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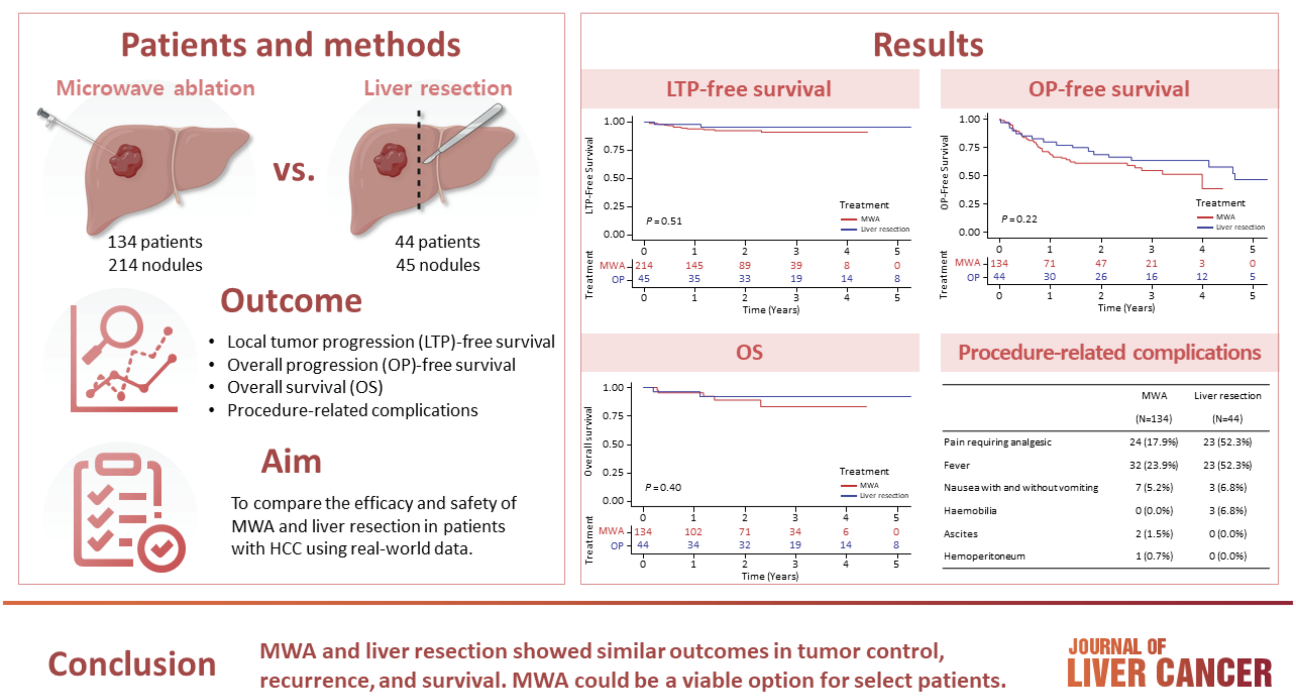

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Microwave ablation vs. liver resection for patients with hepatocellular carcinomas

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Backgrounds/Aims: Microwave ablation (MWA) is an emerging ablative therapy that surpasses previous methods by achieving higher temperatures and creating larger ablation zones within shorter periods. This study compared the therapeutic outcomes of MWA with those of liver resection in real-world clinical practice.

Methods: A total of 178 patients with 259 nodules who underwent MWA or liver resection between January 2015 and July 2023 were enrolled. Local tumor progression (LTP)-free survival, overall progression (OP)-free survival, and overall survival (OS) were assessed based on the treatment modality for the index nodule.

Results: Of the 178 patients, 134 with 214 nodules underwent MWA, and 44 with 45 nodules underwent liver resection. The median follow-up period was 2.0±1.5 years. The annual incidence of LTP was 3.7% for MWA and 1.4% for liver resection. Treatment modality did not significantly affect LTP-free survival (hazard ratio, 0.61; 95% confidence interval, 0.14-2.69; *P*=0.511). For nodules larger than 3 cm, LTP-free survival was not affected by the treatment modality. Similarly, OP-free survival and OS were not influenced by treatment modality.

Conclusions: MWA and liver resection demonstrated comparable treatment outcomes in terms of local tumor control, overall recurrence, and survival. MWA may be an alternative treatment option for select patients; however, further studies are necessary to generalize these findings. **(J Liver Cancer 2025;25:99-108)**

Keywords: Carcinoma, hepatocellular; Ablation techniques; Microwaves; Surgical procedures, operative

INTRODUCTION

Hepatocellular carcinoma (HCC) remains a major global health concern and is the third leading cause of cancer-related death worldwide.[1] Liver resection is the primary curative treatment option for patients with HCC confined to the liver, with 5-year overall survival rates reaching 70%.[2-4] However, only 15% of patients with HCC are eligible for liver resection, as achieving clear resection margins and preserving liver function at the same time is often challenging.[5] Patients with underlying cirrhosis, multiple tumors at different locations, older age, and poor general conditions are not suitable candidates for liver resection.[1,6]

Local ablation therapy offers a promising curative nonsurgical treatment alternative for patients at high risk of surgery-related morbidity or mortality.[2,3] Radiofrequency ablation (RFA) is the most widely used ablation method, and its treatment outcomes, including overall survival and tumor control, are comparable with those of liver resection.[7] Microwave ablation (MWA) has recently emerged as another local ablation method.[2,3] It operates by generating electromagnetic energy, resulting in the oscillation and rotation of dipoles within the microwave electric field. This dipole motion generates heat, leading to coagulation necrosis of the tumor.[8] Unlike conventional RFA, MWA achieves higher temperatures and creates larger ablation zones more rapidly.[8] Additionally, MWA is less susceptible to the cooling effects of vasculature, a significant limitation of RFA, particularly in the liver, a highly vascular organ.[3,8] Therefore, MWA has the potential to outperform RFA in HCC treatment, raising questions about the relative performance of MWA and liver resection. Few studies have compared the efficacy and safety of MWA and liver resection with inconclusive results.[9]

This study aimed to determine the efficacy and safety of MWA compared with liver resection in patients with HCC using real-world data. The effects of MWA and liver resection on tumor progression, survival and treatment-related complications were compared.

METHODS

Study population

Data for this retrospective cohort study were collected from patients with HCC treated with MWA or liver resection at Yeouido St. Mary's Hospital, Seoul, Korea, between January 2015 and July 2023. A total of 190 patients were initially enrolled. Patients were excluded if they had 1) extrahepatic metastasis (n=2), 2) regional lymph node metastasis (n=5), and 3) a malignancy other than HCC (n=7). No patients in this cohort underwent liver transplantation. Two hundred fifty-nine nodules from 178 patients were analyzed. Of these, 134 were treated with MWA, and 44 were treated with liver resection. Among the 134 patients treated with MWA, 24 underwent MWA more than once for newly developed intrahepatic recurrent HCCs during the follow-up period. For the per-person-based analysis, the first MWA treatment was considered the index procedure. All patients were monitored using imaging studies every 3-6 month after the index treatment (Supplementary Fig. 1). This study was approved by the Institutional Review Board (IRB) of Yeouido St. Mary's Hospital (IRB No. SC23RISI0231). The requirement for informed consent was waived due to the retrospective nature of the study. All research procedures adhered to the ethical principles outlined in the 1964 Declaration of Helsinki and its subsequent revisions.

Treatment procedures

Liver resection was performed by a team of experienced surgeons with 20 years of expertise. The type and extent of resection were determined by the surgeons based on several factors, including the number, size, and location of HCC lesions, liver function, and patient preferences. Efforts were made to maintain a resection margin of at least 1 cm. Liver parenchymal dissection was performed using a laparoscopic ultrasonic dissector (Integra LifeSciences, Princeton, NJ, USA), the recommended device for transection, with intermittent application of the Pringle maneuver involving clamping and unclamping for 15 and 5 minutes, respectively.[10]

MWA was performed using an emprint ablation system (Medtronic, Dublin, Ireland) with a maximum power of 100 W at 2,450 MHz. After the administration of local anesthesia, percutaneous insertion of 13-gauge straight antennae equipped with an internal cooling system was guided by ultrasound into the tumor. Depending on the tumor size and location, multiple overlapping ablations were performed to ensure a safety margin of at least 1 cm. In cases involving multiple tumors, all lesions were treated similarly. Technical success and procedure-related complications were assessed within 24 hours after the procedure.

Assessment of response and study endpoints

Patients were regularly monitored for recurrence using dynamic liver computed tomography or magnetic resonance imaging at intervals of 3-6 months after their respective treatments. The primary outcome assessed was local tumor progression (LTP)-free survival of the target lesion after individual treatments. LTP was defined as the reappearance of a tumor adjacent to the treated zone after complete treatment.[11-13] Intrahepatic recurrence HCCs was defined as the emergence of new lesions distinct from LTP, encompassing both intrahepatic metastases and multicentric carcinogenesis. Overall progression (OP) was defined as the progression of a previously treated lesion or the appearance of an intrahepatic recurrent lesion. LTP- or OP-free survival was calculated from the treatment date to the date of progression of the target lesion or any lesion or to the date of the last imaging evaluation. Overall survival (OS) was measured from the date of the procedure to the date of death from any cause or last follow-up. The secondary outcome was the comparison of procedure-related complications between MWA and liver resection. Post-treatment complications, including pain, fever, nausea and vomiting, hemobilia, ascites, hemoperitoneum, and the need for reoperation were assessed in accordance with clinical practice guidelines provided by the Society of Interventional Radiology.[14]

Statistical analysis

Initial baseline characteristics are presented as mean±standard deviation for quantitative variables and count (percentage) for categorical variables, as appropriate. Comparative analyses of results, including response rates and complications, between groups were conducted using suitable statistical tests, such as Student's *t*-test, chi-squared test, or Fisher's exact test, depending on the type of data. Kaplan-Meier analyses and log-rank tests were used to compare LTP-free survival, OP-free survival, and OS between MWA and liver resection. Multivariate Cox proportional hazards models were employed to identify and assess the factors associated with the study outcomes. Hazard ratios (HRs) and 95% confidence intervals (CIs) were calculated. The significance level of $P<0.05$ was considered statistically significant. Additionally,

Table 1. Baseline characteristics of the study population per patients

Characteristic	Total (n=178)	MWA (n=134)	Liver resection (n=44)	*P*-value
Demographics				
Age (years)	66.9±10.3	69.0±9.0	60.4±11.3	<0.001
Male sex	128 (71.9)	93 (69.4)	35 (79.5)	0.269
Hypertension	69 (38.8)	50 (37.3)	19 (43.2)	0.607
Diabetes	54 (30.3)	40 (29.9)	14 (31.8)	0.954
Chronic kidney disease	9 (5.1)	8 (6.0)	1 (2.3)	0.565
Alcohol consumption	21 (11.8)	17 (12.7)	4 (9.1)	0.710
Current smoking	8 (4.5)	7 (5.2)	1 (2.3)	0.689
Etiology of HCC				0.343
HBV	116 (65.2)	84 (62.7)	32 (72.7)	
HCV	24 (13.5)	18 (13.4)	6 (13.6)	
Others	38 (21.3)	32 (23.9)	6 (13.6)	
Laboratory finding				
Platelets ($10^3/mm^3$)	137.5±60.8	126.1±57.9	172.4±56.5	<0.001
Prothrombin time (INR)	1.1±0.1	1.1±0.1	1.0±0.1	0.006
Prothrombin time (%)	88.2±16.1	86.7±16.1	92.8±12.7	0.022
AST (IU/L)	40.9±30.4	39.3±30.4	45.7±30.2	0.223
ALT (IU/L)	34.6±34.7	32.5±35.9	41.0±30.2	0.158
Total bilirubin (mg/dL)	0.9±0.6	0.9±0.7	0.7±0.4	0.008
Albumin (g/dL)	3.9±0.7	3.8±0.8	.0±0.4	0.027
Creatinine (mg/dL)	0.9±0.6	0.9±0.7	0.8±0.2	0.084
Sodium (mmol/L)	138.4±3.4	138.5±3.7	138.2±2.3	0.527
Cholesterol (mg/dL)	156.0±34.9	153.1±35.6	165.1±31.4	0.053
Cirrhosis	47 (26.4)	42 (31.3)	5 (11.4)	0.016
Ascites	10 (5.6)	9 (6.7)	1 (2.3)	0.463
Encephalopathy	3 (1.7)	3 (2.2)	0 (0.0)	0.744
Varix	46 (25.8)	41 (30.6)	5 (11.4)	0.020
Tumor feature				
Number of tumors				0.030
Single	155 (87.1)	112 (83.6)	43 (97.7)	
Multiple	23 (12.9)	22 (16.4)	1 (2.3)	
Size of tumor (cm)				
Maximum	2.6±1.7	2.1±1.2	3.9±2.4	<0.001
Sum	2.9±2.1	2.5±1.7	4.0±2.9	0.002
Bile duct or vessel invasion	6 (3.4)	1 (0.7)	5 (11.4)	0.004
AFP (ng/mL)	178.0±706.7	99.2±414.5	429.5±1,220.4	0.092
PIVKA-II (mAU/mL)	222.6±766.7	121.8±397.2	619.5±1,462.3	0.070
Previous treatment history of the patient*	101 (56.7)	89 (66.4)	12 (27.3)	<0.001
RFA	51 (28.7)	50 (37.3)	1 (2.3)	<0.001
TACE	88 (49.4)	77 (57.5)	11 (25.0)	<0.001
Surgical resection	9 (5.1)	8 (6.0)	1 (2.3)	0.565

Values are presented as mean±standard deviation or number (%).
MWA, microwave ablation; HCC, hepatocellular carcinoma; HBV, hepatitis B virus; HCV, hepatitis C virus; INR, international normalized ratio; AST, alanine aminotransferase; ALT, aspartate aminotransferase; AFP, alpha-fetoprotein; PIVKA-II, protein induced by vitamin K absence/antagonist-II; RFA, radiofrequency ablation; TACE, transarterial chemoembolization.
*It represents patients who have received any anti-hepatocellular carcinoma treatment at least once.

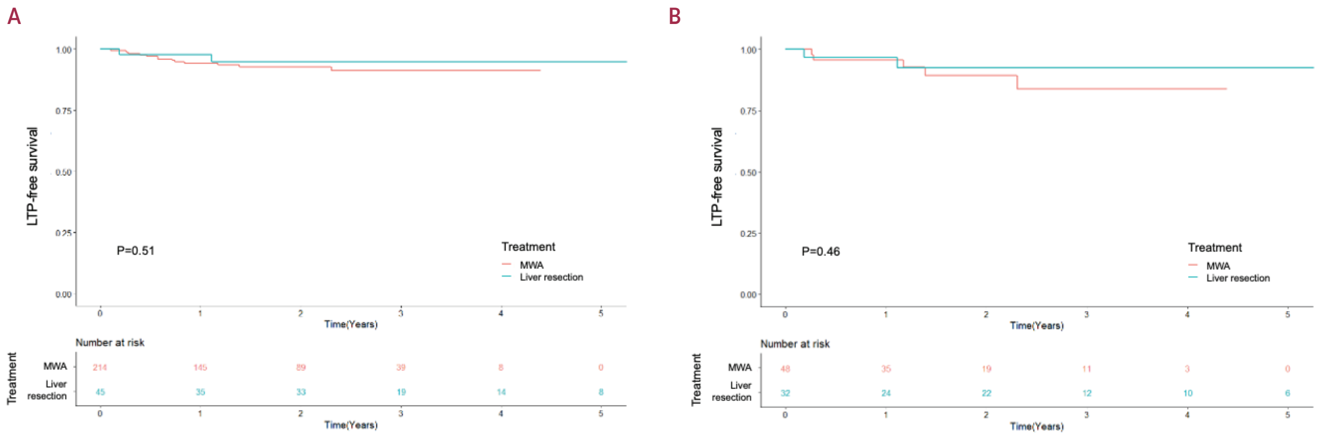

Figure 1. Kaplan-Meier analyses for LTP-free survival of MWA and liver resection-treated (A) entire 259 target nodules and (B) 80 target nodules ≥3 cm. LTP, local tumor progression; MWA, microwave ablation.

we employed propensity score (PS) matching to minimize the potential confounding factors between MWA and liver resection nodules. We calculated the propensity scores based on age, sex, Child-Pugh score, number of tumors, and tumor size. We conducted nearest-neighbor 1:1 matching. All statistical analyses were performed using R statistical package (R software version 4.3.1; R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Baseline characteristics of patients and tumors

The study population comprised 178 patients with 259 lesions. Baseline patient characteristics are shown in Table 1. Baseline characteristics of the nodules and PS-matched cohorts for the nodules are summarized in Supplementary Tables 1 and 2, respectively. Of the patients, 134 with 214 nodules underwent MWA, and 44 patients with 45 nodules underwent liver resection. The mean age of the participants was 66.9±10.3 years. Men constituted 71.9% (n=128) of the patients. In the study population, 65.2% and 26.4% of patients had hepatitis B infection and cirrhosis, respectively. At the time of treatment, 87.1% of the patients had a single tumor, and 12.9% presented with multiple tumors (up to four). Patients treated with MWA tended to be older, have a higher prevalence of cirrhosis, a greater incidence of multiple tumors, and a more extensive history of HCC treatment than patients who underwent liver resection. In contrast, the liver resection group exhibited a higher tumor burden with larger tumor sizes, a greater prevalence of bile duct or vessel invasion, and elevated levels of tumor markers than the MWA group.

Per nodule-based analysis

The distribution of tumor size according to treatment modality is shown in Supplementary Fig. 2. Technical success was achieved in all 214 nodules treated with MWA. A complete response was achieved in 86.0% of the MWA treated nodules, while 93.3% achieved a complete response in the liver resection group (Supplementary Table 3). During a mean follow-up duration of 2.0±1.5 years, 14 of 214 MWA-treated nodules and two of 45 liver resection-treated nodules recurred (annual incidence 3.7% and 1.4%, respectively). The 1-year and 3-year cumulative rates of LTP of the target lesion were 5.8% and 8.8% in the MWA group, respectively. For liver resection nodules, the LTP rates at 1- and 3-year were 2.3% and 5.2%, respectively (Fig. 1A). Cox regression analysis revealed no statistically significant difference in LTP (HR, 0.61; 95% CI, 0.14-2.69; *P*=0.511) between MWA and liver resection groups (Table 2). In the PS-matched cohort, the LTP-free survival did not differ between the two groups (Supplementary Fig. 3).

A comparative analysis of LTP was conducted in nodules with a diameter ≥3 cm, comprising 48 nodules treated with MWA and 32 nodules treated with liver resection. No discernible difference in LTP was observed between the two groups (HR, 0.54; 95% CI, 0.10-2.81; *P*=0.463) (Fig. 1B).

Per person-based analysis

During the study period, the OP rates in the MWA and liver resection groups were 43.6% and 42.2%, respectively. One-year and 3-year cumulative rates of OP were 21.6% and 37.9% in the MWA group and 37.7% and 54.9% in the liver resection group,

Table 2. Factors affecting the local tumor progression of target lesion in the entire cohort of 259 nodules

	Univariable analysis	
	HR (95% CI)	*P*-value
Treatment		
MWA	1 (reference)	
Liver resection	0.61 (0.14-2.69)	0.511
Demographics		
Age (years)	1.02 (0.97-1.07)	0.554
Male sex	0.36 (0.08-1.56)	0.171
Hypertension	0.49 (0.16-1.52)	0.219
Diabetes	0.62 (0.18-2.16)	0.45
Chronic kidney disease	0 (0-Inf)	0.998
Alcohol consumption	0 (0-Inf)	0.998
Current smoking	0 (0-Inf)	0.998
Etiology of HCC		
HBV	1 (reference)	
HCV	0.82 (0.18-3.67)	0.797
Others	0.60 (0.13-2.68)	0.504
Laboratory findings		
Platelets (10^3/mm^3)	1.01 (1.00-1.02)	0.004
Prothrombin time (%)	1.01 (0.97-1.04)	0.701
AST (IU/L)	0.98 (0.95-1.02)	0.28
ALT (IU/L)	0.99 (0.97-1.02)	0.552
Total bilirubin (mg/dL)	0.59 (0.18-1.98)	0.394
Albumin (g/dL)	1.18 (0.59-2.38)	0.638
Creatinine (mg/dL)	1.03 (0.48-2.22)	0.93
Sodium (mmol/L)	0.99 (0.86-1.14)	0.894
Cholesterol (mg/dL)	1.00 (0.98-1.01)	0.574
Cirrhosis	0.44 (0.10-1.96)	0.284
Tumor features		
Number of tumors		
Single	1 (reference)	
Multiple	1.01 (0.33-3.15)	0.983
Maximal size of tumor (cm)	1.09 (0.80-1.50)	0.570
Bile duct or vessel invasion	0 (0-Inf)	0.998
AFP* (ng/mL)	1.11 (0.86-1.43)	0.439
PIVKA-II* (mAU/mL)	1.25 (0.92-1.71)	0.157
Previous treatment history of the target nodule	0.85 (0.24-2.99)	0.803

HR, hazard ratio; CI, confidence interval; MWA, microwave ablation; Inf, infinite; HCC, hepatocellular carcinoma; HBV, hepatitis B virus; HCV, hepatitis C virus; AST, alanine aminotransferase; ALT, aspartate aminotransferase; AFP, alpha-fetoprotein; PIVKA-II, protein induced by vitamin K absence/antagonist-II.
*Log-transformed.

respectively (Fig. 2A). Multivariable Cox regression analysis showed that risk factors of OP in the current cohort were older age (adjusted HR, 1.03; 95% CI, 1.00-1.06; *P*=0.026) (Supplementary Table 4), total sum of tumor size (adjusted HR, 1.21; 95% CI, 1.08-1.36; *P*=0.001), and prothrombin time (adjusted HR, 1.03; 95% CI, 1.00-1.06; *P*=0.026). On the other hand, treatment modality (adjusted HR, 1.04; 95% CI, 0.50-2.15; *P*=0.921) was not associated with OP (Fig. 2A).

During the follow-up duration of 416.8 person-years, 22 patients died, corresponding to an annual incidence of 5.3/100

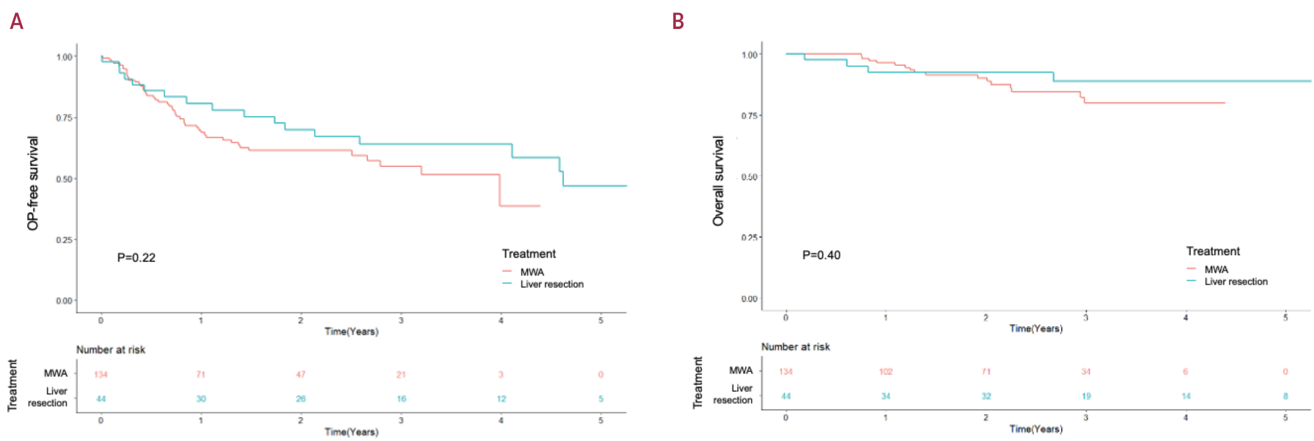

Figure 2. Kaplan-Meier analyses for (A) OP-free survival and (B) overall survival of 178 patients treated with MWA and liver resection. MWA, microwave ablation.

person-years. In the MWA group, 16 deaths occurred in 134 patients. In the liver resection group, six deaths occurred in 44 patients. Factors associated with overall survival were prothrombin time (adjusted HR, 0.97; 95% CI, 0.94-0.99; *P*=0.017) and total sum of tumor size (adjusted HR, 1.30; 95% CI, 1.08-1.56; *P*=0.006) (Table 3). MWA or liver resection (adjusted HR, 0.88; 95% CI, 0.26-2.97; *P*=0.832) did not affect OS (Fig. 2B).

Procedure-related complications

The duration of hospital stay after HCC treatment was longer in the liver resection group than in the MWA group (10.5±10.1 vs. 3.0±1.5 days, *P*<0.001). The proportion of patients requiring analgesics for pain control, fever, and hemobilia was higher in the liver resection group than in the other groups. One patient who underwent liver resection required reoperation due to an abdominal abscess. In contrast, two MWA-treated patients developed ascites due to decreased liver function after treatment. One patient required embolization due to bleeding from the MWA site (Table 4). No severe treatment-related complications, such as life-threatening complications or death, were observed in this cohort.

DISCUSSION

This contemporary historical cohort study of patients with HCC demonstrated that MWA has comparable effectiveness to liver resection in terms of LTP, OP, and OS. MWA was also effective for local tumor control for nodules ≥3 cm. These findings suggest that MWA is a reliable treatment option for HCCs. Furthermore, MWA resulted in fewer postprocedural complications than liver resection.

Advancements in surgical techniques have expanded the feasibility of liver resection to a broader range of patients. The increasing popularity of minimally invasive liver resection has resulted in reduced hospital stays and lowered mortality risks.[15] Nonetheless, patients with cirrhosis, older patients, and those with a significant burden of comorbidities may not be suitable candidates for liver resection.[1,6] Indeed, the MWA-treated patients in this study were also older and had a higher prevalence of cirrhosis than those who underwent liver resection.

Ablative therapy is considered an alternative option for curative treatment, particularly for patients with HCC smaller than 3 cm.[16] The size of nodules is closely linked to tumor recurrence, with recurrence rates ranging from 30% to 50% for RFA treated nodules larger than 3 cm.[17] In this study, 48 of 214 MWA-treated nodules measuring ≥3 cm demonstrated comparable treatment response and LTP to liver resection. A Chinese study by Dou et al.[18] also compared LTP between MWA-treated (n=77) and liver resection-treated tumors (n=94) measuring 3-5 cm and found that the choice of treatment method did not affect LTP. This observation may be attributed to the technological advantages of MWA. MWA can generate higher temperatures, often exceeding 100°C, over a larger volume of tissue within a shorter procedural duration than RFA. Consequently, MWA can effectively address the heat sink effect, which is a significant limitation of RFA.[16] This finding suggests its potential to expand the pool of eligible candidates for MWA.

In the decision-making process for HCC treatment strategies, it is essential to consider the risk of recurrence from previously treated lesions and the potential emergence of intrahepatic recurrent lesions requiring subsequent treatment. In this study of

Table 3. Factors affecting the overall survival in the entire cohort of 178 patients

	Univariable analysis		Multivariate analysis	
	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value
Treatment				
MWA	1 (reference)			
Liver resection	0.63 (0.21-1.88)	0.403	0.88 (0.26-2.97)	0.832
Demographics				
Age (years)	1.05 (1.01-1.10)	0.025	1.02 (0.97-1.07)	0.516
Male sex	1.27 (0.51-3.14)	0.612		
Hypertension	0.72 (0.29-1.76)	0.466		
Diabetes	1.44 (0.59-3.48)	0.423		
Chronic kidney disease	2.62 (0.77-8.98)	0.124		
Alcohol consumption	2.02 (0.67-6.05)	0.211		
Current smoking	1.15 (0.15-8.59)	0.895		
Etiology of HCC				
HBV	1 (reference)			
HCV	6.1 (2.17-17.17)	0.001	7.17 (2.11-24.32)	0.002
Others	3.3 (1.11-9.85)	0.032	2.08 (0.60-7.15)	0.246
Laboratory findings				
Platelets (10^3/mm^3)	0.99 (0.98-1.00)	0.119		
Prothrombin time (%)	0.97 (0.95-0.99)	0.001	0.97 (0.94-0.99)	0.017
AST (IU/L)	1.01 (1.00-1.02)	0.174		
ALT (IU/L)	0.99 (0.97-1.01)	0.336		
Total bilirubin (mg/dL)	1.78 (1.08-2.93)	0.024	1.01 (0.50-2.05)	0.970
Albumin (g/dL)	0.40 (0.24-0.66)	<0.001	0.49 (0.20-1.21)	0.121
Creatinine (mg/dL)	0.86 (0.33-2.20)	0.746		
Sodium (mmol/L)	0.93 (0.81-1.06)	0.279		
Cholesterol (mg/dL)	0.99 (0.98-1.01)	0.372		
Cirrhosis	1.78 (0.73-4.38)	0.208		
Tumor features				
Number of tumors				
Single	1 (reference)			
Multiple	1.41 (0.41-4.83)	0.589		
Sum of tumor size (cm)	1.23 (1.04-1.46)	0.016	1.30 (1.08-1.56)	0.006
Bile duct or vessel invasion	1.04 (0.13-8.25)	0.972		
AFP* (ng/mL)	1.11 (0.90-1.36)	0.320		
PIVKA-II* (mAU/mL)	1.26 (1.00-1.60)	0.053		
Previous treatment history of the patients	2.08 (0.80-5.36)	0.131		

Values are presented as hazard ratio (95% confidence interval).
HR, hazard ratio; CI, confidence interval; MWA, microwave ablation; HCC, hepatocellular carcinoma; HBV, hepatitis B virus; HCV, hepatitis C virus; AST, alanine aminotransferase; ALT, aspartate aminotransferase; AFP, alpha-fetoprotein; PIVKA-II, protein induced by vitamin K absence/antagonist-II.
*Log-transformed.

178 patients, older age, greater tumor burden, and a previous history of anti-HCC treatment were associated with OP. However, MWA or liver resection did not affect OP or OS. The effects of MWA and liver resection on OP have yielded inconclusive results in previous studies. A meta-analysis of 1,845 individuals revealed no significant difference in the 1-year or 5-year

Table 4. Complications of microwave ablation and liver resection after hepatocellular treatment

	Total (n=178)	MWA (n=134)	Liver resection (n=44)	*P*-value
Pain requiring analgesic	47 (26.4)	24 (17.9)	23 (52.3)	<0.001
Fever	55 (30.9)	32 (23.9)	23 (52.3)	0.001
Nausea with and without vomiting	10 (5.6)	7 (5.2)	3 (6.8)	0.983
Hemobilia	3 (1.7)	0 (0.0)	3 (6.8)	0.018
Ascites	2 (1.1)	2 (1.5)	0 (0.0)	>0.999
Hemoperitoneum	1 (0.6)	1 (0.7)	0 (0.0)	>0.999
Operation due to complication	1 (0.6)	0 (0.0)	1 (2.3)	0.557

Values are presented as number (%).
MWA, microwave ablation.

disease-free survival between MWA and liver resection.[17,19] However, at the 3-year mark, liver resection exhibited a superior outcome in disease-free survival compared to MWA (relative risk, 0.78; *P*=0.009).[19] Dou et al.[18] have reported no statistical difference in disease-free survival between MWA and liver resection (HR, 1.03; 95% CI, 0.81-1.32). Another Chinese study by Sun et al.,[20] which included 231 HCC patients within Milan's criteria, found that during a median follow-up of 43.3 months, MWA (n=116) was associated with a higher risk of recurrence than liver resection (n=115; HR, 0.607; *P*=0.007), although no significant difference in 5-year disease-free survival was observed. These findings, along with the present results, suggest that both MWA and liver resection could be viable considerations for patients with HCC. Well-designed large-scale prospective studies are needed for further clarification.

Procedure-related complications are critical factors that require careful consideration. Patients treated with MWA experienced fewer and less severe complications than those treated with liver resection, which shortened the duration of hospital stay. This observation is consistent with the findings of a previous meta-analysis by Wicks et al.,[21] which demonstrated a higher rate of major complications after liver resection than after MWA (32.9% vs. 2.6%).

This study has some limitations. First, despite efforts to minimize biases and confounding factors, this investigation was conducted at a single center based on observational data. The retrospective nature of the study and the lack of standardized criteria for selecting treatment modalities may have introduced a selection bias, affecting the comparability of the patient groups. Second, the relatively small sample size of each treatment group may have limited the statistical power of the analysis and increased the risk of type 2 errors, although efforts were made to include as many patients as possible. Moreover, the follow-up duration was relatively short. Future studies with longer follow-up periods are needed to further compare the efficacies of MWA and liver resection, which will provide insights into tailoring treatment strategies for individual patients and contribute to more personalized therapeutic approaches.

In conclusion, this real-world study comparing MWA and liver resection indicated that these two approaches yield similar treatment outcomes in terms of local tumor control, overall recurrence, and survival. Consequently, well-designed studies are needed to establish the optimal indications for MWA and liver resection to clarify their respective applications in clinical practice.

Conflicts of Interest

The authors have no conflicts of interest to disclose.

Ethic Statement

This study was approved by Institutional Review Board of Catholic Medical Center (IRB No. SC23RISI0231). This study was conducted in accordance with the Helsinki Declaration. Informed consent was not obtained due to the retrospective study design.

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Data Availability

To protect personal information the raw data on which this study is based is not publicly available.

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Supplementary Material

Supplementary data can be found with this article online https://doi.org/10.17998/jlc.2025.02.02.

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