Single Fraction Radiosurgery for the Treatment of Renal Tumors

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Purpose: High dose local stereotactic radiosurgery was performed in select patients to improve local tumor control and overall survival. We report on patients with renal tumors treated with single fraction robotic stereotactic radiosurgery.

Materials and Methods: A total of 40 patients with a median age of 64 years who had an indication for nephrectomy and subsequent hemodialysis were entered in a prospective case-control study of single fraction stereotactic radiosurgery. Of the patients 11 had transitional cell cancer and 29 had renal cell cancer. Tumor response, renal function, survival and adverse events were estimated every 3 months. Followup was at least 6 months.

Results: A total of 45 renal tumors were treated. Median followup was 28.1 months (range 6.0 to 78.3). The local tumor control rate 9 months after stereotactic radiosurgery was 98% (95% CI 89–99). There was a measurable size reduction in 38 lesions, including complete remission in 19. Renal function remained stable. Using the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) equation median creatinine clearance was 76.8 (range 25.3 to 126.3) and 70.3 ml/minute/1.73 m^2 (range 18.6 to 127.3) at baseline and followup, respectively ($p = 0.89$). Grade I erythrodermia developed in 1 patient, 3 reported grade I fatigue and 2 reported grade I nausea. Nephrectomy was avoided in all cases.

Conclusions: Single fraction stereotactic radiosurgery as an outpatient procedure is a treatment modality with short-term safety and efficacy. It avoids treatment related loss of renal function and hemodialysis in select patients with transitional or renal cell cancer. At short followup oncologic results were similar to those of other ablative techniques for renal tumors. To date functional results have been excellent. Further studies are needed to determine the long-term results and limits of stereotactic radiosurgery in this setting.

Key Words: kidney; carcinoma, renal cell; carcinoma, transitional cell; robotics; radiosurgery

Abbreviations and Acronyms

RCC = renal cell carcinoma

RECIST = Response Evaluation Criteria in Solid Tumors

SRS = stereotactic radiosurgery

TCC = transitional cell carcinoma

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THE gold standard treatment for renal masses is surgical removal with preservation of the surrounding healthy renal parenchyma when technically feasible. Progress in technology recently led to effective minimally invasive surgical approaches to renal tumor removal, including laparoscopy and robot-assisted surgery.[1]

Limited therapeutic options exist for bilateral tumors or a contralateral

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recurrent tumor after unilateral nephrectomy or nephroureterectomy. Radical surgical removal leads to chronic hemodialysis with impaired quality of life and decreased overall survival. Although partial nephrectomy is a valid treatment option for RCC, complex intrarenal tumors carry a high risk of loss of renal function despite attempted nephron sparing surgery. In TCC of the upper urinary tract excellent tumor control can be achieved by endoscopic surgery for limited noninvasive disease. However, in cases of extensive disease or an invasive tumor nephroureterectomy remains the only effective oncologic treatment option, leading to hemodialysis in singular renal units or impaired renal function in bilateral disease.[2]

We recently reported on a patient with pT2 G3 TCC of the renal pelvis in a single renal unit after contralateral nephroureterectomy was performed 30 years ago who was treated with single session robotic radiosurgery in an effort to avoid hemodialysis.[3] To our knowledge this was the first report of radiosurgery for TCC of the renal pelvis system. Encouraging results in this patient led to the current prospective, case-control series in patients with impaired renal function in whom nephron sparing surgical removal of a renal tumor was not feasible or nephrectomy of a single renal unit was the only treatment option.

MATERIALS AND METHODS

A total of 40 eligible patients with surgically untreatable renal tumors seen at the Department of Urology, Grosshadern Hospital, University of Munich were entered in a prospective study between December 2007 and May 2011. Institutional review board approval was granted and all patients provided written informed consent. All patients were treated at a single session. Of the patients 35 were male and median age was 65.6 years. Median ± SD time from initial renal tumor diagnosis to SRS was 48.9 ± 55.8 months. A total of 15 men and no women had TCC, and 26 and 4, respectively, had RCC. In those with TCC and RCC median age was 71.5 (range 51.4 to 85.4) and 63.6 years (range 43.6 to 86.4), and median tumor volume was 42.0 (range 25.0 to 77.6) and 33.7 cm^2 (range 7.5 to 120.0), respectively. Grade was 1, 2 and 3 in 4, 3 and 8 patients with TCC, respectively. Of patients with RCC Fuhrman grade was 1 to 3 in 7, 14 and 9, the R.E.N.A.L. (radius, exophytic/endophytic, nearness of tumor to collecting system or sinus, anterior/posterior, hilar tumor touching main renal artery or vein and location relative to polar lines)[4] proximity score was anterior in 3, posterior in 15 and none in 12, and the R.E.N.A.L. complexity score was low (4 to 6) in none, moderate (7 to 9) in 16 and high (10 to 12) in 14, respectively.

Histological specimens were obtained from all patients. In 12 patients the renal tumor was TCC while 21 had primary RCC. Clear cell histology was noted in 20 patients while 1 had type II papillary renal cell cancer. After nephrectomy of the contralateral kidney a single renal unit remained in 29 patients. Four patients had 2 kidneys but were not candidates for surgery.

Only patients with an ECOG (Eastern Cooperative Oncology Group) status of 0 or 1 and a life expectancy of more than 1 year were treated with SRS. Patients in whom lesions could have been removed locally by surgery were not included in analysis. The renal lesions had to be less than 4 cm in diameter due to the technical limitations of SRS with the CyberKnife® system used. Before SRS 3 gold fiducials were planted in the renal parenchyma under ultrasound guidance as an outpatient procedure using local anesthesia. Before treatment all patients received 4 mg dexamethasone and 8 mg ondansetron prophylactically against nausea. All tumors were treated with a 25 Gy dose in a single fraction to the 70% isodose.

Radiosurgery System

The CyberKnife robotic radiosurgery system consists of a 6-MV compact linear accelerator mounted on a computer controlled, 6-axis robotic manipulator. Integral to the system are orthogonally positioned x-ray cameras, which acquire images during treatment. The images are processed automatically to identify radiographic features and documented in the treatment planning study to measure the position of the treatment site in real time. The system adapts to changes in patient position during treatment by repeatedly acquiring targeting images and adjusting the direction of the treatment beam accordingly. The treatment beam can be directed from multiple angles anterior and lateral to the patient (fig. 1). SRS radiation is administered as an outpatient procedure with no anesthesia.

Respiratory Motion Compensation

To compensate for renal tumor motion it is necessary to know the internal position of the target throughout treatment. At any given time the stereo x-ray system acquires

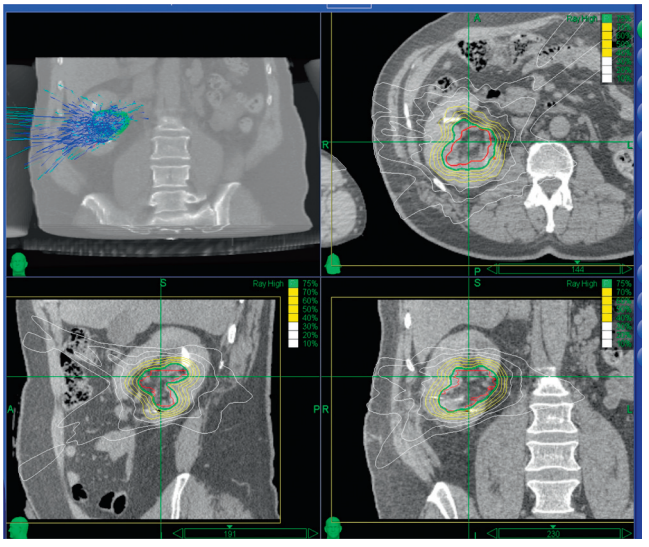

Figure 1. Planning SRS treatment with 19 Gy to 75th percentile in patient with 39 cm TCC.