeks after radiosurgery. Numbness/paresthesias developed slowly over the first 12-15 months. Bothersome levels were experienced by 15% of the patients without prior surgery (22% with prior surgery). Comparison of the occurrence of numbness/paresthesias, with respect to prior surgery, was not statistically significant. Only 2% of all patients had persistently bothersome side effects. In conclusion, radiosurgery is an effective treatment of trigeminal neuralgia, especially for those patients not having prior surgery. Copyright 2005 S. Karger AG, Basel.

15.

**Year of Conference:** 2005

**Patient number:** 256

**Author:** Ellis, T. L.; Balamucki, C.; deGuzman, A. F.; Lovato, J.; Shaw, E. G.; Tatter, S.

B.; Ekstrand, K.; Bourland, J. D.; Branch, C.; Munley, M. T.; Huang, T. W.; Stieber, V. W.  
**Reference:**Conference title: 47th Annual Meeting of the American-Society-for-Therapeutic-Radiology- and-Oncology, October 16 -20, 2005 , Denver, CO, USA, Sponsor: Amer Soc Therapeut Radiol & Oncol., 63, S104-S105, 2005

**Title:** The outcome of gamma knife radiosurgery for facial pain varies by pre- treatment Burchiel classification pain type: Results from 256 gamma knife radiosurgery procedures for facial pain

16.

**Year:** 2005

**Patient number:** 63

**Author:** Henson, Clarissa Febles; Goldman, H. Warren; Rosenwasser, Robert H.; Downes, M. Beverly; Bednarz, Greg; Pequignot, Edward C.; Werner, Wasik Maria; Curran, Walter J.; Andrews, David W.

**Reference:** International journal of radiation oncology biology physics, 63, 1, 82-90, 2005

**Title:** Glycerol rhizotomy versus gamma knife radiosurgery for the treatment of trigeminal neuralgia: an analysis of patients treated at one institution

**Abstract:**BACKGROUND: Medically refractory trigeminal neuralgia (TN) has been treated with a variety of minimally invasive techniques, all of which have been compared with microvascular decompression. For patients not considered good surgical candidates, percutaneous retrogasserian glycerol rhizotomy (GR) and gamma knife (GK) radiosurgery are two minimally invasive techniques in common practice worldwide and used routinely at Jefferson Hospital for Neuroscience. Using a common pain scale outcomes questionnaire, we sought to analyze efficacies and morbidities of both treatments. METHODS AND MATERIALS: Between June 1994 and December 2002, 79 patients were treated with GR and 109 patients underwent GK for the treatment of TN. GR was performed with fluoroscopic guidance as an overnight inpatient procedure. GK was performed using a single 4-mm shot positioned at the root exit zone of the trigeminal nerve. Radiation doses of 70-90 Gy prescribed to the 100% isodose line were used. Treatment outcomes including pain response, pain recurrence, treatment failure, treatment-related side effects, and overall patient satisfaction with GK and GR were compared using a common outcomes scale. Using the Barrow Neurologic Institute pain scale, patients were asked to define their level of pain both before and after treatment: I, no pain and no pain medication required; II, occasional pain not requiring medication; IIIa, no pain and pain medication used; IIIb, some pain adequately controlled with medication; IV, some pain not adequately controlled with medication; and V, severe pain with no relief with medication. We used posttreatment scores of I, II, IIIa, and IIIb to identify treatment success, whereas scores of IV and V were considered treatment failure. Results were compiled from respondents and analyzed using SAS software. Statistical comparisons used log-rank test, univariate and multivariate logistic regression, Fisher's exact test, and Wilcoxon test with significance established at  $p < 0.05$ . RESULTS: There were 63 evaluable GK patients and 36 evaluable GR patients. The median follow-up time was 34 and 29 months for the GR and GK groups, respectively. The median age was 69 and 70

years and the median number of years with TN pain was 6 and 7 years in the GR and GK groups, respectively. Thirty-one GR (86%) and 58 GK (92%) patients achieved a successful treatment outcome ( $p = 0.49$ ). The median time to pain relief was  $\leq 24$  h in the GR group and 3 weeks in the GK group ( $p < 0.001$ , ordinal logistic regression). Nineteen GR and 26 GK patients experienced pain recurrence or pain never relieved ( $p = 0.30$ ). The median time to pain recurrence was 5 and 8 months in the GR and GK groups, respectively ( $p = 0.22$ ). At last follow-up, however, a statistically significant greater number of GR vs. GK patients had failed treatment. Twelve or 33% of GR patients, whereas 8 or 13% of GK patients, had BNI scores of 4 or 5 ( $p = 0.019$ , Fisher's exact test). When both initial and late treatment failures were combined, the overall rate of treatment failures was 39% in the GR group and 24% in the GK group ( $p = 0.023$ , log-rank). More GR patients developed facial numbness and facial numbness morbidity than GK patients: 19 GR (54%) and 17 GK patients (30%) developed new facial numbness and 12 GR and 7 GK patients reported either somewhat or very bothersome facial numbness ( $p = 0.018$ ). On multivariate analysis, only treatment with GK and severity of pain before treatment significantly predicted treatment response. GK patients were more likely to have a lower pain score at last follow-up than were GR patients ( $p = 0.005$ , OR = 4.3), and patients with pretreatment pain scores of 5 were more likely to have lower posttreatment pain scores than patients with pretreatment pain scores of 4 and lower ( $p = 0.003$ , OR = 4.0).

**CONCLUSION:** Despite greater facial numbness morbidity and a higher failure rate, GR provided more immediate pain relief than GK. GR therefore should be considered in patients with disabling trigeminal pain requiring urgent pain relief. For all other patients, GK provides better long-term pain relief with less treatment-related morbidity, and should therefore be considered the preferred treatment for patients with medically refractory trigeminal neuralgia who are not suitable candidates for microvascular nerve decompression.

17.

**Year:** 2005

**Patient number:** 52

**Author:** Jawahar, Ajay; Wadhwa, Rishi; Berk, Caglar; Caldito, Gloria; DeLaune, Allyson; Ampil, Federico; Willis, Brian; Smith, Donald; Nanda, Anil

**Reference:** Neurosurgical focus (electronic resource), {Neurosurg-Focus}, 15 May 2005 (epub), vol. 18, no. 5, p. E8, ISSN: 1092-0684.

**Title:** Assessment of pain control, quality of life, and predictors of success after gamma knife surgery for the treatment of trigeminal neuralgia

**Abstract:** OBJECT: There are various surgical treatment alternatives for trigeminal neuralgia (TN), but there is no single scale that can be used uniformly to assess and compare one type of intervention with the others. In this study the objectives were to determine factors associated with pain control, pain-free survival, residual pain, and recurrence after gamma knife surgery (GKS) treatment for TN, and to correlate the patients' self-reported quality of life (QOL) and satisfaction with the aforementioned factors. METHODS: Between the years 2000 and 2004, the authors treated 81 patients with medically refractory TN by using GKS. Fifty-two patients responded to a

questionnaire regarding pain control, activities of daily living, QOL, and patient satisfaction. The median follow-up duration was 16.5 months. Twenty-two patients (42.3%) had complete pain relief, 14 (26.9%) had partial but satisfactory pain relief, and in 16 patients (30.8%) the treatment failed. Seven patients (13.5%) reported a recurrence during the follow-up period, and 25 (48.1%) reported a significant (> 50%) decrease in their pain within the 1st month posttreatment. The mean decrease in the total dose of pain medication was 75%. Patients' self-reported QOL scores improved 90% and the overall patient satisfaction score was 80%. **CONCLUSIONS:** The authors found that GKS is a minimally invasive and effective procedure that yields a favorable outcome for patients with recurrent or refractory TN. It may also be offered as a first-line surgical modality for any patients with TN who are unsuited or unwilling to undergo microvascular decompression.

18.

**Year:** 2005

**Patient number:** 49

**Author:** McNatt, Sean A.; Yu, Cheng; Giannotta, Steven L.; Zee, Chi Shing; Apuzzo, Michael L. J.; Petrovich, Zbigniew

**Reference:** Neurosurgery, 56, 6, 1295-301, 2005

**Title:** Gamma knife radiosurgery for trigeminal neuralgia

**Abstract:** **OBJECTIVE:** The purpose of this study was to assess outcomes in patients treated with gamma knife radiosurgery for trigeminal neuralgia. **METHODS:** From 1997 to 2003, a total of 49 patients with trigeminal neuralgia underwent gamma knife radiosurgery. The trigeminal root entry zone immediately adjacent to the pons was targeted by use of a 4-mm collimator to deliver 40 Gy to the 50% isodose line (maximum dose, 80 Gy). Special care was taken to limit radiation dose to the adjacent pons to 12 Gy. Of the 49 study patients, all had undergone previous medical therapy, 8 (16%) had undergone microvascular decompression, 8 (16%) had undergone percutaneous rhizotomy, 2 (4%) had undergone linear accelerator-based radiosurgery, and 5 (10%) presented with multiple sclerosis. The median duration of symptoms was 6 years. There were 29 female patients (59%) and 20 male patients (41%). Facial pain outcomes were assessed by use of the Barrow Neurological Institute pain score. Other outcomes assessed included recurrence of symptoms and treatment toxicity. The median follow-up period was 49 months. **RESULTS:** At last evaluation, a total of 27 patients (61%) with idiopathic trigeminal neuralgia reported pain relief (scores of IIIb or less). This included 14 patients (32%) who reported complete pain relief when not receiving medications. Significant recurrence of pain after an initial interval of relief was reported by 10 patients (23%). Mean time to pain recurrence was 9.6 months (range, 2-36 mo). Mild to moderate facial numbness was experienced by 13 patients (29%), whereas 8 (18%) reported mild dysesthesias. **CONCLUSION:** Gamma knife radiosurgery established durable pain relief in 61% of patients with medically refractory idiopathic trigeminal neuralgia. A longer follow-up period is necessary to fully assess the incidence of late complications and recurrences.

19.

**Year:** 2005

**Patient number:** 28

**Author:** Pollock, Bruce E.

**Reference:** Neurosurgical focus (electronic resource), {Neurosurg-Focus}, 15 May 2005 (epub), vol. 18, no. 5, p. E6, ISSN: 1092-0684.

**Title:** Comparison of posterior fossa exploration and stereotactic radiosurgery in patients with previously nonsurgically treated idiopathic trigeminal neuralgia

**Abstract:** OBJECT: Stereotactic radiosurgery (SRS) is commonly performed in patients with trigeminal neuralgia, and numerous investigators have found that facial pain outcomes after this procedure are better for patients in whom prior surgery did not fail. Researchers in some centers claim that the results of SRS are equivalent to posterior fossa exploration (PFE). The goal in this study was to verify that claim. METHODS: Information was retrieved from a prospectively maintained database of patients less than 70 years old with idiopathic trigeminal neuralgia who underwent PFE (55 patients) or SRS (28 patients) as their initial surgery between 1999 and 2004. Of the two groups, patients who underwent radiosurgery were older (60.5 compared with 50.7 years,  $p < 0.001$ ). Microvascular decompression was performed in 49 patients (89%) and partial nerve section was performed in six (11%) in the PFE group. The mean maximum dose for SRS was 89.1 Gy. At a mean follow-up duration of 25.5 months, patients who had undergone PFE were more commonly pain free without medications (75% at 1 year, 72% at 3 years) compared with the patients treated with SRS (59% at 1 and 3 years;  $p = 0.01$ ). Additional surgery was performed in 10 patients (18%) after PFE, compared with eight patients (29%) after SRS ( $p = 0.4$ ). Eight patients (15%) had either new facial numbness (six cases) or dysesthesias (two cases) after PFE, whereas 12 (43%) had either new facial numbness (eight cases) or dysesthesias (four cases) after SRS. No correlation was noted between the development of facial numbness and facial pain outcome after PFE ( $p = 0.37$ ), whereas patients in whom trigeminal dysfunction developed after radiosurgery were more frequently free of pain ( $p = 0.02$ ). CONCLUSIONS: The results support PFE as a more effective primary surgery than SRS in patients with idiopathic trigeminal neuralgia. Moreover, injury to the trigeminal nerve during PFE is not required to achieve excellent facial pain outcomes.

20.

**Year:** 2005

**Patient number:** 69

**Author:** Pollock, B. E.; Ecker, R. D.

**Reference:** Clinical Journal of Pain, 21, 4, 317-322, 2005

**Title:** A prospective cost-effectiveness study of trigeminal neuralgia surgery

**Abstract:** Objectives: Approximately 8000 patients with trigeminal neuralgia undergo surgery each year in the United States at an estimated cost exceeding \$100 million. We compared 3 commonly performed surgeries (microvascular decompression, glycerol rhizotomy, and stereotactic radiosurgery) to evaluate the relative cost-effectiveness of these operations for patients with idiopathic trigeminal neuralgia. Methods: Prospective

nonrandomized trial at a tertiary referral center from July 1999 to December 2001. One hundred twenty-six consecutive patients underwent 153 operations (microvascular decompression, n = 33; glycerol rhizotomy, n = 51; stereotactic radiosurgery, n = 69). Preoperative characteristics were similar between the groups with respect to sex, pain location, duration of pain, and atypical features. Facial pain outcomes were classified as excellent (no pain, no medications), good (no pain, reduced medications), fair (>50% pain reduction), and poor. The cost per quality adjusted pain-free year was compared between the groups. Mean follow-up was 20.6 months. Results: Patients having microvascular decompression more commonly achieved and maintained an excellent outcome (85% and 78% at 6 and 24 months) compared with glycerol rhizotomy (61% and 55%, P = 0.01) and stereotactic radiosurgery (60% and 52%, P < 0.01). No difference was detected between glycerol rhizotomy and stereotactic radiosurgery (P = 0.61). The cost per quality adjusted pain-free year was \$6,342, \$8,174, and \$8,269 for glycerol rhizotomy, microvascular decompression, and stereotactic radiosurgery, respectively. Reduction in the average cost of morbidity and additional surgeries to zero did not make either microvascular decompression or stereotactic radiosurgery more cost-effective than glycerol rhizotomy. Both microvascular decompression and stereotactic radiosurgery would be more cost-effective than glycerol rhizotomy if the cost of additional surgeries after glycerol rhizotomy increased 79% and 83%, respectively. Discussion: This analysis supports the practice of percutaneous surgeries for older patients with medically unresponsive trigeminal neuralgia. At longer follow-up intervals, microvascular decompression is predicted to be the most cost-effective surgery and should be considered the preferred operation for patients if their risk for general anesthesia is acceptable. More data are needed to assess the role that radiosurgery should play in the management of patients with trigeminal neuralgia. Copyright © 2005 by Lippincott Williams & Wilkins.

21.

**Year:** 2005

**Patient number:** 19

**Author:** Pollock, Bruce E.; Foote, Robert L.; Link, Michael J.; Stafford, Scott L.; Brown, Paul D.; Schomberg, Paula J.

**Reference:** International journal of radiation oncology biology physics, 61, 1, 192-5, 2005

**Title:** Repeat radiosurgery for idiopathic trigeminal neuralgia

**Abstract:** PURPOSE: Although frequently performed, the efficacy and safety of repeat trigeminal neuralgia radiosurgery is not well described. METHODS AND MATERIALS: Between August 1997 and December 2002, 19 patients (9 men, 10 women) underwent repeat trigeminal neuralgia radiosurgery. The median interval between procedures was 16 months. The median dose (based on an output factor of 0.87 for the 4-mm collimator) for repeat radiosurgery was 76.1 Gy; the median additive dose was 163.1 Gy. Outcomes were defined as excellent (no pain, no medications), good (no pain, reduced medications), fair (>50% pain reduction), and poor. Median follow-up was 24 months. RESULTS: Outcomes after repeat radiosurgery were excellent (n = 14, 74%), good (n = 1, 5%), fair (n = 3, 16%), and poor (n = 1, 5%). Two patients had recurrent pain at 7 and 22 months; 71%

and 61% of patients had an excellent outcome at 1- and 2-years after radiosurgery, respectively. Eleven patients (58%) described facial parathesias (n = 3), numbness (n = 5) or dyesthesias (n = 3). Two patients (11%) developed corneal numbness. Nine of 11 patients (82%) with new trigeminal deficits had excellent outcomes at last follow-up compared with 3 of 8 patients (38%) with unchanged facial sensation (p = 0.07). CONCLUSIONS: Repeat trigeminal neuralgia radiosurgery at the dosage described has better facial pain outcomes than primary radiosurgery. However, because the procedure is nonselective and the rate of bothersome numbness was relatively high (16%), dose reduction is recommended to reduce the morbidity of repeat trigeminal neuralgia radiosurgery.

22.

**Year:** 2005

**Patient number:** 151

**Author:** Sheehan, Jason; Pan, Hung Chuan; Stroila, Matei; Steiner, Ladislau

**Reference:** Journal of neurosurgery, 102, 3, 434-41, 2005

**Title:** Gamma knife surgery for trigeminal neuralgia: outcomes and prognostic factors

**Abstract:** OBJECT: Microvascular decompression (MVD) and percutaneous ablation surgery have historically been the treatments of choice for medically refractory trigeminal neuralgia (TN). Gamma knife surgery (GKS) has been used as an alternative, minimally invasive treatment in TN. In the present study, the authors evaluated the long-term results of GKS in the treatment of TN. METHODS: From 1996 to 2003, 151 cases of TN were treated with GKS. In this group, radiosurgery was performed once in 136 patients, twice in 14 patients, and three times in one patient. The types of TN were as follows: 122 patients with typical TN, three with atypical TN, four with multiple sclerosis-associated TN, and seven with TN and a history of a cavernous sinus tumor. In each case, the chosen radiosurgical target was located 2 to 4 mm anterior to the entry of the trigeminal nerve into the pons. The maximal radiation doses ranged from 50 to 90 Gy. The median age of the patients was 68 years (range 22-90 years), and the median time from diagnosis to GKS was 72 months (range 1-276 months). The median follow up was 19 months (range 2-96 months). Clinical outcomes and postradiosurgical magnetic resonance (MR) imaging studies were analyzed. Univariate and multivariate analyses were performed to evaluate factors that correlated with a favorable, pain-free outcome. The mean time to relief of pain was 24 days (range 1-180 days). Forty-seven, 45, and 34% of patients were pain free without medication at the 1-, 2-, and 3-year follow ups, respectively. Ninety, 77, and 70% of patients experienced some improvement in pain at the 1-, 2-, and 3-year follow ups, respectively. Thirty-three (27%) of 122 patients with initial improvement subsequently experienced pain recurrence a median of 12 months (range 2-34 months) post-GKS. Among those whose symptoms recurred, 14 patients underwent additional GKS, six MVD, four glycerol injection, and one patient a percutaneous radiofrequency rhizotomy. Twelve patients (9%) suffered the onset of new facial numbness post- GKS. Changes on MR images post-GKS were noted in nine patients (7%). On univariate analysis, right-sided neuralgia (p = 0.0002) and a previous neurectomy (p = 0.04) correlated with a pain-free outcome; on multivariate analysis, both rightsided neuralgia (p = 0.032) and patient age

( $p = 0.05$ ) were statistically significant. New onset of facial numbness following GKS correlated with undergoing more than one GKS ( $p = 0.002$ ). **CONCLUSIONS:** At the last follow up, GKS effected pain relief in 44% of patients. Some degree of pain improvement at 3 years post-GKS was noted in 70% of patients with TN. Although less effective than MVD, GKS remains a reasonable treatment option for those unwilling or unable to undergo more invasive surgical approaches and offers a low risk of side effects.

23.

**Year:** 2005

**Patient number:** 38

**Author:** Tawk, Rabih G.; Duffy, Fronckowiak Mary; Scott, Bryan E.; Alberico, Ronald A.; Diaz, Aidnag Z.; Podgorsak, Matthew B.; Plunkett, Robert J.; Fenstermaker, Robert A.

**Reference:** Journal of neurosurgery, 102, 3, 442-9, 2005

**Title:** Stereotactic gamma knife surgery for trigeminal neuralgia: detailed analysis of treatment response

**Abstract:**OBJECT: The purpose of this study was to assess the durability and completeness of pain relief in patients treated using stereotactic gamma knife surgery (GKS) for trigeminal neuralgia (TN). METHODS: Thirty-eight patients with refractory TN were treated with stereotactic GKS. All patients received a prescription radiation dose of 35, 40, or 45 Gy to the 50% isodose surface through a 4-mm collimator helmet. The group was assessed regularly based on physician-directed interviews for a median follow up of 24 months (range 6-27 months). Pain relief was classified as excellent (no pain without medication), good (well-controlled pain with continued medication), fair (decreased but residual pain with continued medication), or poor (unimproved or increased pain with the same or increased medication). Three months after treatment, pain relief was good or excellent in 71% of patients. By 24 months post-GKS, 50% of the original cohort had poor pain relief, 21% continued to have either excellent or good relief, 3% had fair relief, and 26% had not reached the 24-month follow up. Based on their status at the last follow up, 29% of patients had excellent and 16% had good pain relief. Thirty-seven percent experienced facial numbness, which was dose related. In addition, there was a significantly higher rate of complete pain relief in patients who had facial numbness following treatment ( $p = 0.003$ ). **CONCLUSIONS:** Stereotactic GKS is an effective treatment in patients with TN; however, the durability of pain relief and the time to treatment response are limiting factors. As with other types of ablative treatment, facial numbness is strongly associated with better treatment response.

24.

**Year:** 2005

**Patient number:** 107

**Author:** Urgosik, Dusan; Liscak, Roman; Novotny, Josef, Jr.; Vymazal, Josef; Vladyka, Vilibald

**Reference:** Journal of neurosurgery, 102, 29-33, 2005

**Title:** Treatment of essential trigeminal neuralgia with gamma knife surgery

**Abstract:**OBJECT: The authors present the long-term follow-up results (minimum 5 years) of patients with essential trigeminal neuralgia (TN) who were treated with gamma knife surgery (GKS). METHODS: One hundred seven patients (61 females and 46 males) underwent GKS. The median follow up was time was 60 months (range 12-96 months). The target was the trigeminal root, and the maximum dose was 70 to 80 Gy. Repeated GKS was performed in 19 patients for recurrent pain, and the same dose was used. Initial successful results were achieved in 96% of patients, with complete pain relief in 80.4%. Relief was achieved after a median latency of 3 months (range 1 day-13 months). Gamma knife surgery failed in 4% of patients. Pain recurred in 25% of patients after a median latent interval of 36 months (6-94 months). The initial success rate after a second GKS was 89% and 58% of patients were pain free. Pain relapse occurred in only one patient in this group. Hypesthesia was observed in 20% of patients after the first GKS and in 32% after the second GKS. The median interval to hypaesthesia was 35 months (range 3-94 months) after one treatment and 21 months (range 1-72 months) after a second treatment. CONCLUSIONS: The initial success rate of pain relief was high and comparable to that reported in other studies. A higher than usual incidence of sensory impairment after GKS could be the long duration of follow-up study and due to the detailed neurological examination.

25.

**Year:** 2005

**Patient number:** 73

**Author:** Yuan, Y. H.; Xie, G. S.; Yang, Y. J.; Yu, H. W.; Chen, D.; Guan, J. H.; Diao, H. Y.; Pan, W. R.; Wang, C. L.

**Reference:** Chinese Journal of Clinical Rehabilitation, 9, 10, 6-7, 2005

**Title:** Single-target treatment for primary refractory trigeminal neuralgia with gamma knife: A follow-up observation of 73 cases

**Abstract:**Aim: To evaluate the effectiveness and safety of single-target treatment of refractory trigeminal neuralgia with gamma knife, so as to provide therapeutic methods for improving the physical and mental health and quality of life of patients with trigeminal neuralgia. Methods: From July 1995 to June 2003, 73 patients with refractory trigeminal neuralgia were treated with gamma knife. Totally 31 cases of all patients were male, 42 cases were female, ages from 35 years old to 79 years old, the average was 61 years old. The course of disease was from 1.5 years to 29 years, and the average course was 4.5 years. All patients were treated with single-target. The target was positioned at the root entry zone of the trigeminal nerve. The maximum dose was between 70 and 90 Gy. Collimator was 4 mm. Results: All patients discharged at 24 hours after treated with gamma knife. Follow-up range was from 6 to 68 months, and mean range was 36.7 months. The pain was relieved completely in 18 cases (24.7%), relieved partially in 46 cases (63%), and unchanged in 9 cases (12.3%). The symptoms changed from 2 weeks to 6 months, and the average was 3.5 months. Six cases experienced pain recurrence and were treated with second gamma knife radiosurgery, the clinical symptoms relieved in 3 cases and unchanged in 3 cases. Three cases experienced headache and vomiting

after gamma knife radiosurgery and disappeared in 1 week, 7 cases experienced persistent facial numbness and none of all cases had dysfunction of masticatory muscle, dry-eye and kerat-ulcer. Conclusion: Gamma knife radiosurgery is a safe and effective method in the treatment of refractory trigeminal neuralgia. It can significantly relief pain and improve quality of life.

26.

**Year:** 2005

**Patient number:** 25

**Author:** Zerris, Vasilios A.; Noren, Georg C.; Shucart, William A.; Rogg, Jeff; Friehs, Gerhard M.

**Reference:** Journal of neurosurgery, 102, 107-10, 2005

**Title:** Targeting the cranial nerve: microradiosurgery for trigeminal neuralgia with CISS and 3D-flash MR imaging sequences

**Abstract:**OBJECT: The authors undertook a study to identify magnetic resonance (MR) imaging techniques that can be used reliably during gamma knife surgery (GKS) to identify the trigeminal nerve, surrounding vasculature, and areas of compression. METHODS: Preoperative visualization of the trigeminal nerve and surrounding vasculature as well as targeting the area of vascular compression may increase the effectiveness of GKS for trigeminal neuralgia. During the past years our gamma knife centers have researched different MR imaging sequences with regard to their ability to visualize cranial nerves and vascular structures. Constructive interference in steady-state (CISS) fusion imaging with three-dimensional gradient echo sequences (3D-Flash) was found to be of greatest value in the authors' 25 most recent patients. In 24 (96%) out of the 25 patients, the fifth cranial nerve, surrounding vessels, and areas of compression could be reliably identified using CISS/3D-Flash. The MR images were acceptable despite patients' history of microvascular decompression, radiofrequency (RF) ablation, or concomitant disease. In one of 25 patients with a history of multiple RF lesions, the visualization was inadequate due to severe trigeminal nerve atrophy. CONCLUSIONS: The CISS/3D-Flash fusion imaging has become the preferred imaging method at the authors' institutions during GKS for trigeminal neuralgia. It affords the best visualization of the trigeminal nerve, surrounding vasculature, and the precise location of vascular compression.

27.

**Year:** 2005

**Patient number:** 40

**Author:** Zhang, Pengpeng; Brisman, Ronald; Choi, Julie; Li, Xiang

**Reference:** International Journal of Radiation Oncology Biology Physics, 62, 1, 38-43, 2005

**Title:** Where to locate the isocenter? The treatment strategy for repeat trigeminal neuralgia radiosurgery

**Abstract:** Purpose: The purpose of this study is to investigate how the spatial relationship between the isocenters of the first and second radiosurgeries affects the overall outcome. Methods and Materials: We performed a retrospective study on 40 patients who had repeat gamma knife radiosurgery for trigeminal neuralgia. Only one 4-mm isocenter was applied in both first and second radiosurgeries, with a maximum radiation dose of 75 Gy and 40 Gy, respectively. The MR scan of the first radiosurgery was registered to that of the second radiosurgery by a landmark-based registration algorithm. The spatial relationship between the isocenter of the first and the second radiosurgeries was thus determined. The investigating parameters were the distance between the isocenters of the two separate radiosurgeries and isocenter proximity to the brainstem. The outcome end points were pain relief and dysesthesias. The median follow-up for the repeat radiosurgery was 28 months (range, 6-51 months). Results: Pain relief was complete in 11 patients, nearly complete ( $\geq 90\%$ ) in 7 patients, partial ( $\geq 50\%$ ) in 8 patients, and minimal ( $< 50\%$ ) or none in another 14 patients. The mean distance between the two isocenters was 2.86 mm in the complete or nearly complete pain relief group vs. 1.93 mm in the others. Farther distance between isocenters was associated with a trend toward better pain relief ( $p = 0.057$ ). The proximity of the second isocenter to the brainstem did not affect pain relief, and neither did placing the second isocenter proximal or distal to the brainstem compared with the first one. Three patients developed moderate dysesthesias (score of 4 on a 0-10 scale), and 2 other patients developed more significant dysesthesias (score of 7) after the second radiosurgery. Dysesthesias related neither to distance between isocenters nor to which isocenter was closer to the brainstem. Conclusions: Image registration between MR scans of the first and second radiosurgeries helps target delineation and radiosurgery treatment planning. Increasing the isocenter distance between the two radiosurgeries treated a longer segment of the trigeminal neuralgia nerve and was associated with a trend toward improved pain relief. (c) 2005 Elsevier Inc.

28.

**Year:** 2004

**Patient number:** 293

**Author:** Brisman, Ronald

**Reference:** Journal of neurosurgery, 100, 5, 848-54, 2004

**Title:** Gamma knife surgery with a dose of 75 to 76.8 Gray for trigeminal neuralgia

**Abstract:** OBJECT: The author presents a large series of patients with idiopathic trigeminal neuralgia (TN) who were treated with gamma knife surgery (GKS), at a maximum dose of 75 to 76.8 Gy, and followed up in a nearly uniform manner for up to 4.6 years. METHODS: Two hundred ninety-three patients were treated and followed up for at least 6 months (range 0.4-4.6 years, median 1.9 years). At the final follow-up review, there was complete (100%) pain relief without medicines in 64 patients (21.8%), 90% or greater relief with or without small doses of medicines in 86 (29.4%), between 75 and 89% relief in 31 (10.6%), between 50 and 74% relief in 19 (6.5%), and less than 50% relief in 23 patients (7.8%). Recurrent pain requiring a second procedure occurred in 70 patients (23.9%). Kaplan-Meier analysis showed that 100%, 90% or greater, and 50% or greater pain relief was obtained and maintained for 3.5 to 4.1 years in 5.6, 23.7, and

50.4% patients, respectively. Of 31 patients who described pain relief ranging from 75 to 89%, 80% of patients described it as good and 10% as excellent; of 17 patients who reported between 50 and 74% pain relief, 53% described it as good and none as excellent ( $p = 0.014$ ). Dysesthesia scores greater than 5 (scale of 0-10, in which a score of 10 represents excruciating pain) occurred in four (3.2%) of 126 patients who had not undergone prior surgery; all these patients obtained either good or excellent relief from TN pain. There were 36 patients in whom the TN had atypical features; these patients were less likely to attain at least 50% or at least 90% pain relief compared with those without atypical TN features ( $p = 0.001$ ). **CONCLUSIONS:** Gamma knife surgery is a safe and effective way to relieve TN. Patients who attain between 75 and 89% pain relief are much more likely to describe this outcome as good or excellent than those who attain between 50 and 74% pain relief.

29.

**Year:** 2004

**Patient number:** 112

**Author:** Cheuk, Alice V.; Chin, Lawrence S.; Petit, Joshua H.; Herman, Joseph M.; Fang, Hong Bin; Regine, William F.

**Reference:** International journal of radiation oncology biology physics, 60, 2, 537-41, 2004

**Title:** Gamma knife surgery for trigeminal neuralgia: outcome, imaging, and brainstem correlates

**Abstract:****PURPOSE:** To review our results with gamma knife surgery (GKS) in the treatment of trigeminal neuralgia (TN), and to determine whether pain relief, medication usage, and the development of facial numbness are affected by trigeminal nerve compression, MRI imaging quality, or brainstem radiation dose. **METHODS AND MATERIALS:** One hundred twelve patients with TN refractory to medical or surgical management were treated at the University of Maryland Gamma Knife Center between June 1996 and July 2001. Patients were treated using a 4-mm shot to the trigeminal nerve, at a point 2-4 mm anterior to the root entry zone of the nerve into the pons. The median dose prescribed was 75 Gy (range, 60-80 Gy). T1- and T2-weighted, axial, 1.5-mm-thick MRI images were obtained using three-dimensional gradient echo acquisition after contrast injection for treatment planning. MRI images were evaluated for imaging quality (i.e., the adequacy of visualization of the affected prepontine trigeminal nerve), the presence of trigeminal nerve compression, and the brainstem dose. Follow-up data were obtained via telephone interviews, and patients were asked to rate their pre-GKS and post-GKS pain using the Barrow Neurological Institute (BNI) Pain Intensity Scale. Patients were also asked about side effects from GKS and were asked to rate any facial numbness on the BNI Facial Numbness Scale. Medication use, time to pain response, and duration of relief were also evaluated. **RESULTS:** Ninety-six patients who had follow-up data were included in the analysis. Eighty-six patients (89.6%) responded to GKS with an improvement in BNI pain class. Ten patients (10.4%) were found to have an MRI of poor quality, 30 (31.3%) fair quality, and 56 (58.3%) good quality. Forty-two (43.8%) received 10% of the maximal dose to the brainstem edge, whereas 54 (56.2%)

received 20%. Eleven (11.5%) patients were found to have obvious nerve compression by MRI. Imaging quality ( $p = 0.1863$ ), presence of compression ( $p = 0.1147$ ), and brainstem dose ( $p = 0.3168$ ) did not correlate with treatment response. There was also no correlation between these variables (MRI quality, compression, and brainstem dose) and medication use ( $p = 0.5372$ ,  $p = 0.0913$ ,  $p = 0.6832$ , respectively). Facial numbness was the only side effect experienced. Thirteen patients reported varying degrees of facial numbness, but there was no correlation between imaging quality ( $p = 0.0600$ ), brainstem dose ( $p = 0.6773$ ), and presence of compression ( $p = 0.5785$ ) with the development of facial numbness. **CONCLUSIONS:** Gamma knife surgery is effective in the treatment of TN and has a favorable side effect profile. Treatment response and the development of facial numbness do not correlate with MRI imaging quality, presence of nerve compression, or radiation dose to the brainstem.

30.

**Year:** 2004

**Patient number:** 18

**Author:** Herman, Joseph M.; Petit, Joshua H.; Amin, Pradip; Kwok, Young; Dutta, Pinaki R.; Chin, Lawrence S.

**Reference:** International journal of radiation oncology biology physics, 59, 1, 112-6, 2004

**Title:** Repeat gamma knife radiosurgery for refractory or recurrent trigeminal neuralgia: treatment outcomes and quality-of-life assessment

**Abstract:** **PURPOSE:** Stereotactic radiosurgery (SRS) has become a minimally invasive treatment modality for patients with refractory trigeminal neuralgia. It is unclear, however, how best to treat patients with pain that is refractory or recurrent after initial SRS. We report on treatment outcomes and quality of life for patients treated with repeated SRS for refractory or recurrent trigeminal neuralgia. **METHODS AND MATERIALS:** Between June 1996 and June 2001, 112 patients with trigeminal neuralgia were treated with SRS at the University of Maryland Medical Center. Eighteen patients underwent repeat SRS 3-42 months (median, 8 months) after initial radiosurgery because of unsatisfactory or unsustained pain relief. Patients received a median prescription dose of 75 and 70 Gy, respectively, for the first and second treatments. Self-reports of pain control were assessed with a standard questionnaire containing the complete Barrow Neurologic Institute Pain Scale. **RESULTS:** The median follow-up was 37.5 months (range, 12-68 months) after initial SRS and 24.5 months (range, 6-65 months) after repeat SRS. For the 18 patients in this series, the percentage of patients reporting excellent, good, fair, and poor responses after the initial and repeat SRS was 50%, 28%, 6%, and 16% and 45%, 33%, 0%, and 22%, respectively. None of the 3 patients with pain refractory to initial SRS responded to repeat SRS. Among those with recurrent pain after initial SRS, 14 patients (93%) achieved excellent or good pain outcomes after repeat SRS. The actuarial analysis revealed a 1-year recurrence rate of 22%, with no patients reporting recurrent pain after 9 months of follow-up. Two patients (11%) reported new or increased facial numbness after retreatment, which was described as bothersome by one. Repeat SRS resulted in a median 60% improvement in quality of life, and 56% of patients believed that the procedure was successful. **CONCLUSION:** Despite a modest dose reduction, repeat

SRS provided similar rates of complete pain control as the initial procedure, but was not effective for patients with no response to initial treatment. Repeat SRS was more efficacious for those patients who experienced longer periods of pain relief after the initial SRS. The incidence of complications was not significantly different from that observed for initial SRS. In this series, most patients had significant improvements in quality of life.

31.

**Year:** 2004

**Patient number:** 101

**Author:** Kanner, Andrew A.; Neyman, Gennady; Suh, John H.; Weinhaus, Martin S.; Lee, Shih Yuan; Barnett, Gene H.

**Reference:** Stereotactic and functional neurosurgery, 82, 1, 49-57, 2004

**Title:** Gamma knife radiosurgery for trigeminal neuralgia: comparing the use of a 4-mm versus concentric 4- and 8-mm collimators

**Abstract:** **PURPOSE:** Gamma knife (GK) radiosurgery for trigeminal neuralgia (TN) has been effective in 50-80% of cases when using a single 4-mm collimator and a maximum dose of 60-90 Gy. Attempting to improve the response rate by increasing the dose may lead to increased risk of facial numbness or disturbed sensation. Combined use of 4- and 8-mm collimators results in a larger target volume, which would potentially treat a larger region of the nerve without increasing the maximum dose. **MATERIALS AND METHODS:** One hundred-one patients suffering from medically refractory TN were evaluated. Fifty-four were treated with a single shot using a 4-mm helmet and 47 with concentrically aimed, equally weighted 4- and 8-mm helmets. 75 Gy were prescribed to the 100% isodose line (using a 4-mm helmet output factor of 0.80) in all cases. The outcome was assessed by interview or outpatient visit. **RESULTS:** An excellent/good response was seen in 57.8 vs. 71.4%, respectively, with a partial response of 13.3 vs. 2.3%, respectively ( $p > 0.05$ ). Pain recurrence occurred in 28.6 vs. 23.2%, respectively ( $p > 0.05$ ). **CONCLUSION:** The use of a combined concentric 4- and 8-mm collimator treatment for medically refractory TN at a maximum dose of 75 Gy does not improve outcome as compared with a single 4-mm collimator with an equivalent maximum dose. Copyright 2004 S. Karger AG, Basel.

32.

**Year:** 2004

**Patient number:** Review of literature

**Author:** Lopez, B. C.; Hamlyn, P. J.; Zakrzewska, J. M.

**Reference:** Journal of neurology neurosurgery and psychiatry, 75, 7, 1019-24, 2004

**Title:** Stereotactic radiosurgery for primary trigeminal neuralgia: state of the evidence and recommendations for future reports

**Abstract:** **OBJECTIVE:** To identify systematically all the studies reporting outcomes and complications of stereotactic radiosurgery for trigeminal neuralgia and to evaluate them against predefined quality criteria. **METHODS:** Inclusion criteria for outcome analysis

included thorough demographic documentation, defined diagnostic and outcome criteria, a minimum of 30 patients treated with 12 months median/mean follow up, not more than 20% lost to follow up, Kaplan-Meier actuarial analysis, primary trigeminal neuralgia, not more than 10% of patients retreated for failure or early recurrence, and minimum dose of 70 Gy. **RESULTS:** Of 38 studies identified, four could be used to evaluate rates of pain relief on a yearly basis, and two for actuarial rates of complete pain relief; seven provided data on latencies and 18 were used to evaluate complications. Pain relief typically occurs within three months. Complete relief is initially achieved by three quarters of the patients, but half maintain this outcome at three years. One half or less can permanently stop drug treatments. Sensory disturbance, including anaesthesia dolorosa, is the most frequent complication of stereotactic radiosurgery. **CONCLUSIONS:** Outcomes after stereotactic radiosurgery appear in line with other ablative techniques. Results are better when it is used as primary treatment in patients with typical symptoms. Current data are largely observational and the quality is generally poor. This technique should be evaluated in a randomised, controlled trial with universal outcome measures, actuarial methodology, and validated measures of patient satisfaction and quality of life.

33.

**Year:** 2004

**Patient number:** Review of literature

**Author:** Lopez, B. C.; Hamlyn, P. J.; Zakrzewska, J. M.; Burchiel, K. J.; Sandquist, M.; Henderson, J. M.; Hodge, Jr C. J.; Lunsford, L. D.

**Reference:** Neurosurgery, 54, 4, 973-983, 2004

**Title:** Systematic Review of Ablative Neurosurgical Techniques for the Treatment of Trigeminal Neuralgia

**Abstract:** **OBJECTIVE:** There are no randomized controlled trials comparing retrogasserian percutaneous radiofrequency thermocoagulation, glycerol rhizolysis, balloon compression of the gasserian ganglion, and stereotactic radiosurgery, nor are there systematic reviews using predefined quality criteria. The objective of this study was to systematically identify all of the studies reporting outcomes and complications of ablative techniques for treatment of trigeminal neuralgia, from the development of electronic databases, and to evaluate them with predefined quality criteria. **METHODS:** Inclusion criteria for the outcome analysis included thorough demographic documentation, defined diagnostic and outcome criteria, a minimum of 30 patients treated and median/mean follow-up times of 12 months, not more than 20% of patients lost to follow-up monitoring, Kaplan-Meier actuarial analysis of individual procedures, less than 10% of patients retreated because of failure or early recurrence, and a minimal dose of 70 Gy for stereotactic radiosurgery. High-quality studies with no actuarial analysis were used for the evaluation of complications. **RESULTS:** Of 175 studies identified, 9 could be used to evaluate rates of complete pain relief on a yearly basis and 22 could be used to evaluate complications. In mixed series, radiofrequency thermocoagulation offered higher rates of complete pain relief, compared with glycerol rhizolysis and stereotactic radiosurgery, although it demonstrated the greatest number of complications. **CONCLUSION:** Radiofrequency thermocoagulation offers the highest rates of complete

pain relief, although further data on balloon microcompression are required. It is essential that uniform outcome measures and actuarial methods be universally adopted for the reporting of surgical results. Randomized controlled trials are required to reliably evaluate new surgical techniques.

34.

**Year:** 2004

**Patient number:** 47

**Author:** Massager, Nicolas; Lorenzoni, José; Devriendt, Daniel; Desmedt, Françoise; Brotchi, Jacques; Levivier, Marc

**Reference:** Journal of neurosurgery, 100, 4, 597-605, 2004

**Title:** Gamma knife surgery for idiopathic trigeminal neuralgia performed using a far-anterior cisternal target and a high dose of radiation

**Abstract:** OBJECT: Gamma knife surgery (GKS) has emerged as a suitable treatment of pharmacologically resistant idiopathic trigeminal neuralgia. The optimal radiation dose and target for this therapy, however, remain to be defined. The authors analyzed the results of GKS in which a high dose of radiation and a distal target was used, to determine the best parameters for this treatment. METHODS: The authors evaluated results in 47 patients who were treated with this approach. All patients underwent clinical and magnetic resonance imaging examinations at 6 weeks, 6 months, and 1 year post-GKS. Fifteen potential prognostic factors associated with favorable pain control were studied. The mean follow-up period was 16 months (range 6-42 months). The initial pain relief was excellent (100% pain control) in 32 patients, good (90-99% pain control) in seven patients, fair (50-89% pain control) in three patients, and poor (< 50% pain control) in five patients. The actuarial curve of pain relief displayed a 59% rate of excellent pain control and a 71% excellent or good pain control at 42 months after radiosurgery. Radiosurgery-induced facial numbness was bothersome for two patients and mild for 18 patients. Three prognostic factors were found to be statistically significant factors for successful pain relief: a shorter distance between the target and the brainstem, a higher radiation dose delivered to the brainstem, and the development of a facial sensory disturbance after radiosurgery. CONCLUSIONS: To optimize pain control and minimize complications of this therapy, we recommend that the nerve be targeted at a distance of 5 to 8 mm from the brainstem.

35.

**Year:** 2004

**Patient number:** 40

**Author:** Shaya, Mark; Jawahar, Ajay; Caldito, Gloria; Sin, Anthony; Willis, Brian K.; Nanda, Anil

**Reference:** Surgical neurology, 61, 6, 529-34, 2004

**Title:** Gamma knife radiosurgery for trigeminal neuralgia: a study of predictors of success, efficacy, safety, and outcome at LSUHSC

**Abstract:**BACKGROUND: Trigeminal neuralgia (TN) is a painful condition of controversial origin; however, vascular compression of the root entry zone of the trigeminal nerve is thought to be responsible in some cases. Recently, stereotactic radiosurgery has been established as an alternative treatment for medically intractable TN. METHODS: Forty patients with medically refractory TN underwent gamma knife surgery for pain control at our institution. Dose planning was based on high- resolution, contrast-enhanced, axial, volume acquisition magnetic resonance images. Images were reviewed to detect vascular compression of the trigeminal nerve at the root entry zone by an observer blinded to the affected side and the outcome. Another observer, blinded to radiologic findings, conducted the patient follow-up. Results were classified as excellent and good (favorable outcomes) and failure (unfavorable) based upon the intensity of pain, frequency of episodes, pain medications, and need for additional interventions after radiosurgery. RESULTS: Pain was left-sided in 22 patients and right- sided in 18 patients. Vascular compression of the affected nerve at the root entry zone was demonstrable in 14 patients. Prescription dose ranged from 70 to 90 Gy. At a median follow-up of 14 months (range, 3-31 months), 16 patients (40%) had excellent pain control, 12 (30%) had good control, while 12 (30%) had failed treatment. The Kaplan- Meier actuarial pain control rate at 15 months was 82.25 +/- 0.8% (95%CI). Magnetic resonance detectable vascular compression did not affect the outcome ( $p = 0.6$ ). Increasing marginal dose ( $> \text{ or } = 40\text{Gy}$ ) was a significant predictor of favorable outcome ( $p = 0.015$ ). CONCLUSIONS: gamma knife surgery is an effective and safe treatment for TN. In our study, we found that vascular compression of the nerve at the root entry zone was not a predictor of the outcome of gamma surgery for TN. The outcome improves with marginal prescription dose of 80 Gy or higher.

36.

**Year:** 2003

**Patient number:** 45

**Author:** Brisman, Ronald

**Reference:** Stereotactic and functional neurosurgery, 81, 1-4, 43-9, 2003

**Title:** Repeat gamma knife radiosurgery for trigeminal neuralgia

**Abstract:**BACKGROUND: Although gamma knife radiosurgery (GKRS) has been shown to be safe and effective for the treatment of trigeminal neuralgia (TN), there are few studies that report the results of a second GKRS. METHOD: Between May 22, 1998 and April 1, 2003, we treated 335 primary TN patients with GKRS. All received a maximum dose of 75 Gy to the cisternal trigeminal nerve. 45 patients with recurrent or persistent TN were treated with a maximum dose of 40 Gy at a second GKRS and were available for at least 6 months of follow-up. RESULTS: Final pain relief (mean of 15 months after second GKRS) was 50% or greater in 28 of the 45 patients (62.2%). Patients who had no neurosurgical procedure prior to their first GKRS were more likely to have pain relief of 50% or greater following the second GKRS ( $p = 0.042$ ). Significant new dysesthesias (score greater than 5 on a scale of 0-10) developed in 2 patients (4.4%). CONCLUSION: Repeat GKRS has a good chance of relieving TN pain without complications and is more likely to relieve pain in those who did not have any procedure prior to their first GKRS.

37.

**Year:** 2003

**Patient number:** 54

**Author:** Hirai, T.; Yoshida, M.; Watanabe, S.; Takihana, T.; Shouzuohara, H.; Yamamoto, Y.

**Reference:** Japanese Journal of Neurosurgery, 12, 10, 661-669, 2003

**Title:** Gamma Knife Treatment of Trigeminal Neuralgia

**Abstract:** Effectiveness and limitations of Gamma Knife treatment for various kinds of trigeminal neuralgia (typical, atypical and mixed types) were analyzed from the data of 54 cases treated over the past 4 years. The mean patient age was 74 years (range 50 to 101 years). Forty five patients with typical trigeminal neuralgia, four patients with atypical facial pain and five patients with mixed type trigeminal neuralgia were evaluated. Isodose distribution determined with a 4 mm collimator was centered on the root entry zone of the trigeminal nerve in 35 cases and centered on the retro-Gasserian trigeminal nerve in 19 cases. The maximum dose range used was 70 to 80 Gy. Median follow-up after radiosurgery was 21.4 months (range 3 to 54 months). Typical trigeminal neuralgia treated at the root entry zone became pain free without medication in 53.6% (15/28), 78.6% (22/28) and 78.6% (22/28) of the patients after 3, 6 and 12 months, respectively, while, that treated at the retro-Gasserian nerve became pain free in 29.4% (5/17), 53.8% (7/13) and 70.0% (7/10) of the patients after 3, 6 and 8 months. No matter whether the target was the root entry zone or the retro- Gasserian nerve, 70 to 78% of patients became pain free without medication when examined at 8 to 12 months after radiosurgery. Facial hypesthesia including localized slight hypesthesia occurred in 13 to 20% of the patients at 12 to 24 months after radiosurgery, but no patients developed any other new neurological deficits or systemic complications. Patients with atypical trigeminal neuralgia did not respond well to this treatment. Further study is required to determine the optimal target and dose. Because of its noninvasive nature, radiosurgery is an attractive option for treatment of typical and mixed typed trigeminal pain, particularly in elderly patients and patients not amenable to the various surgical methods available for treatment of trigeminal neuralgia.

38.

**Year:** 2003

**Patient number:** 96

**Author:** Petit, Joshua H.; Herman, Joseph M.; Nagda, Suneel; DiBiase, Steven J.; Chin, Lawrence S.

**Reference:** International journal of radiation oncology biology physics, 56, 4, 1147-53, 2003

**Title:** Radiosurgical treatment of trigeminal neuralgia: evaluating quality of life and treatment outcomes

**Abstract:** PURPOSE: To assess the safety, efficacy, and quality of life (QOL) associated with radiosurgical treatment for trigeminal neuralgia (TN). METHODS AND MATERIALS: Between June 1996 and June 2001, 112 patients with TN refractory to medical or surgical management were treated with gamma knife radiosurgery (GKRS) at the University of Maryland Medical Center. A median prescription dose of 75 Gy (range: 70-80 Gy) was delivered to the involved trigeminal nerve root entry zone. Treatment outcomes were assessed through patient self-reports of pain control and medication usage during follow-up visits. In addition, patients responded to a standard questionnaire containing the Barrow Neurologic Institute Pain Scale (BNI) and selected sections of the McGill Pain Scale. Treatment outcomes and objective quality of life measures were also addressed. RESULTS: Ninety-six patients (86%) completed questionnaires for a median follow-up of 30 months (range: 8-66 months). Seventy-four patients (77%) reported pain relief occurring after a median of 3 weeks (range: 0-24 weeks) after GKRS. A decrease in medication usage was noted in 66% of patients. Actuarial analysis demonstrated 1-year, 2-year, and 3-year recurrence rates of 23%, 33%, and 39%, respectively. Response to treatment was associated with lack of prior surgical treatment ( $p = 0.03$ ) and less than 50 months' pain duration before GKRS ( $p = 0.04$ ). Patients who described their TN pain as more severe than their worst non-TN headache pain (McGill Pain Scale IV-V vs. I-III) were also more likely to respond to treatment ( $p < 0.001$ ). Seven (7.3%) patients reported new or increased trigeminal dysfunction; however, only 3.1% reported these symptoms as bothersome (BNI III-IV). Patients with sustained pain relief reported an average of 100% improvement in their QOL as a direct result of pain relief after GKRS, and 100% believed that the procedure was successful. Furthermore, among those patients with temporary pain relief and subsequent recurrence, 65% felt their treatment was a success with an average of 80% improvement in their QOL. CONCLUSIONS: GKRS provides significant pain relief and improves QOL in the majority of patients treated for TN, with few bothersome side effects. Patients with both temporary and sustained responses to treatment realized significant improvements in QOL after GKRS, and considered their treatment successful. Longer follow-up of these patients may reveal additional recurrences highlighting the importance of studies evaluating repeat GKRS and optimization of current treatment techniques and patient selection.

39.

**Year:** 2002

**Patient number:** 179

**Author:** Brisman, Ronald; Khandji, Alexander G.; Mooij, Robertus B. M.

**Reference:** Neurosurgery, 50, 6, 1261-6, 2002

**Title:** Trigeminal Nerve-Blood Vessel Relationship as Revealed by High-resolution Magnetic Resonance Imaging and Its Effect on Pain Relief after Gamma Knife Radiosurgery for Trigeminal Neuralgia

**Abstract:** OBJECTIVE: Blood vessel (BV) compression of the trigeminal nerve (Cranial Nerve (CN) V) is a common cause of trigeminal neuralgia (TN). High-resolution magnetic resonance imaging scans obtained during gamma knife radiosurgery (GKRS) in patients with TN may be used to analyze the BV-CN V relationship. Follow-up data from a large

series of patients treated with GKRS for TN were used to provide information regarding the BV-CN V relationship and pain relief. **METHODS:** T1-weighted, axial 1-mm-thick volume acquisition magnetic resonance imaging scans were obtained through the area of CN V at its exit from the brainstem after injection of 15 ml of gadolinium. The BV-CN V relationship on the symptomatic side that was treated with GKRS was categorized into the following groups: Group 1 (no close relationship), Group 2 (BV close to CN V but not touching it), and Groups 3 and higher (BV-CN V contact). **RESULTS:** A total of 181 symptomatic nerves were studied in 179 patients with TN who were treated with GKRS. In BV-CN V Groups 1, 2, and 3 and higher, respectively, were 43 sides (24%), 31 sides (17%), and 107 sides (59%). In 100 sides where there was no surgical procedure before GKRS, 50% or greater pain relief was more likely in those with BV-CN V contact (51 (88%) of 58 sides) than in those without BV-CN V (29 (69%) of 42 sides) ( $P = 0.024$ ). BV-CN V contact was observed more often in men (55 (69%) of 80 sides) than in women (52 (52%) of 101 sides) ( $P = 0.023$ ) and more often in patients who had unilateral TN (104 (62%) of 169 patients) rather than bilateral TN (2 (20%) of 10 patients) ( $P = 0.016$ ). **CONCLUSION:** In patients who have not undergone previous surgery for TN, BV-CN V contact revealed by high-resolution magnetic resonance imaging may indicate a particularly favorable response to GKRS.

40.

**Year:** 2002

**Patient number:** 27

**Author:** Hasegawa, Toshinori; Kondziolka, Douglas; Spiro, Richard; Flickinger, John C.; Lunsford, L. Dade

**Reference:** Neurosurgery, 50, 3, 494-500, 2002

**Title:** Repeat radiosurgery for refractory trigeminal neuralgia

**Abstract:** **OBJECTIVE:** Stereotactic radiosurgery has become an important and minimally invasive alternative for patients with refractory trigeminal neuralgia. When a second procedure is necessary, the outcomes are unknown. The degree of pain relief and morbidity after repeat radiosurgery were studied. **METHODS:** Thirty-one patients underwent a second gamma knife radiosurgery procedure because of unsatisfactory or unsustained relief of pain after the first procedure. Twenty-seven patients were assessable at median follow-up periods of 42.7 and 20.4 months after the first and second procedures, respectively. Most patients had undergone multiple previous operations of other types (microvascular decompression, radiofrequency rhizotomy, glycerol rhizotomy, balloon compression). The median target doses of the first and second radiosurgeries were 75 and 64 Gy, respectively. All patients were evaluated by a physician who did not participate in patient treatment. **RESULTS:** After the first radiosurgical procedure, 13 patients had an excellent response initially (complete relief without any medication), 3 had a good response (complete relief with some medication), 7 had a fair response (>50% relief), and 4 had a poor response (<50% pain relief or treatment failure). Repeat radiosurgery was performed in patients with recurrent or residual pain. After the second radiosurgical procedure, 5 patients had an excellent response, 8 had a good response, 10 had a fair response, and 4 had a poor response.

Thirteen patients (48%) achieved complete pain relief (with or without medication). Two patients (7.4%) experienced new sensory symptoms after the first radiosurgical procedure, and three (12.7%, actuarial) experienced new sensory symptoms after the second procedure. **CONCLUSION:** Repeat radiosurgery provided a similar rate of pain relief as the first procedure, despite a modest dose reduction. The risk of new sensory symptoms was increased, but no other morbidity was identified. For patients who experience recurrent pain and choose to undergo a second procedure, our current procedure is to deliver a maximum dose of 50 to 60 Gy to a trigeminal target anterior to the root entry zone near the entrance of the nerve beneath the petrous dura.

41.

**Year:** 2002

**Patient number:** 220

**Author:** Kondziolka, Douglas; Lunsford, L. Dade; Flickinger, John C.

**Reference:** The Clinical journal of pain, 18, 1, 42-7, 2002

**Title:** Stereotactic radiosurgery for the treatment of trigeminal neuralgia

**Abstract:** Stereotactic radiosurgery is an increasingly used and the least invasive surgical option for patients with medically refractory trigeminal neuralgia (TN). The authors began use of this technique at our center in 1992 and have evaluated outcomes serially. Independently acquired data from 220 patients with idiopathic TN that had Gamma Knife radiosurgery was reviewed. The median radiosurgery dose was 80 Gy with a range of 60 to 90 Gy. Most patients had features of typical TN, although 16 (7.3%) described additional atypical features. One hundred thirty-five patients (61.4%) had prior surgery. Patients were followed to a maximum of 6.5 years (median, 2 years). Complete or partial pain relief was achieved in 85.6% of patients at 1 year. Complete pain relief was achieved in 64.9 % of patients at 6 months, 70.3% at 1 year, and 75.4% patients at 33 months. Patients with an atypical pain component had a lower rate of achieving pain relief (  $p = 0.025$ ). Due to recurrences, 55.8% of patients had complete or partial pain relief at 5 years. The absence of preoperative sensory disturbance or prior surgery correlated with an increased proportion of patients in complete or partial pain relief over time. Ten percent of patients developed new or increased subjective facial paresthesia or facial numbness. Radiosurgery for idiopathic TN was safe and effective, and provided benefit to a patient population with a high frequency of prior surgical intervention. It is an important addition to the surgical armamentarium for TN.

42.

**Year:** 2002

**Patient number:** 41

**Author:** Matsuda, Shinji; Serizawa, Toru; Sato, Makato; Ono, Junichi

**Reference:** Journal of neurosurgery, 97, 5Suppl, 525-8, 2002

**Title:** Gamma knife radiosurgery for trigeminal neuralgia: the dry-eye complication

**Abstract:** OBJECT: The purpose of this paper is to report a unique complication of

gamma knife radiosurgery (GKS) for trigeminal neuralgia (TN). The nature of this complication and its related factors are discussed. **METHODS:** Forty-one medically refractory patients with TN were treated with GKS. All patients received 80 Gy to the proximal trigeminal nerve root, using a 4-mm collimator and a single isocenter. Follow up consisted of three monthly outpatient sessions after GKS. Improvement, recurrence, complications, and changes in magnetic resonance imaging were recorded. To evaluate the factors behind the complications, a subgroup of 33 patients was assessed in whom the follow-up duration was more than 9 months. The follow-up duration was 3 to 36 months (mean 13 months). The results were excellent in 20 patients, good in 11, and fair in seven. No patient had a poor result. Three patients suffered recurrences. Seven patients suffered complications 9 to 24 months after GKS. All seven patients complained of facial numbness and hypesthesia was recorded. Three of them also complained of dry eye with diminution or absence of corneal reflex but no other abnormalities of the cornea and conjunctiva were found on ophthalmological examination. In these three patients, hypesthesia of the first division of the trigeminal nerve area had been found before their dry eye symptoms appeared. The irradiated volume on the brainstem was significantly related to this complication. **CONCLUSIONS:** The dry eye symptom seems to be a special form of sensory disturbance. An overdose of radiation to the brainstem may play an important role in the manifestation of this complication.

43.

**Year:** 2002

**Patient number:** 117

**Author:** Pollock, Bruce E.; Phuong, Loi K.; Gorman, Deborah A.; Foote, Robert L.; Stafford, Scott L.

**Reference:** Journal of neurosurgery, 97, 2, 347-53, 2002

**Title:** Stereotactic radiosurgery for idiopathic trigeminal neuralgia

**Abstract:**OBJECT: Each year a greater number of patients with trigeminal neuralgia (TN) undergo radiosurgery, including a large number of patients who are candidates for microvascular decompression (MVD). **METHODS:** The case characteristics and outcomes of 117 consecutive patients who underwent radiosurgery were retrieved from a prospectively maintained database. The mean patient age was 67.8 years; and the majority (58%) of patients had undergone surgery previously. The dependent variable for all analyses of facial pain was complete pain relief without medication (excellent outcome). Median follow-up duration was 26 months (range 1-48 months). The actuarial rate of achieving and maintaining an excellent outcome was 57% and 55% at 1 and 3 years, respectively, after radiosurgery. A greater percentage of patients who had not previously undergone surgery achieved and maintained excellent outcomes (67% at 1 and 3 years) than that of patients who had undergone prior surgery (51% and 47% at 1 and 3 years, respectively; relative risk (RR) = 1.77, 95% confidence interval (CI) 1.01-3.13,  $p = 0.04$ ). New persistent trigeminal dysfunction was noted in 43 patients (37%). Tolerable numbness or paresthesias occurred in 29 patients (25%), whereas bothersome dysesthesias developed in 14 patients (12%). Only a radiation dose of 90 Gy correlated with new trigeminal deficits or dysesthesias (RR = 3.10, 95% CI 1.64-5.81,  $p < 0.001$ ).

Excellent outcomes in patients with new trigeminal dysfunction were achieved and maintained at rates of 76% and 74% at 1 and 3 years, respectively, after radiosurgery, compared with respective rates of 46% and 42% in patients who did not experience postradiosurgery trigeminal dysfunction (RR = 4.53, 95% CI 2.03-9.95,  $p < 0.01$ ).  
**CONCLUSIONS:** Radiosurgical treatment provides complete pain relief for the majority of patients with idiopathic TN. There is a strong correlation between the development of new facial sensory loss and achievement and maintenance of pain relief after this procedure. Because the long-term results of radiosurgery still remain unknown, MVD should continue to be the primary operation for medically fit patients with TN.

44.

**Year:** 2002

**Patient number:** 15

**Author:** Rogers, C. Leland; Shetter, Andrew G.; Ponce, Francisco A.; Fiedler, Jeffrey A.; Smith, Kris A.; Speiser, Burton L.

**Reference:** Journal of neurosurgery, 97, 5Suppl, 529-32, 2002

**Title:** Gamma knife radiosurgery for trigeminal neuralgia associated with multiple sclerosis

**Abstract:**OBJECT: The authors assessed the efficacy and complications from gamma knife radiosurgery (GKS) for multiple sclerosis (MS)-associated trigeminal neuralgia (TN).  
METHODS: There were 15 patients with MS-associated TN (MS-TN). Treatment involved three sequential protocols, 70 to 90-Gy maximum dose, using a single 4-mm isocenter targeting the ipsilateral trigeminal nerve at its junction with the pons with the 50% isodose. Pain was appraised by each patient by using Barrow Neurological Institute (BNI) Scores I through IV: I, no pain; II, occasional pain not requiring medication; IIIa, no pain but continued medication; IIIb, some pain, controlled with medication; IV, some pain, not controlled with medication; and V, severe pain/no pain relief. With a mean follow up of 17 months (range 6-38 months), 12 (80%) of 15 patients experienced pain relief. Three patients (20%) reported no relief (BNI Score V). For responders, the mean latency from treatment to the onset of pain relief was 13 days (range 1-61 days). Maximal relief was achieved after a mean latency of 56 days (range 1-157 days). Five patients underwent a second GKS after a mean interval of 534 days (range 231-946 days). The mean maximum dose at this second treatment was 48 Gy. The target was unchanged from the first treatment. All five patients who underwent repeated GKS improved. Complications were limited to delayed facial hypesthesias. Two (13%) of 15 patients experienced onset of numbness after the first GKS, as well as two of five patients following a second GKS. The patients found this mild and not bothersome. Each patient who developed hypesthesias also experienced complete pain relief.  
**CONCLUSIONS:** Gamma knife radiosurgery is an effective treatment for

45.

**Year:** 2002

**Patient number:** 19

**Author:** Shetter, Andrew G.; Rogers, C. Leland; Ponce, Francisco; Fiedler, Jeffrey A.; Smith, Kris; Speiser, Burton L.

**Reference:** Journal of neurosurgery, 97, 5Suppl, 536-8, 2002

**Title:** Gamma knife radiosurgery for recurrent trigeminal neuralgia

**Abstract:**OBJECT: Pain may fail to respond or may recur after initial gamma knife radiosurgery (GKS) for trigeminal neuralgia (TN). The authors examined their experience with performing a second GKS procedure in these patients. METHODS: Twenty-nine patients underwent repeated GKS for TN at our institution between March 1997 and March 2002. Questionnaires were mailed to patients to assess the degree of their pain relief and the extent of facial numbness. Nineteen patients responded. All patients underwent repeated GKS involving a single 4-mm isocenter directed at the trigeminal nerve as it exited the brainstem (mean maximum dose 23.2 Gy). At a mean follow up of 13.5 months after the second procedure, 10 patients (53%) were pain free and medication free. Four patients (21%) were pain free but elected to continue medication in reduced dose, and two patients (11%) had incomplete but satisfactory pain control and were still taking medication. There was new-onset facial numbness in eight patients (42%), rated as tolerable in all instances. CONCLUSIONS: Patients with facial numbness had a greater likelihood of being pain free than those with no sensory loss. The authors observed no cases of corneal anesthesia, keratitis, or deafferentation pain.

46.

**Year:** 2001

**Patient number:** 15

**Author:** Alberico, R. A.; Fenstermaker, R. A.; Lobel, J.

**Reference:** AJNR. American journal of neuroradiology, 22, 10, 1944-8, 2001

**Title:** Focal enhancement of cranial nerve V after radiosurgery with the Leksell gamma knife: experience in 15 patients with medically refractory trigeminal neuralgia

**Abstract:**BACKGROUND AND PURPOSE: Gamma knife radiosurgery is an alternative for the treatment of medically refractory trigeminal neuralgia. Few reports of posttreatment MR imaging appearance of cranial nerve V exist. Our purpose was to define MR imaging characteristics in cranial nerve V after gamma knife radiosurgery. METHODS: We retrospectively reviewed MR images of 15 patients who underwent gamma knife radiosurgery for trigeminal neuralgia. Radiation doses were 35-45 Gy at the 50% isodose line. Thin-section T2-weighted images and contrast-enhanced and nonenhanced T1-weighted images were obtained the day of radiosurgery and within the next 5 mo. Images were scored for enhancement and hyperintensity on T2-weighted images. Time to follow-up imaging and radiation dose were recorded. RESULTS: Mean time to follow-up imaging was 61 +/- 29 d. Posttreatment T2-weighted images showed stable signal intensity in all cases, with radiosurgical target site enhancement in 10. All five patients whose images did not show treatment-related enhancement received radiation doses of 35 Gy. The data suggested a correlation between enhancement with radiation dose ( $P = .06$ ). No correlation of enhancement with treatment response or time to follow-up existed ( $P > .05$ ). CONCLUSION: The trigeminal nerve often enhances at the

target site after radiosurgery. Lack of trigeminal nerve enhancement occurred only with lower doses (35 Gy at 50%). MR imaging may be useful to confirm the presence and location of the treatment site after gamma knife radiosurgery for trigeminal neuralgia.

47.

**Year:** 2001

**Patient number:** 87

**Author:** Flickinger, J. C.; Pollock, B. E.; Kondziolka, D.; Phuong, L. K.; Foote, R. L.; Stafford, S. L.; Lunsford, L. D.

**Reference:** International journal of radiation oncology biology physics, 51, 2, 449-54, 2001

**Title:** Does increased nerve length within the treatment volume improve trigeminal neuralgia radiosurgery? A prospective double-blind, randomized study

**Abstract:** **PURPOSE:** To test the hypothesis that increasing the nerve length within the treatment volume for trigeminal neuralgia radiosurgery would improve pain relief.

**METHODS AND MATERIALS:** Eighty-seven patients with typical trigeminal neuralgia were randomized to undergo retrogasserian gamma knife radiosurgery (75 Gy maximal dose with 4-mm diameter collimators) using either one (n = 44) or two (n = 43) isocenters. The median follow-up was 26 months (range 1-36). **RESULTS:** Pain relief was complete in 57 patients (45 without medication and 12 with low-dose medication), partial in 15, and minimal in another 15 patients. The actuarial rate of obtaining complete pain relief (with or without medication) was 67.7% +/- 5.1%. The pain relief was identical for one- and two-isocenter radiosurgery. Pain relapsed in 30 of 72 responding patients. Facial numbness and mild and severe paresthesias developed in 8, 5, and 1 two-isocenter patients vs. 3, 4, and 0 one-isocenter patients, respectively (p = 0.23). Improved pain relief correlated with younger age (p = 0.025) and fewer prior procedures (p = 0.039) and complications (numbness or paresthesias) correlated with the nerve length irradiated (p = 0.018). **CONCLUSIONS:** Increasing the treatment volume to include a longer nerve length for trigeminal neuralgia radiosurgery does not significantly improve pain relief but may increase complications.

48.

**Year:** 2001

**Patient number:** 26

**Author:** Friedman, D. P.; Morales, R. E.; Goldman, H. W.

**Reference:** Journal of computer assisted tomography, 25, 5, 727-32, 2001

**Title:** Role of enhanced MRI in the follow-up of patients with medically refractory trigeminal neuralgia undergoing stereotactic radiosurgery using the gamma knife: initial experience

**Abstract:** **PURPOSE:** The purpose of this work was to evaluate the early posttreatment MR findings, and their clinical utility, in patients with trigeminal neuralgia undergoing stereotactic radiosurgery using the gamma knife. **METHOD:** Twenty-six patients with

medically refractory trigeminal neuralgia underwent stereotactic radiosurgery. A single dose of 70-90 Gy was administered to the proximal root entry zone (n = 21) or the retrogasserian portion (n = 5) of the trigeminal nerve. Posttreatment enhanced MRI and clinical assessment were performed at 3-6 months. **RESULTS:** Five patients did not have radiologic follow-up. There were no changes identified in the treated trigeminal nerve or adjacent brainstem in 19 of 21 patients. Two patients with multiple sclerosis developed abnormal signal and enhancement in the brainstem and/or trigeminal nerve; neither had clinical complications. Onset of therapeutic effect ranged from 3 weeks to 3 months; 19 patients had a beneficial response. **CONCLUSION:** Results of enhanced MRI 3-6 months after stereotactic radiosurgical treatment of trigeminal neuralgia do not correlate with the clinical response. Because beneficial clinical responses or treatment failures are apparent by 3 months, routine posttreatment MRI in these patients is not warranted.

49.

**Year:** 2001

**Patient number:** 275

**Author:** Jawahar, A.; Kondziolka, D.; Kanal, E.; Bissonette, D. J.; Lunsford, L. D.

**Reference:** Neurosurgery, 48, 1, 101-6, 2001

**Title:** Imaging the trigeminal nerve and pons before and after surgical intervention for trigeminal neuralgia

**Abstract:** **OBJECTIVE:** To study the various imaging changes occurring in the trigeminal nerve and brainstem in patients before or after trigeminal neuralgia surgery. **METHODS:** During a 7-year period, 275 patients with trigeminal neuralgia underwent high-resolution, contrast-enhanced magnetic resonance imaging (MRI) of the pons during gamma knife radiosurgery. Ninety-seven patients had no previous surgical intervention for trigeminal neuralgia, and 178 patients had undergone one or more previous procedures. Two independent observers, one of whom was blinded to patients' clinical details, reviewed MRI scans retrospectively. The analysis of the independent observers was then correlated with all previous therapeutic interventions. **RESULTS:** One hundred one MRI scans demonstrated no radiological changes related to trigeminal neuralgia, and 174 MRI scans exhibited some radiological abnormality. The average axial plane diameter of the nerve for all patients was 4 mm (range, 2-6 mm). In the group that had not undergone previous surgery, 65 patients (67%) exhibited vascular compression. In the 88 patients who had undergone previous microvascular decompression, 21 (24%) had evidence of a pontine infarction. Twenty-six patients experienced facial sensory loss, 22 (88%) of whom had undergone previous surgery with evidence of a pontine infarction (n = 11) or perineural scarring (n = 6). **CONCLUSION:** The majority of patients who had undergone previous trigeminal neuralgia surgery demonstrated readily identifiable abnormalities of the trigeminal nerve or brainstem. The frequency of such changes correlated with the type and number of procedures. Evidence of vascular compression was detected in the majority of patients. Most patients with postoperative facial sensory loss demonstrate changes in the nerve or pons on MR images.

50.

**Year:** 2001

**Patient number:** 220

**Author:** Maesawa, S.; Salame, C.; Flickinger, J. C.; Pirris, S.; Kondziolka, D.; Lunsford, L. D.

**Reference:** Journal of neurosurgery, 94, 1, 14-20, 2001

**Title:** Clinical outcomes after stereotactic radiosurgery for idiopathic trigeminal neuralgia

**Abstract:**OBJECT: Stereotactic radiosurgery is an increasingly used and the least invasive surgical option for patients with trigeminal neuralgia. In this study, the authors investigate the clinical outcomes in patients treated with this procedure. METHODS: Independently acquired data from 220 patients with idiopathic trigeminal neuralgia who underwent gamma knife radiosurgery were reviewed. The median age was 70 years (range 26-92 years). Most patients had typical features of trigeminal neuralgia, although 16 (7.3%) described additional atypical features. One hundred thirty-five patients (61.4%) had previously undergone surgery and 80 (36.4%) had some degree of sensory disturbance related to the earlier surgery. Patients were followed for a maximum of 6.5 years (median 2 years). Complete or partial relief was achieved in 85.6% of patients at 1 year. Complete pain relief was achieved in 64.9% of patients at 6 months, 70.3% at 1 year, and 75.4% at 33 months. Patients with an atypical pain component had a lower rate of pain relief ( $p = 0.025$ ). Because of recurrences, only 55.8% of patients had complete or partial pain relief at 5 years. The absence of preoperative sensory disturbance ( $p = 0.02$ ) or previous surgery ( $p = 0.01$ ) correlated with an increased proportion of patients who experienced complete or partial pain relief over time. Thirty patients (13.6%) reported pain recurrence 2 to 58 months after initial relief (median 15.4 months). Only 17 patients (10.2% at 2 years) developed new or increased subjective facial paresthesia or numbness, including one who developed deafferentation pain. CONCLUSIONS: Radiosurgery for idiopathic trigeminal neuralgia was safe and effective, and it provided benefit to a patient population with a high frequency of prior surgical intervention.

51.

**Year:** 2001

**Patient number:** 68

**Author:** Pollock, B. E.; Phuong, L. K.; Foote, R. L.; Stafford, S. L.; Gorman, D. A.

**Reference:** Neurosurgery, 49, 1, 58-62, 2001

**Title:** High-dose trigeminal neuralgia radiosurgery associated with increased risk of trigeminal nerve dysfunction

**Abstract:**OBJECTIVE: Stereotactic radiosurgery is being used with more frequency in the management of patients with trigeminal neuralgia. To improve facial pain outcomes, many centers have increased the prescribed radiation dose to the trigeminal nerve. METHODS: Between April 1997 and December 1999, 68 patients underwent radiosurgery for trigeminal neuralgia with use of the Leksell gamma knife (Elekta Instruments, Norcross, GA) and a single 4-mm isocenter of radiation. Twenty-seven patients (40%) received 70 Gy (low dose) of irradiation and 41 patients (60%) received 90

Gy (high dose). The groups were similar with regard to age, sex, duration of pain, number of prior surgeries, and preexisting trigeminal deficits. The primary facial pain outcomes for analysis were excellent (pain-free, no medications) and good (pain-free, reduced medications). The mean length of follow-up after radiosurgery was 14.4 months (range, 2-36 mo). **RESULTS:** At last follow-up examination, 11 (41%) of the 27 patients with low-dose radiosurgery remained pain-free compared with 25 (61%) of the 41 patients with high-dose radiosurgery ( $P = 0.17$ ). Additional surgery was performed in 12 low-dose patients (44%) and 8 high-dose patients (20%) ( $P = 0.05$ ). High-dose radiosurgery was associated with an increased rate of permanent trigeminal nerve dysfunction (54% versus 15%,  $P = 0.003$ ). Bothersome dysesthesias occurred in 13 high-dose patients (32%), whereas only 1 low-dose patient had this complication ( $P = 0.01$ ). Three high-dose patients (8%) developed corneal numbness after radiosurgery. Pain recurred with more frequency in patients not developing trigeminal nerve dysfunction after radiosurgery (9 of 22 patients, 41 %) compared with those who sustained facial numbness, paresthesias, or dysesthesias (4 of 27 patients, 15%); however, the difference was not statistically significant ( $P = 0.08$ ). **CONCLUSION:** Higher doses of radiation may correlate with better facial pain outcomes after radiosurgery for trigeminal neuralgia. However, the incidence of significant trigeminal nerve dysfunction is markedly increased after radiosurgery for patients receiving high-dose radiosurgery. Because of the nonselective nature of this ablative technique, dose prescription should be limited to less than 90 Gy.

52.

**Year:** 2001

**Patient number:** 53

**Author:** Régis, J.; Metellus, P.; Dufour, H.; Roche, P. H.; Muracciole, X.; Pellet, W.; Grisoli, F.; Peragut, J. C.

**Reference:** Journal of neurosurgery, 95, 2, 199-205, 2001

**Title:** Long-term outcome after gamma knife surgery for secondary trigeminal neuralgia  
**Abstract:**OBJECT: This study was directed to evaluate the potential role of gamma knife surgery (GKS) in the treatment of secondary trigeminal neuralgia (TN). The authors have identified three anatomicoclinical types of secondary TN requiring different radiosurgical approaches. **METHODS:** Pain control was retrospectively analyzed in a population of patients harboring tumors of the middle or posterior fossa that involved the trigeminal nerve pathway. This series included 53 patients (39 women and 14 men) treated using GKS between July 1992 and June 1997. The median follow-up period was 55 months. Treatment strategies differed according to lesion type, topography, and size, as well as visibility of the fifth cranial nerve in the prepontine cistern. Three different treatment groups were established. When the primary goal was treatment of the lesion (Group IV, 46 patients) we obtained pain cessation in 79.5% of cases. In some patients in whom GKS was not indicated for treatment of the lesion, TN was treated by targeting the fifth nerve directly in the prepontine cistern if visible (Group II, three patients) or in the part of the lesion including this nerve if the nerve root could not be identified (Group III, four patients). No deaths and no radiosurgically induced adverse effects were observed, but in two cases there was slight hypesthesia (Group IV). The neuropathic component of the

facial pain appeared to be poorly sensitive to radiosurgery. At the last follow-up examination, six patients (13.3%) exhibited recurrent pain, which was complete in four cases (8.8%) and partial in two (4.4%). **CONCLUSIONS:** The results of GKS regarding facial pain control are very similar to those achieved by microsurgery according to series published in the literature. Nevertheless, the low rate of morbidity and the greater comfort afforded the patient render GKS safer and thus more attractive.

53.

**Year:** 2001

**Patient number:** 80

**Author:** Zheng, L. G.; Xu, D. S.; Kang, C. S.; Zhang, Z. Y.; Li, Y. H.; Zhang, Y. P.; Liu, D.; Jia, Q.

**Reference:** Stereotactic and functional neurosurgery, 76, 1, 29-35, 2001

**Title:** Stereotactic radiosurgery for primary trigeminal neuralgia using the Leksell Gamma unit

**Abstract:** **OBJECTIVE:** Previous papers have reported Gamma Knife radiosurgery to be a safe, effective method for primary trigeminal neuralgia. Since November 1996, we have treated primary trigeminal neuralgia using the Leksell Gamma Knife at the Tianjin Medical University. The present study reports clinical results of Gamma Knife radiosurgery in the treatment of trigeminal neuralgia in 80 cases. **METHODS:** The mean patient age was 67 years (range 32-92), the mean duration of facial pain was 7.6 years (range 1.5-29). The male:female ratio was 31:49. The right side of the face was involved in 45 patients (56.25%) and the left side in 30 cases (37.5%), with bilateral involvement in 5 cases (6.25%). Under local anesthesia, all patients underwent stereotactic MRI to identify the trigeminal nerve. A single isocenter, using a 4-mm collimator, was positioned at the sensory root of the trigeminal nerve entry zone of the pons, 4-6 mm from the brainstem surface, so that no more than the 20% isodose was administered to the brainstem. The maximum dose was between 70 and 90 Gy, with a mean of 75.6 Gy. For bilateral trigeminal neuralgia, two separate matrices were employed, and bilateral Gamma Knife radiosurgery was performed on the same day. **RESULTS:** Follow-up ranged from 12 to 43 months (mean 23.7 months). Neurological evaluation indicated excellent response in 42 cases (52.5%), good response in 25 cases (31.25%), effective response in 8 cases (10%), so the total pain control rate was 93.75%. The latency from Gamma Knife surgery to pain relief ranged from 1 to 120 days (mean 22 days). Among the 75 patients 7 with pain control experienced pain recurrence 5-26 months after being completely free from pain. A second Gamma Knife radiosurgery was performed in 7 recurrent cases and 5 patients with treatment failure. A maximal dose ranging from 70 to 80 Gy was given (mean 74.2 Gy). After a mean follow-up of 18 months (8-33 months), 9 patients achieved excellent results, and 2 had good results. The latency interval to pain relief ranged from 1 to 120 days (mean 15 days). Nine patients developed new facial numbness, while no other complication appeared in the remainder of the patients. **CONCLUSIONS:** Gamma Knife radiosurgery is a safe and effective method in the treatment of trigeminal neuralgia once diagnosis is established. Copyright 2002 S. Karger AG, Basel.

54.

**Year:** 2000

**Patient number:** 172

**Author:** Brisman, R.

**Reference:** Journal of neurosurgery, 93, Suppl 3, 159-61, 2000

**Title:** Gamma knife radiosurgery for primary management for trigeminal neuralgia

**Abstract:**OBJECT: The purpose of this study was to assess the efficacy of gamma knife radiosurgery (GKS) as the primary rather than secondary management for trigeminal neuralgia. METHODS: Eighty-two patients underwent GKS as their first neurosurgical intervention (Group A), and 90 patients underwent GKS following a different procedure (Group B). All GKS patients were treated with a maximum dose of 75 Gy. The single 4-mm isocenter was placed close to the junction of the trigeminal nerve and the brainstem. Six-month follow up was available for 126 patients and 12-month follow up for 84 patients. Excellent (no pain and no medicine) or good (at least 50% reduction in pain and less medicine) relief was more likely to occur in Group A than in Group B patients 6 and 12 months following GKS for trigeminal neuralgia ( $p = 0.058$ ). Excellent or good results were also more likely in patients with trigeminal neuralgia without multiple sclerosis (MS) ( $p = 0.042$ ). The number and type of procedures performed prior to GKS, the interval between the last procedure and GKS, and the interval from first symptom to GKS (within Groups A and B) did not affect 6-month outcome. The interval between first symptom and GKS was shorter in Group A patients without MS (87 months) than in Group B (148 months;  $p < 0.004$ ). There were no significant differences between Group A and B patients with regard to sex, age, or laterality. CONCLUSIONS: Patients with trigeminal neuralgia who are treated with GKS as primary management have better pain relief than those treated with GKS as secondary management. Patients are more likely to have pain relief if they do not have MS.

55.

**Year:** 2000

**Patient number:** 126

**Author:** Brisman, R.; Mooij, R.

**Reference:** Journal of neurosurgery, 93, Suppl 3, 155-8, 2000

**Title:** Gamma knife radiosurgery for trigeminal neuralgia: dose-volume histograms of the brainstem and trigeminal nerve

**Abstract:**OBJECT: The purpose of this study was to assess the relationship between the volume of brainstem that receives 20% or more of the maximum dose (VB20) and the volume of the trigeminal nerve that receives 50% or more of the maximum dose (VT50) on clinical outcome following gamma knife radiosurgery (GKS) for trigeminal neuralgia (TN). METHODS: Patients with TN were treated with a single 4-mm isocenter with a maximum dose of 75 Gy directed at the trigeminal nerve close to where it leaves the brainstem. The VB20 and VT50, as determined on dose-volume histograms, were correlated with clinical outcomes at 6 and 12 months, laterality, presence of multiple

sclerosis (MS), and each other. At 6 months excellent pain relief (no pain or required medicine) was achieved in 27 of 48 patients ( $p = 0.009$ ) when VB20 was greater than or equal to 20 mm<sup>3</sup> and in 25 of 78 when VB20 was less than 20 mm<sup>3</sup>, when all patients are considered. At 12 months excellent pain relief was achieved in 16 of 32 patients ( $p = 0.038$ ) when VB20 was greater than or equal to 20 mm<sup>3</sup> and in 14 of 52 when VB20 less than 20 mm<sup>3</sup>, when all patients are considered. When VB20 was less than 20 mm<sup>3</sup> in MS patients, five of 21 had an excellent result at 6 months and two of 13 at 12 months. The VB20 was 20 mm<sup>3</sup> or more in 38 of 64 on the right side and in eight of 41 on the left side ( $p < 0.001$ ) in patients with TN and without MS. There is a difference between left and right dose-volume histograms even when the same isodose is placed on the surface of the brainstem. The VB20 was 20 mm<sup>3</sup> or more in 45 of 105 patients with TN and without MS but in only three of 21 patients with TN and MS ( $p = 0.014$ ). There was an inverse relationship between VB20 and VT50 ( $p = 0.01$ ). **CONCLUSIONS:** Isocenter proximity to the brainstem, as reflected in a higher VB20, is associated with a greater chance of excellent outcome at 6 and 12 months. Worse results in patients with TN and MS may be partly explained by a lower VB20.

56.

**Year:** 2000

**Patient number:** 53

**Author:** Chang, J. W.; Chang, J. H.; Park, Y. G.; Chung, S. S.

**Reference:** Journal of neurosurgery, 93, Suppl 3, 147-51, 2000

**Title:** Gamma knife radiosurgery for idiopathic and secondary trigeminal neuralgia

**Abstract:** **OBJECT:** The aim of this study was to identify pain relief and treatment morbidity following gamma knife radiosurgery (GKS) for idiopathic and secondary trigeminal neuralgia. **METHODS:** Between May 1992 and December 1999, 15 patients with idiopathic trigeminal neuralgia and 38 patients with secondary trigeminal neuralgia were treated with GKS. Pain improvement was achieved in 13 of the patients with idiopathic pain (pain response rate 86.7%). Seven patients were pain free and another six experienced pain reduction. There were no serious complications; however, two patients suffered a mild facial sensory change 8 months and 9 months, respectively, after GKS. The patients with secondary trigeminal neuralgia were divided into two groups (Group I, 32 patients in whom the trigeminal root entry zone (REZ) near the tumor could not be visualized; and Group II, six patients in whom the trigeminal REZ near the tumor or brainstem lesion could be visualized). In Group I, the pain subsided completely in eight patients and was reduced in seven (pain response rate 46.9%). In Group II, the pain subsided completely in one patient at 2.8 months and was reduced in three patients at a mean follow up of 0.8 months (range 0.6-1 month) after GKS. The pain response rate was 66.7%. **CONCLUSIONS:** The authors believe that GKS is an effective treatment modalities for idiopathic and secondary trigeminal neuralgia, particularly in patients with inoperable lesions.

57.

**Year:** 2000

**Patient number:** 42

**Author:** Nicol, B.; Regine, W. F.; Courtney, C.; Meigooni, A.; Sanders, M.; Young, B.

**Reference:** Journal of neurosurgery, 93, Suppl 3, 152-4, 2000

**Title:** Gamma knife radiosurgery using 90 Gy for trigeminal neuralgia

**Abstract:**OBJECT: The purpose of this paper was to assess the treatment of trigeminal neuralgia (TN) with the higher than normal dose of 90 Gy. METHODS: Forty-two patients with typical TN were treated over a 3-year period with gamma knife radiosurgery. Every patient received a maximum dose of 90 Gy in a single 4-mm isocenter targeted to the root entry zone of the trigeminal nerve. Thirty of 42 patients had undergone no prior treatments. The median follow-up period was 14 months (range 2-30 months). Thirty-one patients (73.8%) achieved complete relief of pain. Nine patients (21.4%) obtained good pain control. Complications were limited to increased facial paresthesia in seven patients (16.7%) and dysgeusia in four patients (9.5%). CONCLUSIONS: The authors conclude that the use of 90 Gy is a safe and effective dose for the treatment of TN.

58.

**Year:** 2000

**Patient number:** 10

**Author:** Pollock, B. E.; Foote, R. L.; Stafford, S. L.; Link, M. J.; Gorman, D. A.; Schomberg, P. J.

**Reference:** Journal of neurosurgery, 93, Suppl 3, 162-4, 2000

**Title:** Results of repeated gamma knife radiosurgery for medically unresponsive trigeminal neuralgia

**Abstract:**OBJECT: Gamma knife radiosurgery (GKS) is being increasingly performed in the management of patients with medically unresponsive trigeminal neuralgia. The authors report the results of repeated GKS in patients with recurrent facial pain after their initial procedure. METHODS: Between April 1997 and December 1999, 100 patients with idiopathic trigeminal neuralgia underwent GKS at the authors' center. To date, 26 patients have required additional surgery because GKS provided no significant pain relief (15 patients) or because they had recurrent facial pain (11 patients). Ten of these patients underwent repeated GKS at a median of 13 months (range 4-27 months). All patients undergoing repeated GKS had a significant reduction in their facial pain after the first procedure (eight were pain free); no patient developed facial numbness or paresthesias. Initially, nine of 10 patients became pain free 1 to 4 weeks following repeated GKS. At a median follow up of 15 months (range 3-32 months), eight patients remained pain free and required no medication. All eight patients with persistent pain relief developed minor neurological dysfunction after repeated GKS (six patients had facial numbness and two had paresthesias). CONCLUSIONS: Repeated GKS can be associated with a high rate of pain relief for patients with trigeminal neuralgia who experienced a significant reduction in their facial pain after the first operation. However, every patient with sustained pain relief after the second operation also developed some degree of trigeminal dysfunction. These findings of improved pain relief for patients who develop facial numbness after GKS for

trigeminal neuralgia support the experimental data currently available.

59.

**Year:** 2000

**Patient number:** 54

**Author:** Rogers, C. L.; Shetter, A. G.; Fiedler, J. A.; Smith, K. A.; Han, P. P.; Speiser, B. L.

**Reference:** International journal of radiation oncology biology physics, 47, 4, 1013-9, 2000

**Title:** Gamma knife radiosurgery for trigeminal neuralgia: the initial experience of The Barrow Neurological Institute

**Abstract:** **PURPOSE:** To assess the efficacy and complications of Gamma Knife radiosurgery for trigeminal neuralgia. **METHODS AND MATERIALS:** The Barrow Neurological Institute (BNI) Gamma Knife facility has been operational since March 17, 1997. A total of 557 patients have been treated, 89 for trigeminal neuralgia (TN). This report includes the first 54 TN patients with follow-up exceeding 3 months. Patients were treated with Gamma Knife stereotactic radiosurgery (RS) in uniform fashion according to two sequential protocols. The first 41 patients received 35 Gy prescribed to the 50% isodose via a single 4-mm isocenter targeting the ipsilateral trigeminal nerve adjacent to the pons. The dose was increased to 40 Gy for the remaining 13 patients; however, the other parameters were unvaried. Outcome was evaluated by each patient using a standardized questionnaire. Pain before and after RS was scored as level I-IV per our newly-developed BNI pain intensity scoring criteria (I: no pain; II: occasional pain, not requiring medication; III: some pain, controlled with medication; IV: some pain, not controlled with medication; V: severe pain/no pain relief). Complications, limited to mild facial numbness, were similarly graded by a BNI scoring system. **RESULTS:** Among our 54 TN patients, 52 experienced pain relief, BNI score I in 19 (35%), II in 3 (6%), III in 26 (48%), and IV in 4 (7%). Two patients (4%) reported no relief (BNI score V). Median follow-up was 12 months (range 3-28). Median time to onset of pain relief was 15 days (range 0-192), and to maximal relief 63 days (range 0-253). Seventeen (31%) noted immediate improvement ( $\leq$  24 h). Prior to RS, all patients were on pharmacologic therapy felt to be optimal or maximal. Twenty-two (41%) were able to stop medications entirely (BNI score I or II). Another 16 (30%), with BNI Score III relief, decreased medication intake by at least 50%. Patients with classical TN pain symptoms were more likely to stop medications than those with atypical features, 49% (21 of 43) versus 9% (1 of 11). This difference was significant at  $p = 0.040$ . Statistically, the finding most predictive for pain relief was new facial numbness following RS. Each of the 5 patients with new numbness after RS developed BNI score I relief, contrasting with 35% for the 49 patients with no new numbness ( $p = 0.019$ ). Complications have been limited to delayed, mild facial sensory loss. Before RS, 17 patients had numbness from prior invasive procedures, none of whom reported a worse numbness score after treatment. Thirty-seven patients had no facial numbness at the time of RS, of whom 5 developed facial hypesthesia. Each rated this as mild, not bothersome. There have been no other sequelae. **CONCLUSION:** RS is an effective treatment, and is the least invasive nonpharmacologic therapy for TN. It carries a small risk of mild facial hypesthesia, a side effect which, somewhat ironically,

may be desirable, because it appears to correlate favorably with an excellent pain response. We currently include radiosurgery among the appropriate options for TN patients who have failed optimal medical management, with or without prior invasive neurosurgical procedures. We present here BNI scoring systems for pain intensity and facial numbness. These have proved simple and reliable, have facilitated data collection, rendered analysis more objective, and improved our ability to discuss results with patients and colleagues.

60.

**Year:** 2000

**Patient number:** 16

**Author:** Urgosík, D.; Vymazal, J.; Vladyka, V.; Liscák, R.

**Reference:** Journal of neurosurgery, 93, Suppl 3, 165-8, 2000

**Title:** Treatment of postherpetic trigeminal neuralgia with the gamma knife

**Abstract:**OBJECT: Postherpetic neuralgia is a syndrome characterized by intractable pain. Treatment of this pain has not yet been successful. Patients with postherpetic neuralgia will therefore benefit from any progress in the treatment strategy. The authors performed gamma knife radiosurgery (GKS) as a noninvasive treatment for postherpetic trigeminal neuralgia (TN) and evaluated the success rate for pain relief. METHODS: Between 1995 and February 1999, six men and 10 women were treated for postherpetic TN; conservative treatment failed in all of them. The median follow up was 33 months (range 8-34 months). The radiation was focused on the root of the trigeminal nerve in the vicinity of the brainstem (maximal dose 70-80 Gy in one fraction, 4-mm collimator). The patients were divided into five groups according to degree of pain relief after treatment. A successful result (excellent, very good, and good) was reached in seven (44%) patients and radiosurgery failed in nine (56%). Pain relief occurred after a median interval of 1 month (range 10 days-6 months). No radiation-related side effects have been observed in these patients. CONCLUSIONS: These results suggest that GKS for postherpetic TN is a relatively successful and safe method that can be used in patients even if they are in poor condition. In case this method fails, other treatment options including other neurosurgical procedures are not excluded.

61.

**Year:** 1999

**Patient number:** 43

**Author:** Han, P. P.; Shetter, A. G.; Smith, K. A.; Fiedler, J. A.; Rogers, C. L.; Speiser, B.; Feiz, Erfan I.

**Reference:** Stereotactic and functional neurosurgery, 73, 1-4, 131-3, 1999

**Title:** Gamma knife radiosurgery for trigeminal neuralgia: experience at the Barrow Neurological Institute

**Abstract:**Forty-three patients with trigeminal neuralgia (TN) unresponsive to pharmacologic treatment and/or prior invasive procedures underwent stereotactic

radiosurgery with the Gamma Knife (GK). Outcome was evaluated by a standardized questionnaire mailed to each patient. The mean follow-up was 9 months. Fifteen patients (35%) reported no trigeminal pain and were no longer taking medication. Three patients (7%) experienced occasional pain, but were no longer taking medication. In 15 patients (35%), pain improved and was adequately controlled by medication, often in lower dosages than preoperatively. Pain was reduced in 9 patients (21%), but their symptoms were still inadequately controlled by drug therapy, and 1 patient (2%) reported no pain relief after treatment. Three patients (7%) described new facial numbness, but in none was this bothersome. GK radiosurgery for

62.

**Year:** 1999

**Patient number:** 20

**Author:** Pollock, B. E.; Gorman, D. A.; Schomberg, P. J.; Kline, R. W.

**Reference:** Mayo Clinic proceedings, 74, 1, 5-13, 1999

**Title:** The Mayo Clinic gamma knife experience: indications and initial results

**Abstract:**OBJECTIVE: To review the results and expectations of contemporary stereotactic radiosurgery. MATERIAL AND METHODS: We conducted a retrospective analysis of 1,033 consecutive patients who underwent gamma knife radiosurgery at Mayo Clinic Rochester between January 1990 and January 1998. RESULTS: The number of patients undergoing radiosurgery increased from 57 in 1990 to 216 in 1997. Of 97 patients with arteriovenous malformations who underwent follow-up angiography 2 years or more after a single radiosurgical procedure, 72 (74%) had complete obliteration of the vascular malformation. Of 209 patients who underwent radiosurgery for benign tumors (schwannomas, meningiomas, or pituitary adenomas) and had radiologic studies after 2 years or more of follow-up, tumor growth control was noted in 200 (96%). Tumor growth was also controlled in 90% of brain metastatic lesions at a median of 7 months after radiosurgery. Of 20 patients with trigeminal neuralgia and follow-up for more than 2 months, 14 (70%) were free of pain after radiosurgery. CONCLUSION: Radiosurgery is a safe and effective management strategy for a wide variety of intracranial disorders. Use of radiosurgical treatment should continue to increase as more data become available on the long-term results of this procedure.

63.

**Year:** 1999

**Patient number:** 16

**Author:** Régis, J.; Bartolomei, F.; Metellus, P.; Rey, M.; Genton, P.; Dravet, C.; Bureau, M.; Semah, F.; Gastaut, J. L.; Peragut, J. C.; Chauvel, P.

**Reference:** Neurosurgery clinics of North America, 10, 2, 359-77, 1999

**Title:** Radiosurgery for trigeminal neuralgia and epilepsy

**Abstract:**The role of Gamma Knife surgery in the field of functional surgery recently has evolved dramatically. For treatment of trigeminal neuralgia, Gamma Knife surgery is the

least invasive procedure, with a low rate of hypesthesia. If a rate of complete relief similar to that of other surgical techniques could be achieved, this approach will become one of the main techniques used to treat the disease initially. The authors present their experience with a group of 16 patients with mesial temporal lobe epilepsy who have been treated successfully (15 completely seizure-free and 1 with rare, nondisabling seizures) without significant complication. After additional follow-up to demonstrate the absence of long-term consequences, this fascinating new approach could change epilepsy surgery practice dramatically.

64.

**Year:** 1998

**Patient number:** 23

**Author:** Kondziolka, D.; Lunsford, L. D.; Flickinger, J. C.

**Reference:** Stereotactic and Functional Neurosurgery, 70, SUPPL. 1, 187-191, 1998

**Title:** Gamma knife radiosurgery as the first surgery for trigeminal neuralgia

**Abstract:** To evaluate the role of Gamma Knife radiosurgery as the first surgical therapy in the management of medically refractory trigeminal neuralgia, we reviewed outcomes on our first 23 patients who had radiosurgery as primary surgical therapy. These patients represented 19% of our overall series. Mean patient age was 66 years, and mean follow-up after radiosurgery was 12 months (range 5-33 months). For most patients, radiosurgery was performed because the patient had medical contraindications to open surgery. 14 patients had 70-Gy radiosurgery, and 9 patients, 80 Gy. Radiosurgery was performed using a single 4-mm isocenter. Postoperative imaging 6 to 9 months following radiosurgery confirmed regions of enhancement at the radiosurgical target. Nine patients received 70 Gy, and 8 patients had 80 Gy. 17 patients (74%) had an excellent result (total pain relief). Five patients (22%) achieved a good result (50-90% improvement). One patient had a poor result (4%) after 70-Gy radiosurgery and subsequently underwent microvascular decompression. No patient developed facial numbness or any other complication after Gamma Knife radiosurgery. Gamma Knife radiosurgery using 70 or 80 Gy targeted to the proximal trigeminal nerve proved to be a safe and effective primary surgical therapy for medically refractory trigeminal neuralgia. The overall response rate (96%) was similar to that obtained with other surgical therapies performed as a first procedure.

65.

**Year:** 1998

**Patient number:** 106

**Author:** Kondziolka, D.; Perez, B.; Flickinger, J. C.; Habeck, M.; Lunsford, L. D.

**Reference:** Archives of neurology, 55, 12, 1524-9, 1998

**Title:** Gamma knife radiosurgery for trigeminal neuralgia: results and expectations

**Abstract:** BACKGROUND: Trigeminal neuralgia is a disabling pain syndrome responsive to both medical and surgical therapies. Stereotactic radiosurgery using the gamma knife

can be used to inactivate a specified volume in the brain by cross firing 201 photon beams. We evaluated pain relief and treatment morbidity after trigeminal neuralgia radiosurgery. **METHODS:** All evaluable patients (n = 106) had medically or surgically refractory trigeminal neuralgia. A single 4-mm isocenter of radiation was focused on the proximal trigeminal nerve just anterior to the pons. For follow-up an independent physician who was unaware of treatment parameters contacted all patients. **RESULTS:** After radiosurgery, 64 patients (60%) became free of pain and required no medical therapy (excellent result), 18 (17%) had a 50% to 90% reduction (good result) in pain severity or frequency (some still used medications), and 9 (9%) had slight improvement. At last follow-up (median, 18 months; range, 6-48 months), 77% of patients maintained significant relief (good plus excellent results). Only 6 (10%) of 64 patients who initially attained complete relief had some recurrent pain. Radiosurgery dose (70-90 Gy), age, surgical history, or facial sensory loss did not correlate with pain relief. Poorer results were found in patients with multiple sclerosis. Twelve patients developed new or increased facial paresthesias after radiosurgery (10%). No patient developed anesthesia dolorosa. There was no other procedural morbidity. **CONCLUSIONS:** Gamma knife radiosurgery is a minimally invasive technique to treat trigeminal neuralgia. It is associated with a low risk of facial paresthesias, an approximate 80% rate of significant pain relief, and a low recurrence rate in patients who initially attain complete relief. Longer-term evaluations are warranted. Grant ID: K08NS01723, Acronym: NS, Agency: NINDS.

66.

**Year:** 1998

**Patient number:** 53

**Author:** Regis, J.; Metellus, P.; Lazorthes, Y.; Porcheron, D.; Peragut, J. C.

**Reference:** Stereotactic and Functional Neurosurgery, 70, SUPPL. 1, 210-217, 1998

**Title:** Effect of gamma knife on secondary trigeminal neuralgia

**Abstract:** The following study was conducted to evaluate the results of Gamma Knife stereotactic radiosurgery in the management of secondary trigeminal neuralgia. 53 patients suffering from secondary trigeminal neuralgia were studied and the results reported. We defined four therapeutic groups: group I correspond to essential trigeminal neuralgia. The primary aim was tumor control in group IV and pain cessation in group III and II (visualization of the fifth nerve root was possible in group II but not in group III). The target dose of the radiosurgery used in the current study varied from 20 to 40 Gy in group III and IV and from 70 to 90 Gy in group I and II. At short-term follow-up, 37 patients (74%) were pain-free, 9 patients (18%) were improved (50%-90% relief) and only 4 patients (8%) experienced treatment failure. Among the patients with early treatment success, 10 patients experienced a complete recurrence of pain in the four succeeding years, and 11 initially painfree patients deteriorated to partial pain relief. The median time to pain relief was three months (range 1 day to 1 year). The mean follow-up was 32 months (range 7 to 60 months). No patient developed increased facial pain or deafferentation pain. Among the 53 patients, only two exhibit a slight facial hypesthesia and one patient described motor fasciculation related to Gamma Knife treatment. In our experience Gamma Knife

surgery appears a safe and effective method for the treatment of secondary trigeminal neuralgia.

67.

**Year:** 1998

**Patient number:** 49

**Author:** Urgosik, D.; Vymazal, J.; Vladyka, V.; Liscak, R.

**Reference:** Stereotactic and Functional Neurosurgery, 70, SUPPL. 1, 200-209, 1998

**Title:** Gamma knife treatment of trigeminal neuralgia: Clinical and electrophysiological study

**Abstract:** Between October 1995 and October 1996, we treated 49 patients suffering from trigeminal neuralgia with Gamma Knife radiosurgery. There were 23 males and 26 females. The mean age was 68 (range 38-94 years). The root of the trigeminal nerve close to brain stem was chosen as the target. The maximum dose was 70 Gy in 24 cases and 80 Gy in 25 cases. A single shot with the 4-mm collimator was used. 13 patients underwent Gamma Knife treatment of trigeminal nerve root without any previous surgical procedures. 31 patients suffered from an essential neuralgia (EN), while 7 had neuralgia related to multiple sclerosis (MS). Three had atypical neuralgia (AN) and 8 patients had postherpetic neuralgia (PN). Patients were divided into five groups according to pain reduction. The success rate of pain relief (excellent, very good and good responses) in these patients was: EN 77% of patients, MS 43%, AN 33% and PN 38% of patients. Pain relief occurred after latent intervals of between 1 day and 8 months (median 2 months and mean 2.8 months). Clinically detected complications after radiosurgery occurred only in the form of tactile hypesthesia in 6%. In a selected group of 18 patients, we observed slight electrophysiological changes in 2 patients (11%) after Gamma Knife treatment.

68.

**Year:** 1998

**Patient number:** 110

**Author:** Young, R. F.; Vermeulen, S.; Posewitz, A.

**Reference:** Stereotactic and Functional Neurosurgery, 70, SUPPL. 1, 192-199, 1998

**Title:** Gamma knife radiosurgery for the treatment of trigeminal neuralgia

**Abstract:** One hundred and ten patients with trigeminal neuralgia were treated with the Gamma Knife using a single isocenter, the 4 mm secondary collimator helmet and a radiosurgical dose maximum of 70 or 80-Gy. The isocenter was placed at the trigeminal sensory root adjacent to the pons as identified on stereotactic MRI scans. Follow-up periods range from 4-49 months (mean 19.8 months). Initial pain relief was achieved in 95.5% of patients with typical trigeminal neuralgia symptoms, who had not had prior surgical intervention, and only 3.3% of these patients experienced recurrent pain during the followup period. Patients with atypical features to their pains or who had prior unsuccessful surgical attempts to relieve their pains achieved initial and long-term pain relief in 88 and 69%, respectively. Three patients (2.7%) developed delayed loss of facial

sensation following treatment, but no other complications of any kind were noted. We believe that Gamma Knife radiosurgery is the safest and most effective form of treatment which is currently available for trigeminal neuralgia. We recommend early radiosurgical treatment of trigeminal neuralgia once the diagnosis is clearly established.

69.

**Year:** 1997

**Patient number:** 12

**Author:** Rand, R. W.

**Reference:** Neurosurgery clinics of North America, 8, 1, 75-8, 1997

**Title:** Leksell Gamma Knife treatment of tic douloureux

**Abstract:** Stereotactic radiosurgery with the Leksell Gamma Knife under local anesthesia can effectively treat patients with recurrent tic douloureux after unsuccessful medical/surgical procedures. Eight of 12 patients have shown complete relief or improvement of their trigeminal neuralgia after 3 to 4 year follow-up. No complications have been observed, with the exception of 1 patient who developed a small area of radionecrosis in the medial temporal lobe.

70.

**Year:** 1997

**Patient number:** 51

**Author:** Young, R. F.; Vermeulen, S. S.; Grimm, P.; Blasko, J.; Posewitz, A.

**Reference:** Neurology, 48, 3, 608-14, 1997

**Title:** Gamma Knife radiosurgery for treatment of trigeminal neuralgia: idiopathic and tumor related

**Abstract:** Sixty patients with trigeminal neuralgia who did not have a response to pharmacologic treatment (including 22 who had no response to conventional surgical treatment) underwent stereotactic radiosurgical treatment with the Leksell Gamma Knife. A radiosurgical maximum dose of 70 Gy was delivered to the trigeminal nerve root adjacent to the pons via a 4-mm collimator helmet in 51 patients who presented with trigeminal neuralgia unrelated to tumors. In these patients, the root was localized by stereotactic MRI. Follow-up assessment of pain relief was accomplished by a third party not involved in the patients' clinical care. Within a latency period of 1 day to 4 months following the treatment, 38 of 51 patients (74.5%) were completely free of pain and eventually all medications were tapered off. An additional seven patients (13.7%) experienced reductions in pain from 50 to 90% and utilized little or no medications. Patients who had no prior surgical intervention fared much better than those who had previous surgery to relieve their facial pains. At last follow-up, a mean of 16.3 months (range 6-36 months) after treatment, 41 patients (80.4%) remained pain-free or had marked pain reduction. There were four patients with recurrent pain. All 26 patients with classical symptoms of trigeminal neuralgia with no atypical features who had no prior surgery, had complete or nearly complete pain relief, and none of these patients had

recurrent pain. Nine patients with trigeminal neuralgia due to tumors received standard radiosurgical treatment directed at their tumors, and eight of nine (88.8%) had pain relief. Of the total of 60 patients treated for trigeminal neuralgia, 49 (81.7%) experienced complete or nearly complete relief of pain at last follow-up. Only one patient with pre-existing facial sensory loss due to a tumor had a mild increase in facial numbness. No other patient experienced either loss of facial sensation or any other complication. Gamma Knife radiosurgery appears to be a minimally invasive, safe, and effective therapy of trigeminal neuralgia.

71.

**Year:** 1996

**Patient number:** 51

**Author:** Kondziolka, D.; Flickinger, J. C.; Lunsford, L. D.; Habeck, M.

**Reference:** Stereotactic and functional neurosurgery, 66, Suppl 1, 343-8, 1996

**Title:** Trigeminal neuralgia radiosurgery: the University of Pittsburgh experience

**Abstract:** The results of Gamma Knife stereotactic radiosurgery in the management of 51 patients who had typical trigeminal neuralgia were evaluated at the University of Pittsburgh. In all cases, a 4-mm isocenter was targeted at the proximal nerve at the root entry zone. The target dose varied from 60 to 90 Gy. Forty-four patients (86%) had undergone prior surgery. The mean follow-up after radiosurgery was 9.6 months (range, 2-29 months). The initial response rate was 86%. At the last follow-up, 19 patients (37%) had excellent control (pain free), 21 (41%) had good control (50-90% relief), and 11 (21%) had failed treatment. No patient developed further sensory loss or deafferentation pain. A maximum radiosurgery dose  $\geq$  70 Gy was associated with a significantly greater chance for complete pain relief. Using magnetic resonance imaging stereotactic targeting, the proximal trigeminal nerve is an appropriate anatomic target for radiosurgery. Gamma Knife radiosurgery is a useful additional surgical approach in the management of medically or surgically refractory trigeminal neuralgia.

72.

**Year:** 1996

**Patient number:** 50

**Author:** Kondziolka, D.; Lunsford, L. D.; Flickinger, J. C.; Young, R. F.; Vermeulen, S.; Duma, C. M.; Jacques, D. B.; Rand, R. W.; Regis, J.; Peragut, J. C.; Manera, L.; Epstein, M. H.; Lindquist, C.

**Reference:** Journal of neurosurgery, 84, 6, 940-5, 1996

**Title:** Stereotactic radiosurgery for trigeminal neuralgia: a multiinstitutional study using the gamma unit

**Abstract:** A multiinstitutional study was conducted to evaluate the technique, dose-selection parameters, and results of gamma knife stereotactic radiosurgery in the management of trigeminal neuralgia. Fifty patients at five centers underwent radio-surgery performed with a single 4-mm isocenter targeted at the nerve root entry

zone. Thirty-two patients had undergone prior surgery, and the mean number of procedures that had been performed was 2.8 (range 1-7). The target dose of the radiosurgery used in the current study varied from 60 to 90 Gy. The median follow-up period after radiosurgery was 18 months (range 11-36 months). Twenty-nine patients (58%) responded with excellent control (pain free), 18 (36%) obtained good control (50%-90% relief), and three (6%) experienced treatment failure. The median time to pain relief was 1 month (range 1 day-6.7 months). Responses remained consistent for up to 3 years postradiosurgery in all cases except three (6%) in which the patients had pain recurrence at 5, 7, and 10 months. At 2 years, 54% of patients were pain free and 88% had 50% to 100% relief. A maximum radiosurgical dose of 70 Gy or greater was associated with a significantly greater chance of complete pain relief (72% vs. 9%,  $p = 0.0003$ ). Three patients (6%) developed increased facial paresthesia after radiosurgery, which resolved totally in one case and improved in another. No patient developed other deficits or deafferentation pain. The proximal trigeminal nerve and root entry zone, which is well defined on magnetic resonance imaging, is an appropriate anatomical target for radiosurgery. Radiosurgery using the gamma unit is an additional effective surgical approach for the management of medically or surgically refractory trigeminal neuralgia. A longer-term follow-up review is warranted. Grant ID: 1 K08 NS01723-01, Acronym: NS, Agency: NINDS.

73.

**Year of Conference:** 1996

**Patient number:** 26

**Author:** Mark, Rufus J.; Duma, Christopher M.; Jacques, Dean B.; Kopyov, Oleg V.; Copcutt, Brian

**Reference:** Conference title: 38th Annual Meeting of the American Society for Therapeutic Radiology and Oncology, October 27-30, 1996, Los Angeles, California, USA., 36, 194, 1996

**Title:** Intractable trigeminal neuralgia: A single institution experience in 26 patients treated with stereotactic gamma knife radiosurgery

74.

**Year:** 1996

**Patient number:** 19

**Author:** Young, R. F.

**Reference:** Stereotactic and functional neurosurgery, 66, 1-3, 19-23, 1996

**Title:** Functional neurosurgery with the Leksell Gamma knife

**Abstract:** Sixty patients underwent a total of 64 separate Gamma Knife radiosurgical procedures for treatment of a variety of functional disorders between July 1992 and February 1995. Thirty-four patients with intractable pain received unilateral (32 patients) or bilateral (2 patients) lesions in the intralaminar thalamus. Twenty-nine patients with facial pain, including 19 with typical trigeminal neuralgia, 8 with facial pain due to tumors

involving the trigeminal nerve and 2 with other forms of facial pain, were also treated. Five patients with Parkinson's disease underwent pallidotomy (2) or thalamotomy (3) with the Gamma Knife and 2 patients with non- Parkinson's tremor were also treated with gamma-thalamotomy. The rate of improvement or resolution of the functional disorders was similar to that seen with other forms of surgical therapy. No immediate complications were seen, but 4 patients who underwent thalamotomy for pain developed delayed transient complications and 1 death was seen following bilateral thalamotomy.

75.

**Year:** 1995

**Patient number:** 20

**Author:** Régis, J.; Manera, L.; Dufour, H.; Porcheron, D.; Sedan, R.; Peragut, J. C.

**Reference:** Stereotactic and functional neurosurgery, 64, Suppl 1, 182-92, 1995

**Title:** Effect of the Gamma Knife on trigeminal neuralgia

**Abstract:** The Gamma Knife radiosurgical treatment of 20 patients suffering from trigeminal neuralgia is reported. Eleven patients received radiosurgical treatment with the goal of pain relief. Six had secondary trigeminal neuralgia due to AVM, large cavernous sinus and petrous bone meningiomas, trigeminal neurinoma, or chordoma; 5 others had essential trigeminal neuralgia. Radiosurgical treatment was considered only after the failure of conventional medical and surgical treatment. For the other 9 patients, the control of the tumor was the main objective (four acoustic and one trigeminal neurinoma, one petroclival chordoma, and three tumors of the cavernous sinus: one hemangiopericytoma, one metastasis, one meningioma). We have not been using this method for sufficient time to evaluate long-term results. However, we believe that a large majority of our patients benefited greatly from this technique with a rapid clinical improvement, which is a reflection of the relevance of the chosen target.