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ORIGINAL ARTICLE

Long-term outcomes of microwave versus radiofrequency ablation for hepatocellular carcinoma by surgical approach: A retrospective comparative study

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KEYWORDS
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Summary *Background:* Both microwave ablation (MWA) and radiofrequency ablation (RFA) are commonly employed local ablation techniques for malignant liver tumors. However, comparative data on long-term results between these two techniques is scarce in the literature.
Methods: This is a retrospective comparative study between MWA and RFA for hepatocellular carcinoma (HCC) using surgical approach.
Results: The MWA group consisted of 26 patients while the RFA group consisted of 47 case-matched patients. The two groups were comparable, except patients were older and their platelet count was lower in the MWA group. The median follow-up period was 47.5 months in MWA group and 52.9 months in RFA group ($p = 0.322$). There was no difference in 5-year overall survival (MWA 73.1%, RFA 46.3%, $p = 0.082$) and 5-year disease free survival (MWA 13.8%, RFA 14.6%, $p = 0.736$). When a subgroup analysis of tumors $\geq$ 3.5 cm was performed, there were 16 patients in the MWA group and 21 patients in the RFA group, the 5-year overall and disease-free survival were MWA 75.0%, RFA 28.6% ($p = 0.022$) and MWA 25.0%, RFA 4.8% ($p = 0.207$), respectively.

Conflicts of interest: All authors have no conflicts of interest to declare.

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Conclusion: MWA is comparable to RFA for HCC in terms of long-term outcomes. For tumors $\geq$ 3.5 cm, MWA is associated with a better overall 5-year survival.

1. Introduction

Local ablation therapy is now recognized as a form of curative treatment for hepatocellular carcinoma (HCC).[1–3] Amongst others, two commonly used local ablation therapies are radiofrequency ablation (RFA) and microwave ablation (MWA).[4–7] Initial studies on RFA or MWA for liver tumors mostly reported on short-term treatment efficacy such as complete tumor ablation rate and short-term local recurrence rate while the results of long-term outcomes are lacking. Furthermore, comparative data on long-term results between these two techniques are scarce in the literature. Here we would like to report our experience on the use of RFA and MWA for HCC by surgical approach (by laparoscopy or laparotomy) and perform a retrospective comparative study between them.

2. Methods

RFA has been used for ablation of malignant liver tumors in our institute since 2003. The RFA needle used was either the cool-tip radiofrequency ablation needle (Covidien, Fridley, MN, USA) or the LeVeen needle (Boston Scientific, Natick, MA, USA). The needle was inserted into the tumor either percutaneously, laparoscopically, or by open laparotomy. In general, the laparoscopic or open approach was only adopted when the percutaneous approach was not feasible due to close proximity of the tumor to hollow viscera or the diaphragm. The laparoscopic approach again was considered before the open approach unless the tumor was difficult for laparoscopic ablations such as tumors located in the superoposterior segments of the liver or patients not suitable for laparoscopic procedure. In some cases, open RFA was done for patients presenting for liver resection who were found to be unresectable on the operating table. The initial results of RFA for malignant liver tumors has been reported previously.[8]

In 2009, we started a program of MWA for HCC with funding from a local charity organization. The model of MWA used was a 2.45-GHz microwave machine (Microsulis Medical Ltd, Waterlooville, Hants, UK). Because the microwave antenna supplied at that period was 5 mm in size, we only applied MWA by laparoscopy or by open laparotomy. Again, the laparoscopic approach would always be considered before the open approach, except in cases when patients were opened up with the intention for liver resection but were found to be inoperable on the operating table.

Between March 2009 and January 2011, 26 consecutive patients with a diagnosis of HCC were recruited for MWA. The diagnosis was based on histology or the typical imaging appearance and raised α-fetal protein (AFP) according to the criteria of the European Association for the Study of Liver: cirrhotic patients with two images showing focal lesion $>$ 2 cm with arterial hypervascularization or one image showing focal lesion $>$ 2 cm with arterial hypervascularization together with AFP $>$ 400 mg/mL. The indications for MWA were: unresectable tumor; resectable tumor but patient preferred local ablation treatment to hepatectomy; tumor not feasible for percutaneous RFA; and no macroscopic vascular or bile duct invasion by the tumor. We limited the use of MWA to patients with a maximum of two tumors and size of tumor up to 6 cm. Recurrent tumor after previous treatment was not considered a contraindication for MWA. The short-term treatment outcomes of this group of patients have been reported previously.[9]

Between May 2003 and January 2011, a total of 219 patients underwent RFA treatment for malignant liver tumors in our institute. To match the patient characteristics of the MWA group, we only selected patients who underwent RFA treatment for HCC using surgical approach, with tumors larger than 2 cm but smaller than 6 cm, and excluded patients with more than two tumor nodules. Patients with concomitant hepatectomy were also excluded. Finally, there were 47 patients in the RFA arm for analysis. Figure 1 shows how the cohort of RFA was generated.

2.1. Ablation techniques

For MWA, the procedure was done in the operating theatre under general anesthesia. Prophylactic antibiotics were given as a routine. Any coagulopathy if present was corrected before procedure. If tumor location was favorable, the tumor would be ablated via the laparoscopic route, otherwise open laparotomy via a right subcostal incision with possible upper midline extension was necessary. A thorough inspection of the peritoneal cavity was performed to exclude extrahepatic disease. Operative ultrasound (Aloka, Tokyo, Japan) was used to exclude preoperatively undetected lesions and to guide insertion of the microwave applicator. Insertion of the applicator and the whole ablation process was monitored using operative ultrasound. Surrounding organs were cooled by constant irrigation of ice-cold saline to prevent thermal injury. The ablation was carried out according to the standard protocol. The aim was to create a 1-cm ablation margin around the tumor nodule. After ablation, the track was burnt and in some cases packed with a piece of gel-foam to prevent bleeding. With a single application, MWA could create a maximum ablation zone of 5 cm $\times$ 7 cm in 8 minutes.

For RFA using the cool-tip needle, a single needle was used for small lesions with cluster needles for larger

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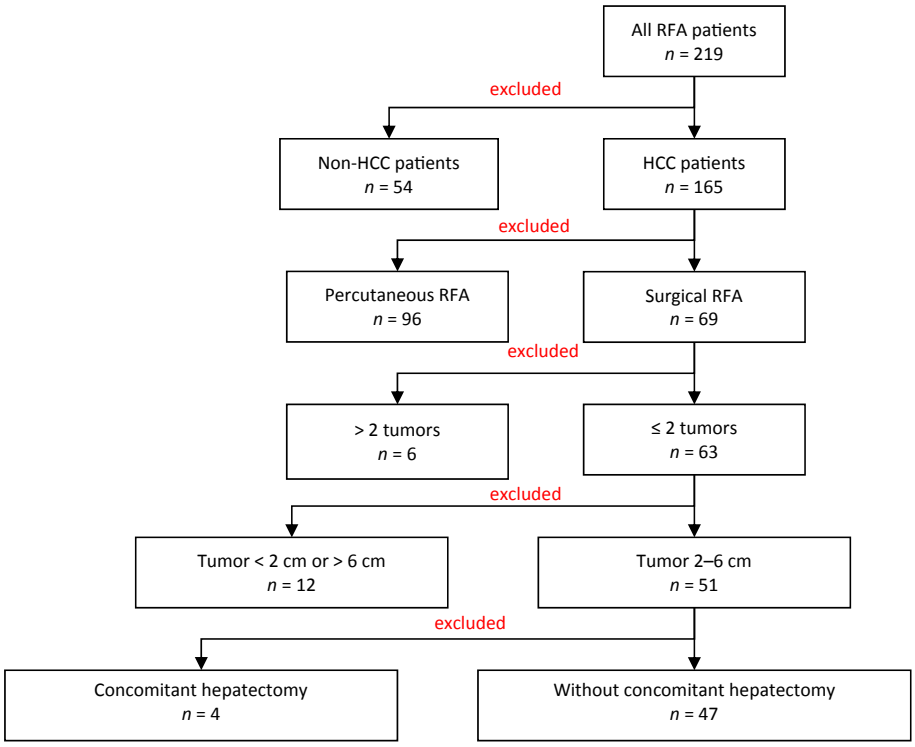

Figure 1 Diagram showing how the cohort of radiofrequency ablation including 47 patients was generated for analysis in this study. HCC = hepatocellular carcinoma; RFA = radiofrequency ablation.

lesions. Each treatment cycle lasted 12 minutes as recommended. For RFA using LeVeen needles, after the tines were deployed, by using the standard algorithm, the power was increased stepwise until either the required application time had elapsed or the power declined. For both types of needles, overlapping zones of ablation were made if needed to ensure adequate coverage of the tumor with a margin of 1 cm. The needle tract was burnt at the end of the procedure. For ablation zones, the cool-tip needle could create a maximum size of 2.5 cm $\times$ 5 cm with a single application of clustered needles, while for the LeVeen needle, the maximum was a spherical 5-cm size using a 5-cm needle.

Patients receiving MWA or RFA were followed up at 1 month for the first visit, and then every 3 months during the first 2 years, and every 6 months thereafter. Follow-up contrast computed tomography (CT) of the abdomen was performed at 1 month, 3 months, 6 months, and 12 months postablation, and 6 monthly in the subsequent year and then yearly thereafter. CT was evaluated by radiologists experienced in liver tumor ablation. A chest X-ray was taken every 6 months or if clinically indicated. Serum AFP was monitored for disease recurrence. In selected cases, positron emission tomography, bone scan, hepatic angiogram, or liver biopsy were performed if recurrence was suspected. Any intra- or extrahepatic recurrence was treated accordingly.

All the data were prospectively collected and kept in a database. The data were censored for analysis in July 2014 for both groups of patients. As a previous study[10] on RFA showed that complete ablation dropped to 50—70% for tumors $\geq$ 3.5 cm, a subgroup analysis was done by stratifying tumor size $<$ 3.5 cm and $\geq$ 3.5 cm. Survival was calculated from the date of MWA or RFA using the Kaplan—Meier method and was compared by the log-rank test. The date of recurrent disease was dictated by the first imaging study showing the recurrence. Incomplete ablation was defined as the presence of residual disease on the first CT scan at 1 month after ablation. For patients with two tumors, both tumors were taken for determination of treatment effect. Ablation was only considered completed if both ablation sites showed no residual tumors on the first CT scan postoperatively. Any subsequent development of the disease after initial complete ablation was regarded as recurrence. Local recurrence was defined as disease occurring adjacent to previous ablation sites while remote recurrence was defined as those recurrences occurring distant to previous ablation sites. Multifocal recurrence was defined as multiple intrahepatic recurrent tumors away from the ablation site. Fisher exact test was used for comparison of categorical variables. A p-value $<$ 0.05 was considered statistically significant.

3. Results

There were 26 patients in the MWA group and 47 in the RFA group. Eight patients (31%) in the MWA group and 21 patients (44%) in RFA group were offered liver resection. There was no significant difference between the two groups (p = 0.245). Liver resection was not performed due to small liver remnant or unfavorable tumor location during exploration. One patient in each group refused liver resection but agreed to local ablation only. The rest were

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not offered liver resection due to either poor liver reserve or coexisting medical condition. The patient demographics, tumor characteristics, and perioperative outcomes are shown in Table 1. The two groups were comparable except patients were older and platelet count was lower in the MWA group. The number and size of tumors did not differ between the two groups. The median tumor size was 3.75 cm in the MWA group and 3.1 cm in the RFA group. The laparoscopic approach was used more in the MWA group while more concomitant procedures, which were mostly cholecystectomy, were done in the RFA group. The operative time was significantly greater in the RFA group. There was no 30-day mortality in this study. There were no differences in complication rate and postoperative hospital stay. Six complications occurred in four patients in the MWA group: chest infection; adult respiratory distress syndrome; atrial fibrillation; hand cellulitis; skin bruising; and intra-abdominal collection. Nineteen complications occurred in 16 patients in the RFA group: four pleural effusions; three wound complications; two chest infections; two atrial fibrillations; two ascites; one lung collapse; one liver abscess; one subphrenic collection; one supraventricular tachycardia; one deep vein thrombosis; and one acute retention of urine. Of note, there were no biliary or vascular complications in either group.

The long-term outcomes, recurrent diseases, and survival data are shown in Table 2. The incidence of residual disease was 3.8% and 6.4% in MWA and RFA groups, respectively. For the 4 patients who had residual tumors, two received percutaneous RFA and two received transcatheter arterial chemoembolization. The follow-up period was 47.5 (11.3–62.5) months in the MWA group and 52.9 (3.6–121.8) months in the RFA group ($p = 0.322$).The overall disease recurrence rate was 80.8% in MWA and 83.0% in RFA. There was no difference between the two groups in incidence of local recurrence, remote recurrence, multifocal recurrence, or extrahepatic recurrence. Two patients in the MWA group and six patients in the RFA group were

Table 1 Patient demographics and perioperative outcomes.

	MWA ($n = 26$)	RFA ($n = 47$)	p
Age (y)	62.5 (49–79)	58 (43–77)	0.033*
Male	19 (73.1%)	40 (85.1%)	0.230
No. of comorbidities	1 (0–4)	1 (0–5)	0.538
HBsAg +	21 (80.8%)	39 (83.0%)	> 0.999
Child's grading			
A	23 (88.5%)	42 (89.4%)	> 0.999
B	3 (11.5%)	5 (10.6%)	
α-fetal protein (μg/L)	13.5 (1–23,956)	25 (2–10,174)	0.310
Platelet (10^9/L)	92.5 (25–265)	127 (41–250)	0.019*
Albumin (g/L)	39.5 (30–47)	39 (14–77)	0.380
Bilirubin (μM)	17 (4–37)	13 (6–61)	0.294
INR	1.125 (0.98–1.42)	1.120 (0.99–1.53)	0.699
ALP (IU/L)	108 (6–229)	90 (50–195)	0.895
Recurrent HCC	5 (19.2%)	4 (8.5%)	0.266
No. of lesions			
Solitary	24 (92.3%)	42 (89.4%)	> 0.999
Two lesions	2 (7.7%)	5 (10.6%)	
Tumor size (cm)	3.75 (2.0–6.0)	3.1 (2.0–6.0)	0.066
Tumor > 5 cm	3 (11.5%)	2 (4.3%)	0.340
Approach			
Open	10 (38.5%)	35 (74.5%)	0.002*
Laparoscopic	15 (57.7%)	9 (19.1%)	
Laparoscopic converted to open	1 (3.8%)	3 (6.4%)	
Concomitant procedure	2 (7.7%)	28 (59.6%)	< 0.001*
Types of concomitant procedure			
Cholecystectomy only	1 (3.8%)	26 (55.3%)	
Colectomy	0 (0%)	1 (2.1%)	
Cholecystectomy and excision of pelvic tumor	1 (3.8%)	0 (0%)	
Hernia repair	0 (0.0%)	1 (2.1%)	
Operative time (min)	117.5 (65–250)	195 (93–480)	< 0.001*
30-d mortality	0 (0.0%)	0 (0.0%)	NA
Reoperation rate	0 (0.0%)	1 (2.1%) (wound disruption)	> 0.999
Complication rate	4 (15.4%)	16 (34.0%)	0.087
Postop hospital stay	6 (2–13)	6 (2–16)	0.102

* Statistically significant $p < 0.05$.
ALP = alkaline phosphatase; HBsAg+ = hepatitis B surface antigen positive; HCC = hepatocellular carcinoma; INR = international standardized ratio; MVA = microwave ablation; NA = not applicable; RFA = radiofrequency ablation.

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Table 2 Long-term outcomes after ablation.

	MWA ($n = 26$)	RFA ($n = 47$)	p
Follow-up period (mo)	47.5 (11.3–62.5)	52.9 (3.6–121.8)	0.322
Residual disease	1 (3.8%)	3 (6.4%)	> 0.999
Overall recurrence rate	21 (80.8%)	39 (83.0%)	> 0.999
Intrahepatic recurrence	21 (80.8%)	39 (83.0%)	> 0.999
Local recurrence	6 (23.1%)	12 (25.5%)	0.816
Remote recurrence	7 (26.9%)	15 (31.9%)	0.656
Multifocal recurrence	8 (30.8%)	12 (25.5%)	0.631
Extrahepatic recurrence	2 (7.7%)	10 (21.3%)	0.192
Overall survival			
1-y survival	96.2%	89.4%	0.299
3-y survival	73.1%	61.7%	0.218
5-y survival	73.1%	46.3%	0.081
Disease-free survival			
1-y survival	57.7%	68.1%	0.439
3-y survival	34.6%	23.4%	0.594
5-y survival	13.8%	14.6%	0.736

MVA = microwave ablation; RFA = radiofrequency ablation.

given sorafenib for recurrent disease in this study, there was no significant difference in prescription of the drug between the two groups ($p = 0.703$). The 5-year overall and disease-free survival for MWA were 73.1% and 13.8% respectively. The 5-year overall and disease-free survival for RFA were 46.3% and 14.6% respectively. Figure 2 shows that there was no difference between the two groups in overall and disease-free survival by log-rank test ($p = 0.082$ and 0.736, respectively).

When analysis was made on subgroups according to tumor size < 3.5 cm and ≥ 3.5 cm, the long-term outcomes are shown in Tables 3 and 4 and the survival in Figures 3 and 4. For tumors < 3.5 cm, there were 10 patients in the MWA group and 26 patients in the RFA group. The 5-year overall and disease-free survival for MWA were 70.0% and 0.0%, respectively, while the 5-year overall and disease-free survival for RFA were 61.1% and 22.4%, respectively. Figure 3 shows that there was no difference between the two groups in overall and disease free survival by log-rank test ($p = 0.732$ and 0.639, respectively).

For tumors ≥ 3.5 cm, there were 16 patients in the MWA group and 21 patients in the RFA group. The 5-year overall and disease-free survival for MWA were 75.0% and 25.0%, respectively, while the 5-year overall and disease survival for RFA were 28.6% and 4.8%, respectively. By log-rank test (Figure 4) there was a significant difference in overall survival favoring MWA ($p = 0.022$) but there was no difference in disease-free survival ($p = 0.207$).

4. Discussion

Both RFA and MWA have gained wide acceptance as reliable thermal ablation treatments for malignant liver tumors. Studies have reported high complete ablation rates and low local recurrence rates. The complete ablation rate is closely related to tumor size. For RFA, the rates of

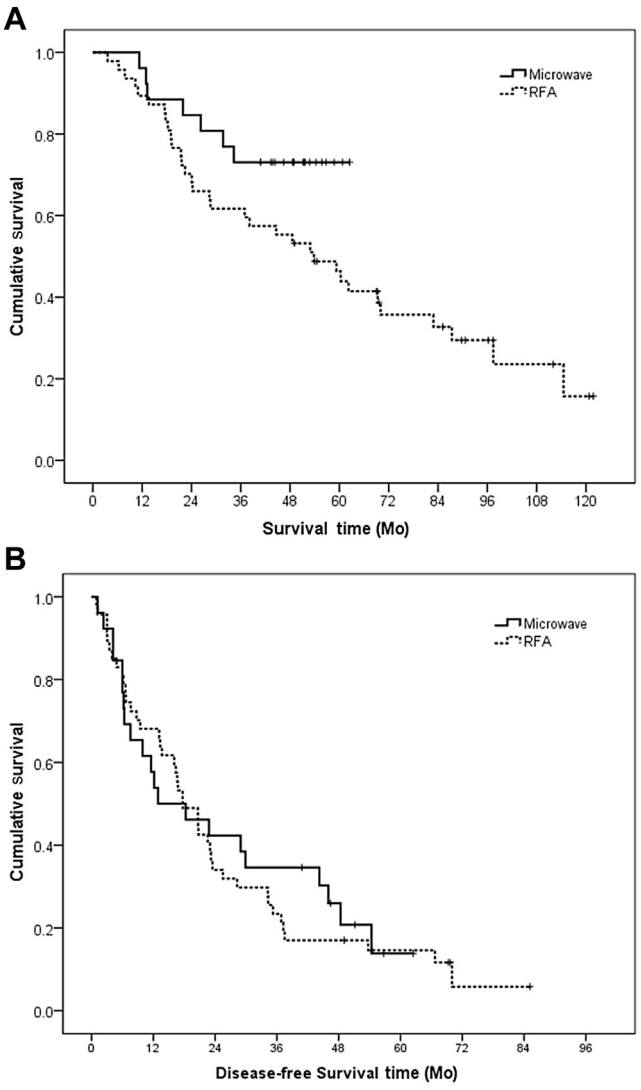

Figure 2 Log-rank test showed no difference between the two groups in overall and disease-free survival. (A) Log-rank test: $p = 0.082$. (B) Log-rank test: $p = 0.736$. RFA = radiofrequency ablation.

complete ablation were 90%, 70–90%, 50–70%, and < 50% for HCC of size < 2.5 cm, 2.5–3.5 cm, 3.5–5 cm, and > 5 cm, respectively.[10] For MWA, the rates of complete ablation were 92% and 80–95% for tumors < 2 cm and > 2 cm, respectively.[11,12] However, data were difficult to interpret due to different ways of applying ablation: percutaneous, laparoscopic, or via laparotomy. Furthermore, results would be affected by the pathology of the liver tumor treated, mostly HCC or colorectal liver metastasis. Finally, as different types of commercially available models of RFA and MWA machines are present in the market, the efficacy of the machine may also be different. Even within the MWA category, two types of frequency are commonly used (915 MHz and 2.45 GHz) which may differ in clinical efficacy.[13] In the present study we tried to confine our study disease to HCC only with either laparoscopic or open approach, although we did employ two different brands of RFA machine during the study period. The median

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Table 3 Long-term outcomes after ablation for tumors < 3.5 cm.

	MWA ($n = 10$)	RFA ($n = 26$)	p
Overall recurrence rate	9 (90.0%)	19 (73.1%)	0.397
Intrahepatic recurrence	9 (90.0%)	19 (73.1%)	0.397
Local recurrence	2 (20.0%)	5 (19.2%)	> 0.999
Remote recurrence	4 (40.0%)	9 (34.6%)	> 0.999
Multifocal recurrence	3 (30.0%)	5 (19.2%)	0.658
Extrahepatic recurrence	2 (20.0%)	3 (11.5%)	0.603
Overall survival			
1-y survival	90.0%	92.3%	0.856
3-y survival	70.0%	73.1%	0.961
5-y survival	70.0%	61.1%	0.736
Disease-free survival			
1-y survival	60.0%	76.9%	0.386
3-y survival	50.0%	38.5%	0.801
5-y survival	0.0%.	22.4%	0.639

MVA = microwave ablation; RFA = radiofrequency ablation.

Table 4 Long-term outcomes after ablation for tumors ≥ 3.5 cm.

	MWA ($n = 16$)	RFA ($n = 21$)	p
Overall recurrence rate	12 (75.0%)	20 (95.2%)	0.144
Intrahepatic recurrence	12 (75.0%)	20 (95.2%)	0.144
Local recurrence	4 (25.0%)	7 (33.3%)	0.723
Remote recurrence	3 (18.8%)	6 (28.6%)	0.702
Multifocal recurrence	5 (31.3%)	7 (33.3%)	0.893
Extrahepatic recurrence	0 (0.0%)	7 (33.3%)	0.012*
Overall survival			
1-y survival	100%	85.7%	0.121
3-y survival	75.0%	47.6%	0.102
5-y survival	75.0%	28.6%	0.022*
Disease-free survival			
1-y survival	56.3%	57.1%	0.987
3-y survival	25.0%	4.8%	0.207
5-y survival	25.0%	4.8%	0.207

* Statistically significant $p < 0.05$.
MVA = microwave ablation; RFA = radiofrequency ablation.

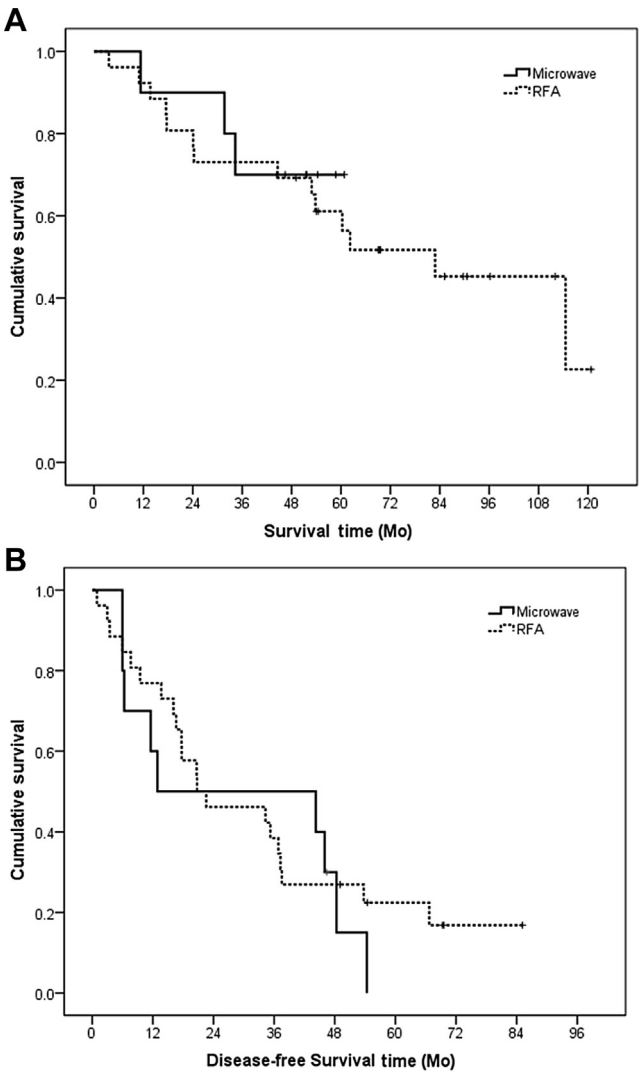

Figure 3 Log-rank test for tumors < 3.5 cm showed no difference between the two groups in overall and disease free survival. (A) Log-rank test: $p = 0.732$. (B) Log-rank test: $p = 0.639$. RFA = radiofrequency ablation.

follow-up periods of at least 4 years can provide us more valid information on the treatment outcomes in the long term.

For the short-term outcomes in this study, both MWA and RFA yielded similar results in procedure related morbidity and hospital stay, and both had no mortality. The rate of residual disease was 3.8% in MWA and 6.4% in RFA, which was not statistically different. Despite matching, the patients in the MWA group in this study were significantly older and had a lower platelet count than the RFA group. Although the tumor size was similar, the median size in the MWA group was 3.75 cm in comparison to 3.1 cm in the RFA group, and the open approach was employed more in the RFA group. It appears that MWA bears more unfavorable factors, but achieved similar treatment outcomes as RFA.

Several studies have addressed the long-term outcomes of RFA or MWA for malignant liver tumors. In the study by Peng et al,[14] 224 patients with HCC of median size of 2.5 cm received RFA as primary treatment. The overall 5-year and 10-year survival was 59.8% and 33.9%, respectively. The tumor free 5-year and 10-year survival was 42.4% and 28.2%, respectively. In a more recent study on RFA for HCC of mean tumor size of 2.59 cm, the overall 5-year survival was 67.9% and the 5-year recurrence-free survival was 25.9%.[15] By contrast, a study on long-term outcomes of MWA for malignant liver tumors, mostly colorectal liver metastases, revealed a 4-year overall survival of 57.6%.[16] In the study by Takami et al,[17] MWA was offered as initial treatment for 719 patients with HCC of median size 2.69 cm, the 5-year and 10-year overall survival was 62.1% and 34.1%, respectively, while the 5-year and 10-year disease-free survival was 31.0% and 16.5%, respectively.

Most of the studies in the literature comparing MWA and RFA for HCC utilized the percutaneous route.[10,18–22] All

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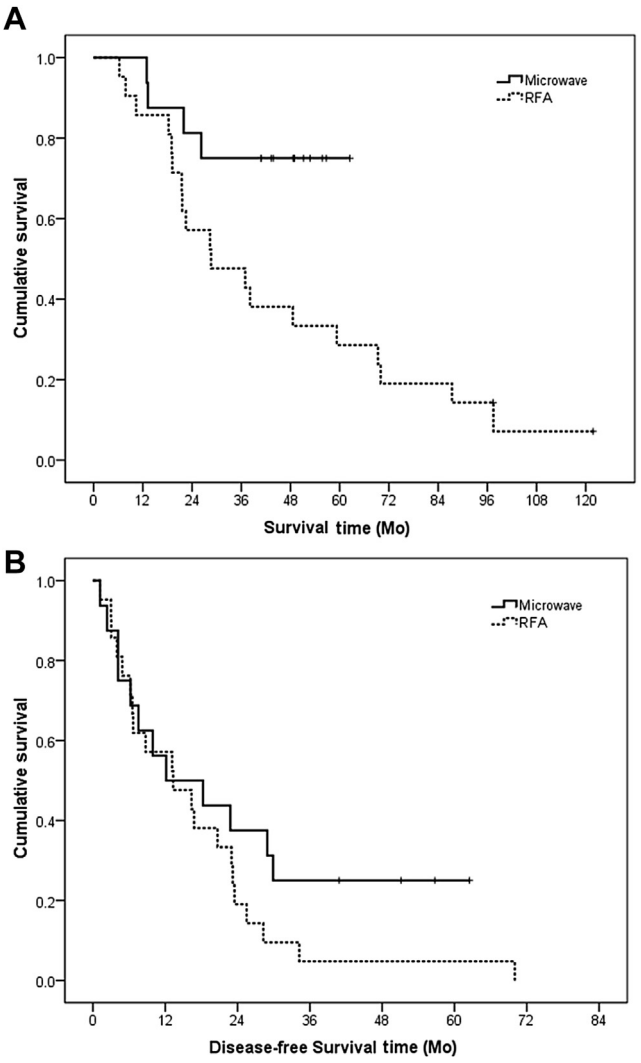

Figure 4 Log-rank test showing significant difference in overall survival favoring microwave ablation, however, there was no difference in disease-free survival for tumors $\geq$ 3.5 cm. (A) Log-rank test: $p = 0.022$*. (B) Log-rank test: $p = 0.207$. RFA = radiofrequency ablation.

studies except one showed that the two ablation modalities produced equivalent clinical efficacy in terms of ablation rates, complication rates, and survival rates. The study that showed a difference favored RFA because it achieved a lower local recurrence rate, higher survival rate, and more extensive necrosis with fewer treatment sessions.[19] However, that study only involved patients with small HCC $\leq$ 2 cm in size. One study compared laparoscopic-assisted MWA with laparoscopic-assisted RFA for HCC.[23] It involved 13 patients with 15 tumors in the MWA group and 22 patients with 27 tumors in the RFA group. It was found that laparoscopic MWA achieved outcomes similar to laparoscopic RFA, but MWA carried shorter operative times.

In the current study, with sufficient follow up, recurrent diseases were found in 80.8% and 83% of patients after MWA and RFA, respectively. There was no difference in the incidence of different types of recurrence between the two groups. The local recurrence rates were 23.1% and 25.5% for MWA and RFA, respectively. These were comparable to other studies because most of the previous studies involved shorter follow up (2—3 years) for smaller tumor sizes of 2—3 cm with reported local recurrence rate ranging from 2% to 20%.[5,10,16] The overall 5-year survival was better in MWA than RFA (73.1% vs. 46.3%) but was not statistically different. The better 5-year overall survival, but not the disease-free survival, in the MWA group (although not statistically significant) may be due to better local control of disease by MWA, which was more amendable for retreatment despite recurrence, or due to more effective treatments for recurrent disease, because patients receiving MWA were concentrated in the later period, during which advances in treatment technology such as transarterial therapy, repeat local ablation, or even hepatectomy may prolong survival. The difference became significant when only larger tumors, $\geq$ 3.5 cm, were compared ($p = 0.022$). However, the 5-year disease-free survival was similar even when only larger tumors were studied. The difference may be explained by the larger ablation zone created with single application of MWA. RFA needs multiple applications at overlapping sites to create a similar ablation zone. Any malposition of the needle results in microscopic residual disease that gives rise to recurrence. Less heat sink effect with MWA might also account for more successful complete ablation for perivascular tumors.[24]

Apparently, within the MWA group, the 5-year overall and disease-free survival were better for tumors $\geq$ 3.5 cm compared with tumors $<$ 3.5 cm. However, when we performed the survival analysis for tumors $<$ 3.5 cm versus $\geq$ 3.5 cm using microwave treatment, the *p*-value of the log-rank test for overall survival was 0.846, and for disease-free survival was 0.964, therefore, there was no significant difference between the two. When we looked in detail for other factors that might affect the ablation result, we found that the open approach was adopted significantly more often than laparoscopic approach in patients with larger tumors ($n = 10$, 62.5% vs. $n = 1$, 10%; $p = 0.014$). The open approach might make insertion of the microwave applicator more precise and ablation more complete.

There are several drawbacks and limitations to the present study. The diagnosis of HCC was not histologically proven in every patient and therefore there is a chance of overestimation of treatment response. The patient number is small, hence difference in outcomes may not show up on comparative analysis. For the RFA arm, two types of machine were used, which may have affected the treatment outcomes for RFA. Finally, the difference in experience in usage of the ablative tool may also have directly affected the treatment result. Our institute is currently conducting a prospective randomized trial of MWA versus RFA for HCC patients, and hopefully results will be available in a few years' time.

5. Conclusion

MWA provides similar short- and long-term treatment outcomes as compared with RFA for HCC using laparotomy or the laparoscopic approach. However, MWA seems to convey a better 5-year overall survival for tumors $\geq$ 3.5 cm in size. A prospective randomized trial of MWA versus RFA involving a larger study population is warranted to verify the finding of this retrospective study.

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