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Sate of Art of Stereotaxic Techniques for Recurrent Nasopharyngeal Carcinoma

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Abstract **Original Research Article**

Recurrent nasopharyngeal carcinoma (NPC) is a challenging condition to treat, requiring effective strategies due to its aggressiveness and resistance to conventional therapies. Stereotactic techniques, including stereotactic radiosurgery (SRS) and stereotactic body radiation therapy (SBRT), have emerged as promising options for managing recurrent NPC. These techniques deliver highly precise radiation doses to the tumor while minimizing damage to surrounding healthy tissues, maximizing tumor control, and reducing side effects. This review explored the current evidence and clinical outcomes of stereotactic techniques in managing recurrent NPC. A systematic review was conducted using PubMed as the primary database, and 58 relevant articles were analyzed. The selected studies demonstrated the efficacy of stereotactic techniques, with high response rates and favorable local control and survival rates reported in various cohorts. However, the review also noted the potential risk of complications associated with stereotactic techniques, including late toxicities such as radionecrosis or hemorrhage. While the studies showed promising results, the level of evidence was primarily based on retrospective analyses and some pilot and prospective studies, highlighting the need for further validation and longer-term follow-up. More research is required to establish optimal protocols, minimize risks, and further understand the role of these techniques in improving patient outcomes.

Keyword: Recurrent nasopharyngeal carcinoma (NPC), stereotactic radiosurgery, healthy tissues, hemorrhage.

INTRODUCTION

Recurrent nasopharyngeal carcinoma (NPC) poses a significant challenge in terms of treatment due to its localization and the high doses of radiotherapy (RT) and chemotherapy given forprimary therapy, making retreatment difficult. In recent years, stereotactic techniques have emerged as a promising approach for managing recurrent NPC, offering precise treatment options (Suárez *et al.*, 2010).

Stereotactic techniques, including stereotactic radiosurgery (SRS) and stereotactic body radiation therapy (SBRT), utilize advanced imaging and sophisticated treatment delivery systems to deliver highly focused radiation to the tumor with sub-millimeter accuracy. These techniques enable the delivery of high doses of radiation to the recurrent NPC while minimizing damage to surrounding healthy tissues, thus maximizing tumor control and minimizing treatment- related side effects, and offering the potential for improved local control and better patient outcomes (Lee *et al.*, 2019).

Moreover, the precise targeting capabilities of stereotactic techniques allow for dose escalation, which is particularly beneficial in cases of recurrent NPC, where achieving adequate tumor control can be challenging partly due to the doses received during the initial irradiation.

In this review, we aim to explore the current evidence and clinical outcomes of stereotactic techniques in the management of recurrent NPC. We will examine the efficacy, safety, and potential advantages of these techniques, as well as discuss ongoing research and future directions in this rapidly evolving field.

MATERIALS AND METHODS

The systematic review was conducted using PubMed as the primary database. The search strategy

involved utilizing specific Mesh terms, identified by Hetop, namely “recurrence” AND "nasopharyngeal cancer" AND "stereotaxic techniques," to identify relevant articles.

After conducting an initial search, a thorough examination was carried out on the abstracts of all identified articles. Only articles directly related to the subject matter of the review were deemed relevant and included for further analysis. Conversely, articles that were deemed too general or lacking in relevance to the specific topic were excluded from the study.

Subsequently, the full texts of the selected papers were obtained and subjected to careful scrutiny to extract the pertinent data and insights. The comprehensive review of these papers facilitated a detailed assessment of the employed methodology, study design, reported outcomes, and any identified limitations.

By adhering to a stringent methodology and making effective use of available resources, the systematic review aimed to provide a comprehensive and dependable synthesis of the existing literature pertaining to the utilization of stereotactic techniques in recurrent nasopharyngeal cancer.

RESULTS

A total of 58 articles were generated. These articles were published between 1991 and 2023. 86% of them were written between 2000 and 2023. Twenty-four articles were eliminated as they did not align with the topic, by being too general about head and neck recurrences treated by stereotactic techniques or stereotactic techniques, or dealing with other salvage treatments, or not being specific to the recurrence condition or the pathology. 87,5 % of the selected articles were cohort studies, with the results predominantly explored in a retrospective manner.

The first article about treating recurrent nasopharyngeal cancer with stereotactic techniques was published in 1991. In this report, the first extracranial lesion treated with radiosurgery, a recurrent squamous cell carcinoma, was discussed, highlighting the potential role of radiosurgery in selected head and neck malignancies (Kondziolka & Lunsford, 1991). It was followed by a small cohort where stereotactic radiosurgery was used to treat three patients with locally recurrent nasopharyngeal carcinoma. One patient remained disease-free at 1-year follow-up, another patient had uncertain neurologic deterioration after 6 months, and the third patient experienced local recurrence after 6 months. Stereotactic radiosurgery was declared to be a feasible option for delivering a boost dose of radiation to recurrent nasopharyngeal carcinomas, offering potential advantages compared to other techniques (Buatti *et al.*, 1995).

Two years later, 11 patients with primary nasopharyngeal carcinoma received linac radiosurgery as a boost after fractionated radiotherapy, resulting in all patients remaining locally controlled. Among 48 recurrent/metastatic lesions, 33 (69%) were locally controlled, including 7 out of 12 locally recurrent nasopharyngeal lesions. The follow-up ranged from 1 to 60 months. There was no correlation between local control and lesion size, histology, or radiosurgical dose. Major complications occurred in 5 out of 59 treatments (8.4%), including cranial nerve palsies and trismus. The study concluded that stereotactic radiosurgery is a viable treatment modality for skull base malignancies, including primary and recurrent nasopharyngeal carcinoma, with effective dose distribution and better homogeneity compared to intracavitary implants for nasopharyngeal lesions (Cmelak *et al.*, 1997).

The journey went on in another retrospective study where SBRT was evaluated as a treatment for NPC. Five patients with recurrent NPC were treated with daily static multiportal irradiation using SBRT. The median follow-up time from SRT was 34 months. Four out of five recurrent tumors responded well and achieved complete regression. Three patients survived without evidence of local recurrence. However, one patient experienced marginal recurrence. Overall, SBRT provided local control with acceptable toxicity for recurrent NPC. Further clinical experience and longer follow-up were told te be needed to determine the full role of SRT in treating nasopharyngeal carcinoma (Mitsuhashi *et al.*, 1999).

In the same year, another study treated 13 patients with locally recurrent nasopharyngeal carcinoma using stereotactic hypofraction. Most patients had undifferentiated carcinoma and stage IV disease. Stereotactic radiation therapy (SRT) was performed using a head frame and personalized mask. A total dose of 24 Gy was given in two or four fractions. Five patients achieved complete response. The overall survival rate at three years was 31%, with minimal complications. SRT showed promise for treating recurrent nasopharyngeal carcinoma (Orecchia *et al.*, 1999).

These ninety’s studies lead to larger cohorts and the first one explored eleven patients with persistent or recurrent T1-2 NPC who were treated with stereotactic radiosurgery. The overall response rate was 91%, with a complete response rate of 82%. Two patients developed local relapse and one had neck node recurrence. The estimated 1-year local control rate was 82%. One patient experienced temporal lobe necrosis, likely due to prior radiation. Ten patients were alive at the time of the study, while one patient with local relapse had distant metastases and died. Stereotactic radiosurgery showed promise as an effective salvage treatment for early-stage persistent and recurrent NPC (Chua DTT *et al.*, 2001).

Then, fractionated stereotactic radiosurgery (FSRS) was evaluated as a boost treatment in 44 patients with residual or recurrent NPC and as salvage treatment in 6 patients with recurrent NPC. The FSRS treatment involved delivering a total dose of 14-35 Gy in multiple fractions over a period of time. The study found that 76% of patients had a complete tumor response. The overall survival rates at 1, 2, and 3 years were 83.6%, 65.0%, and 59.6%, respectively. The disease-free survival rates for patients with residual tumor were 89.94% at 1 year and 73.97% at both 2 and 3 years. FSRS was considered a suitable treatment for recurrent or residual NPC at the primary site (Xiao *et al.*, 2001).

Another study explored combining treatments for 36 patients with locally recurrent NPC with stereotactic radiosurgery (SRS) as a boost treatment after reirradiation. The external radiation therapy dose ranged from 20 to 60 Gy. The 3-year local control rate was 56%, and the 5-year overall survival rate was 49%. Persistence after radiosurgery was associated with worse survival. Age and gender showed marginal significance. No severe complications were observed after retreatment, but 11% of patients experienced nasopharyngeal necrosis. Conformal radiotherapy and SRS provided good local control and survival outcomes for patients with recurrent NPC (Pai *et al.*, 2002).

In a study by Chua *et al.*, 18 patients with persistent or recurrent nasopharyngeal carcinoma (NPC) underwent linear accelerator-based SRS as salvage treatment. The results showed an 89% complete regression of tumors after SRS. The 2-year local control rate was 72%, and the 2-year survival rate was 86%. SRS was considered an effective treatment with minimal complications (Chua DTT *et al.*, 2003).

Wu *et al.*, (n=90) evaluated four years later, FSRT as a salvage option for locally persistent and recurrent NPC. The complete response rates after FSRT were 66% for Group 1 (persistent NPC) and 63% for Group 2 (recurrent NPC). The 1-, 2-, and 3-year disease-specific survival (DSS) rates were 82.6%, 74.8%, and 57.5%, respectively, while the progression-free survival (PFS) rates were 72.9%, 60.4%, and 54.5%, respectively. The 3-year local failure-free survival, DSS, and PFS rates were 89.4%, 80.7%, and 72.3% for Group 1, and 75.1%, 45.9%, and 42.9% for Group 2. Recurrent disease and large tumor volume were identified as independent factors predicting poorer DSS and PFS. Seventeen patients developed late complications, including 2 with fatal hemorrhage. The study concluded that FSRT is effective in treating persistent and recurrent NPC with satisfactory tumor control and survival rates and a lower risk of complications compared to radiosurgery (Wu S-X *et al.*, 2007).

Another study was conducted about FSRT in 32 patients with residual or recurrent NPC. The 1- and 3-year local progression-free survival rates were 67.8% and 37.9%, and the overall survival rates were 89.7% and 71.2%, respectively. Patients with tumor volume ≤100 cc and those without chemotherapy had better local tumor control. Complications after FSRT were observed in 25% of patients, mostly grade 2-3, with one case of grade 4 complication that fully recovered (Dhanachai *et al.*, 2007).

Two years later,a retrospective study was published, where 30 patients with locally recurrent NPC were treated with SRT. The 5-year actuarial overall survival rate, disease-specific survival rate, and local failure-free survival (LFFS) rate for the entire group were 40%, 41.4%, and 56.8%, respectively. The 3-year LFFS rates were 65% for rT1-2 diseases and 66.7% for rT3-4 diseases. Patients who received a total equivalent dose (TED) <55 Gy had a significantly lower 5- year LFFS rate compared to those who received ≥55 Gy (22.2% vs. 75.8%, p = 0.005). TED was the only significant factor affecting local control. SRT was found to be an effective treatment for locally recurrent NPC, with higher TED associated with improved local control (Leung *et al.*, 2009).

Another similar study evaluated FSRT in locally recurrent NPC. The 5-year overall survival rate was 60%, and the local failure-free survival rate was 79%. T stage at recurrence was a significant prognostic factor. Severe late toxicities occurred in 5 patients (Seo *et al.*, 2009).

Then acomparative study aw edited, where locally recurrent NPC patients were treated with either robotic stereotactic radiotherapy (SBRT) or three-dimensional conformal radiotherapy (CRT) with or without brachytherapy (BRT). The two-year actuarial local control rates were 82% for SBRT and 80% for CRT. The two-year cancer-specific survival rates were 64% for SBRT and 47% for CRT. Serious late toxicities (Grade 3 and above) occurred in 21% of SBRT patients compared to 48% of CRT patients. Fatal complications were observed in 12.5% of SBRT patients and 14.8% of CRT patients. The study suggests that robotic SBRT is feasible and associated with less toxicity compared to CRT for reirradiation of locally recurrent NPC patients (Ozyigit *et al.*, 2011). Another comparative study enrolled seventeen patients with recurrent NPCwho were treated with intensity-modulated reirradiation (n = 14) or stereotactic reirradiation (n = 3). The median follow-up was 20 months. The 1- and 2-year rates of local/locoregional control were 76%/59% and 69%/52%, respectively. The median overall survival was 23 months, with 1-, 2-, and 3-year rates of 82%, 44%, and 37%, respectively. Patients with less advanced stage, higher retreatment doses (>50 Gy), concurrent systemic treatment, and complete response had improved overall survival and local control. Severe

late toxicity occurred in 29% of patients (Roeder *et al.,* 2011).

In 2014, 24 patients with recurrent NPC were treated with FSRT using CyberKnife®. The median follow-up was 19.5 months. The 1-, 2-, and 3-year locoregional control rates were 64%, 38%, and 21% respectively. The corresponding progression-free survival rates were 60%, 30%, and 17%, and the overall survival rates were 83%, 43%, and 31%. Recurrent tumor stage was found to be the only prognostic factor for overall survival. One patient experienced grade III temporal lobe necrosis, and one patient died due to grade IV mucositis and infection (Dizman *et al.,* 2014).

In 2022, twenty patients with locally recurrent NPC were treated with FSRT using CyberKnife. The median follow-up was 44 months, and the 3-year overall survival, local failure-free survival, and disease progression-free survival rates were 89%, 73%, and 53%, respectively. Nine patients achieved a complete response, three had a partial response, and six had no response. Higher cumulative total radiotherapy dose, gross tumor volume, and recurrent time interval were prognostic factors for local failure-free survival. The incidence of temporal lobe necrosis was 10% and trismus was 20%. FSRT showed again promise as a salvage treatment for recurrent NPC (Dogan *et al.,* 2022).

Another approach was evaluated in a retrospective analysis compared stereotactic radiosurgery (SRS) and gold grain implantation (GGI) for salvaging local failures of nasopharyngeal carcinoma. The study included 74 patients with a median follow-up of 42 months. The GGI group had better local control with a 3-year failure-free rate of 77.9% compared to 68.3% in the SRS group. In patients with tumor volume ≤5 cm^3, both groups had similar 3-year failure-free rates: 79.3% for GGI and 72.4% for SRS. Neuroendocrine complications were more common in the SRS group, while headache and fistula were more common in the GGI group. Both treatments showed comparable high tumor control rates in limited local failure cases (Chua DTT *et al.,* 2007).

All of these results are summarized in the table below.

Table 1: Summary table of the results of specific studies

Study	Treatment Technique	Number of Patients	Follow-up	Results
Kondziolka & Lunsford, 1991	SRS	1	7 months	Radiosurgery showed potential in treating head and neck malignancies
Buatti *et al.,* 1995	SRS	3	1 year	Feasible option for delivering a boost dose of radiation
Cmelak *et al.,* 1997	SRS	11	1-60 months	Locally controlled 69% of recurrent/metastatic lesions, including 7 out of 12 locally recurrent nasopharyngeal lesions
Mitsuhashi *et al.,* 1999	SBRT	5	34 months	SBRT provided local control with acceptable toxicity
Orecchia *et al.,* 1999	Stereotactic Hypofractionated Radiation Therapy (SRT)	13	3 years	SRT showed promise with 31% overall survival rate at three years
Chua DTT *et al.,* 2001	SRS	11	18 months	82% complete response rate, 82% estimated 1-year local control rate
Xiao *et al.,* 2001	FSRS	44	3 years	76% complete tumor response, 83.6% overall survival rate at 1 year
Pai *et al.,* 2002	SRS	36	22,1 months	56% 3-year local control rate, 49% 5-year overall survival rate
Chua DTT *et al.,* 2003	SRS	18	2 years	89% complete regression of tumors, 72% 2-year local control rate
S.-X. Wu *et al.,* 2007	FSRS	90	3 years	Effective treatment with 82.6% 3-year disease-specific survival rate
Dhanachai *et al.,* 2007	FSRS	32	3 years	67.8% 1-year local progression-free survival rate, 89.7% 1-year disease-free survival rate
Leung *et al.,* 2009	SRT	30	5 years	56.8% 5-year local failure-free survival rate, higher total equivalent dose associated with improved local control
Seo *et al.,* 2009	FSRT	35	5 years	60% 5-year overall survival rate, 79% 5-year local failure-free survival rate
Ozyigit *et al.,* 2011	SBRT vs. CRT	24 vs 27	2 years	SBRT associated with higher local control and less toxicity
Roeder *et al.,* 2011	Intensity-Modulated Reirradiation vs. SRS	17	31 months	76% 1-year local/locoregional control rate, 82% 1-year overall survival rate
Dizman *et al.,* 2014	FSRT (CyberKnife)	24	3 years	21% 3-year locoregional control rate, 17% 3-year overall survival rate
Dogan *et al.,* 2022	FSRT (CyberKnife)	20	3 years	53% 3-year disease progression-free survival rate, 10% temporal lobe necrosis incidence
Chua DTT *et al.,* 2007	SRS vs. Gold Grain Implantation	74	42 months	Similar high tumor control rates in limited local failure cases

Which stereotactic split? A study compared the outcomes of single fraction stereotactic radiotherapy (SRS) versus multiple fraction stereotactic radiotherapy (SRM) in salvaging local failures of NPC. The records of 125 NPC patients who received salvage stereotactic radiation were analyzed. Eighty-six patients were selected for the matched-pair analysis, with equal numbers in the SRS and SRM groups. The results showed that SRM was superior to SRS in terms of local control, especially for recurrent and advanced-stage NPC. The overall survival rates were similar between the two groups. The incidence of severe late complications was slightly lower in the SRM group. The study concluded that fractionated treatment with SRM is preferred for salvaging local failures of NPC (Chua DTT *et al.,* 2009). Another study evaluated, not comparatively, the outcomes of SRS and FSRT as retreatment modalities for recurrent NPC. SRS was delivered to 6 patients with a median dose of 16.5 Gy, while FSRT was administered to 2 patients with a total dose of 24.4 Gy in five fractions. The median locoregional recurrence-free survival (LRRFS) for patients treated with SRS was not reached, and the actuarial 1-, 2-, and 3-year LRRFS estimates were 68.2%, 54.5%, and 54.5%, respectively. The efficacy of FSRT in this study was not specifically mentioned. These results suggested that SRS and FSRT have both potential as salvage treatments for recurrent NPC (Agas *et al.,* 2019).

The combination of treatments including stereotactic techniques was also explored in the literature. That was notably a retrospective study about combinations comparing the effectiveness of brachytherapy and FSRT boost in treating persistent NPC after primary radiotherapy. Among 52 patients with persistent local disease, 24 received brachytherapy boost and 21 received FSRT boost. The overall 3-year local failure-free control rate was significantly lower for patients with persistent disease compared to the rest. However, the FSRT subgroup achieved a local failure-free control rate similar to complete responders. The study suggests that FSRT boost is more effective in improving outcomes for patients with persistent NPC (Yau *et al.,* 2004).

Another one was reported in a study which included 36 patients with locally recurrent NPC who were treated with SRS plus intracavitary irradiation (ICI). The 5-year disease-free survival and overall survival rates were 57% and 62%, respectively. The 5-year local control rate was 65%. Late complications were observed in 44% of patients, including palatal fibrosis, trismus, cranial nerve palsies, temporal lobe necrosis, and osteoradionecrosis. The combination of SRS and ICI showed effectiveness in salvaging early-stage recurrent NPC, with favorable survival rates but considerable late complications (Low *et al.,* 2006). One more contemporary study reported two patients with locally recurrent unresectable rT4 NPCthat received low-dose SBRT (28 Gy in 5 fractions) and pembrolizumab. Both patients showed remarkable tumor response without radiation toxicity. SBRT combined with immune checkpoint inhibitors may offer a new treatment option for locally recurrent NPC. Preclinical and clinical evidence suggested synergy between radiotherapy and checkpoint inhibitors (Wu J-S *et al.,* 2021).

All of these results were drawn from cohort analyses. The other papers were reviews whose subject was border, like the therapeutic options for the management of residual or recurrent NPC. The literature review included surgical approaches (open, endoscopic, and robot-assisted), radiation techniques (intensity-modulated radiotherapy, stereotactic radiation, and brachytherapy), and the use of chemotherapy and targeted agents. The optimal therapy depends on the size, extent, and location of the residual or recurrent NPC, as well as the biological behavior of the tumor (Wei & Kwong, 2011). More specifically, Stocker and al reviews attested that SRT was commonly used for NPC patients who were unsuitable for other treatments. Tumors with skull base erosion, orbit invasion, or intracranial extension are good candidates for SRT. Studies show high rates of complete response and 3-year local control for T1-3 disease. Fractionated SRT is attested to have better outcomes than single fraction SRT, especially for recurrent disease and tumors beyond the nasopharynx. However, there was no significant benefit of either approach for persistent disease (Stoker *et al.,* 2013).

In 2014, a French review highlighted the central role of radiotherapy in the management of head and neck cancers and the increasing use of stereotactic radiotherapy in situations that require high dose gradients and excellent conformity to the target volume, which recurrent NPC were. SRT was found to generally be used for volumes less than 6 cm in diameter, and even less for volumes under 3 cm. In NPC, stereotactic techniques were used for boost or focal dose escalation in the macroscopic tumor volume after initial conformal radiation therapy, as well as for reirradiation in cases of recurrence. The level of evidence for SRT in NPC was primarily based on retrospective studies and some pilot and prospective studies. Reirradiation with stereotactic techniques was told to possibly be an effective treatment option for local recurrence, with reported local control rates of 59% to 83% at 2 years. However, there wass a risk of severe late toxicity, such as radionecrosis or hemorrhage, ranging from 5% to 29% (Benhaïm *et al.,* 2014).

The research also found papers speaking of techniques, like this dosimetric comparison who was conducted for four stereotactic techniques (IMSRT, CARC, SmMLC, mARC) in treating locally recurrent NPC. IMSRT showed the smallest conformity index (CI) of 1.37 and homogeneity index (HI) of 0.40,

indicating superior dose conformity and homogeneity compared to the other techniques. IMSRT also spared the greatest number of organs at risk (OARs), including the brainstem, temporal lobes, optic chiasm, and optic nerve. Furthermore, IMSRT resulted in the smallest volume of normal tissue exposed to low-dose radiation. The study concluded that IMSRT is optimal for locally recurrent NPC, delivering a conformal and homogeneous dose to the target while sparing critical structures (Kung *et al.*, 2011). Another study compared the HyperArc (HA) technique with CyberKnife (CK) for recurrent NPC. HA plans showed similar or better target coverage and significantly reduced dose to OARs compared to CK plans. The HA technique reduced the mean maximal doses to the spinal cord, brainstem, optic nerves, and optic chiasm by approximately 60%. HA plans also exhibited improved dose spillage, conformity, and homogeneity indices. The study concludes that HA was a feasible and effective stereotactic body radiotherapy technique for recurrent NPC treatment (Ho *et al.*, 2021).

Lastly, we report one original study about the effect of SRS on NPC which was analyzed using flow cytometry. Four recurrent cases were treated with SRS, and the distribution of cells through the cell cycle was measured. The percentage of cells in the S phase and the proliferating index decreased after treatment. The DNA index also increased. These findings suggested that stereotactic radiosurgery can affect the DNA content and cell cycle distribution in nasopharyngeal carcinoma (Hu *et al.*, 2000).

DISCUSSION

The early studies in the 1990s demonstrated the potential of stereotactic radiosurgery (SRS) in treating recurrent nasopharyngeal carcinoma (NPC). Over the years, larger cohorts were evaluated, and various stereotactic techniques such as linac radiosurgery, fractionated stereotactic radiosurgery (FSRS), and CyberKnife® were used.

The results of the studies indicated promising outcomes for SRS and FSRS as salvage treatments for persistent and recurrent NPC. The overall response rates ranged from 76% to 91%, and complete regression of tumors was observed in 82% to 89% of patients. The 2-year local control rates ranged from 54% to 72%, and the 2-year survival rates ranged from 65% to 86%.

The studies highlighted that the effectiveness of SRS and FSRS varied depending on factors such as disease stage (rT1 vs. rT2), treatment modality (SRS vs. FSRS), tumor volume, and prior radiation dose. Patients with persistent disease generally had better local control rates compared to those with recurrent disease.

The treatment modalities were generally well-tolerated, with minimal acute side effects reported. However, late complications were observed in a subset of patients, including temporal lobe necrosis, neuroendocrine complications, palatal fibrosis, trismus, and osteoradionecrosis. The incidence of severe complications ranged from 5% to 29%.

Comparative studies between different techniques, such as single fraction SRS vs. multiple fraction SRM, and SRS vs. gold grain implantation, provided insights into the relative effectiveness and toxicity profiles of these approaches. Fractionated treatments showed improved outcomes compared to single fraction treatments, and certain techniques demonstrated better local control rates and lower toxicity.

The combination of treatments, including brachytherapy, intracavitary irradiation, and immune checkpoint inhibitors, was also explored in some studies. These combinations showed promise in improving outcomes, but they also posed a risk of complications.

Dosimetric comparisons highlighted the advantages of certain techniques, such as intensity-modulated stereotactic radiotherapy (IMSRT) and the HyperArc (HA) technique, in terms of dose conformity, homogeneity, and sparing of critical structures.

The review acknowledged that the level of evidence for SRS in NPC was primarily based on retrospective studies and some pilot and prospective studies. There was a need for further validation and longer-term follow-up to establish the role of SRS and FSRS in salvaging local failures of NPC. The risk of severe late toxicity, such as radionecrosis or hemorrhage, was also recognized as a concern.

CONCLUSION

In conclusion, the review presented a comprehensive analysis of the results of various studies on SRS and FSRS as salvage treatments for recurrent NPC. While the findings demonstrated promising outcomes in terms of tumor control and survival rates, the potential for late complications and the need for further research and longer follow-up were highlighted as important considerations. Thus, stereotactic techniques offer a valuable treatment option for recurrent NPC, but more studies are required for definitive conclusions.

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