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RESEARCH ARTICLE

STEREOTACTIC IRRADIATION: EVALUATION OF EFFICACY IN THE RADIOTHERAPY DEPARTMENT

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Abstract

This study evaluates the efficacy and safety of Stereotactic Radiotherap y (STRT) at the National Oncology Institute (INO) in Rabat on a cohort of 92 patients, from January 2022 to December 2024. It represents the first evaluation of this advanced technique in Morocco. The study reveals very encouraging results:

●**Efficacy:** A response and local control rate of 83.7% was observed six months post-treatment, which is comparable to international standards. The majority of treated cases were metastases, primarily of the brain, bones, and lungs.

●**Safety:** The study noted an excellent toxicity profile, with the absence of significant acute side effects, confirming the high tolerance of the treatment. In conclusion, the study validates the successful implementat ion of stereotactic radiotherapy at the INO of Rabat and demonstrates that high-quality care can be provided in a national context, paving the way for broader future research.

Introduction:-

Cancer treatment has seen major advances in recent decades, particularly due to progress in radiotherapy. Traditionally, radiotherapy involved irradiating large fields to reach the tumor, which inevitably led to the irradiation of surrounding healthy tissues and significant side effects. The advent of advanced technologies has allowed for the development of high-precision techniques, including stereotactic radiotherapy.

This therapeutic modality represents a revolution in the management of tumors, whether primary or secondary, especially for small and medium-sized lesions. It allows for the delivery of very high doses of radiation in a reduced number of sessions (1 to 8), which results in high biological efficacy and a reduced total treatment duration for the patient [1].

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Thanks to sophisticated imaging systems and planning software, stereotaxy targets the tumor volume with millimeter precision, thus minimizing the impact on adjacent at-risk organs and critical structures. Its efficacy has been demonstrated by numerous international studies, particularly for the treatment of brain, lung, or liver metastases, where it has shown local control rates above 90% [2, 3].

Despite this solid scientific evidence and its growing adoption in developed countries, its implementation in middle-income countries remains a challenge. In Morocco, the National Oncology Institute (INO) of Rabat has integrated stereotactic radiotherapy into its therapeutic arsenal to offer its patients care that meets international standards. The main objective of our study is to evaluate the efficacy of stereotaxy six months after treatment in a cohort of patients from the INO, marking a first step in assessing its impact on therapeutic outcomes at a national level.

Materials and methods:-

Study design and population:-

This is a longitudinal cross-sectional study conducted in the Radiotherapy Department of the National Oncology Institute (INO) in Rabat. The study cohort consists of 92 consecutive patients treated with stereotactic radiotherapy over a period from January 1, 2022, to June 30, 2024. All patients included in the study received their complete treatment within the institution.

Treatment machine and irradiation technique:-

All patients were treated with stereotaxy within the INO's radiotherapy department. Irradiations were performed on a linear accelerator equipped with the following technologies:

- A multi-leaf collimator (MLC) for beam shaping.
- A six-degrees-of-freedom (6D) robotic treatment couch, allowing for precise patient positioning and real-time correction of positional errors.
- On-board imaging (CBCT), used before and during treatment for a three-dimensional visualization of the target.
- A high dose rate, allowing for the delivery of required high doses in a very short time.

The prescribed radiation doses varied from 8 to 20 Gy, administered in a reduced number of sessions, depending on the size, location of the lesion, and the proximity of at-risk organs

Description of Images: The Dosimetry Process for Stereotactic Radiotherapy

The three images sequentially illustrate the dosimetry process, a crucial step before a stereotactic radiotherapy treatment.
Image 1 (left): An overview of the scanning room (PET-CT scanner). This image shows the clinical environment where the dosimetric scan is performed. This is a key step to acquire high-precision patient imaging necessary for treatment planning.

Image 2 (center): Detail of patient positioning. This photo highlights the precision required for stereotaxy. The patient is meticulously positioned on the scanner table with the help of immobilization devices. This positioning ensures that the tumor target will be irradiated with millimeter accuracy during treatment.

Image 3 (right): The control room. This image shows the workstation where medical physicists and technicians operate the scanner. From here, they monitor the procedure in real time and collect imaging data that will be used for detailed dosimetric planning.

Figure 1: The dosimetry process for stereotactic radiotherapy.

Image left: This photo shows a radiotherapy treatment room. At the center is an Elekta brand linear particle accelerator. This is the main equipment used for cancer treatment. The room is designed for patient comfort, with a bright ceiling decorated with a sky, clouds, and flowers. The floor is blue, and the room appears spacious and clean.
Image right: We see the physicists' and technicians' station. This is the control room from which staff monitor and manage the treatment. Several workstations are equipped with computer screens, keyboards, and office chairs.

These screens display real-time treatment data and allow for precise control of the machine in the treatment room. A blue shelf with compartments is installed on the wall.
Figure 2: Treatment room and patient treatment room at the National Oncology Institute.

Evaluation of therapeutic response:
Tumor response was evaluated clinically and radiologically for each patient. Follow-up was conducted three to six months after the end of treatment. Clinical evaluation was based on a physical examination to assess the regression or persistence of the initial symptoms.

Radiological evaluation was performed using imaging scans (CT, MRI, or PET scans), chosen according to the tumor's location, to document the stability or progression of the lesions.

Results:-

The data from this cross-sectional study are based on a cohort of 92 patients treated with stereotactic radiotherapy, representing the first institutional evaluation of this technique at the INO of Rabat over a 30-month period.

Demographic and clinical characteristics:
The median age of our population was 59.5 years, with a wide age range (from 28 to 89 years). The gender distribution showed a slight female predominance, with a sex ratio (M/F) of 0.91 (40 men to 52 women). The analysis by age group revealed that the 60 to 89-year-old category was the most represented, totaling 43 patients, which highlights the value of stereotaxy as a therapeutic option for older patients (Figure 3).

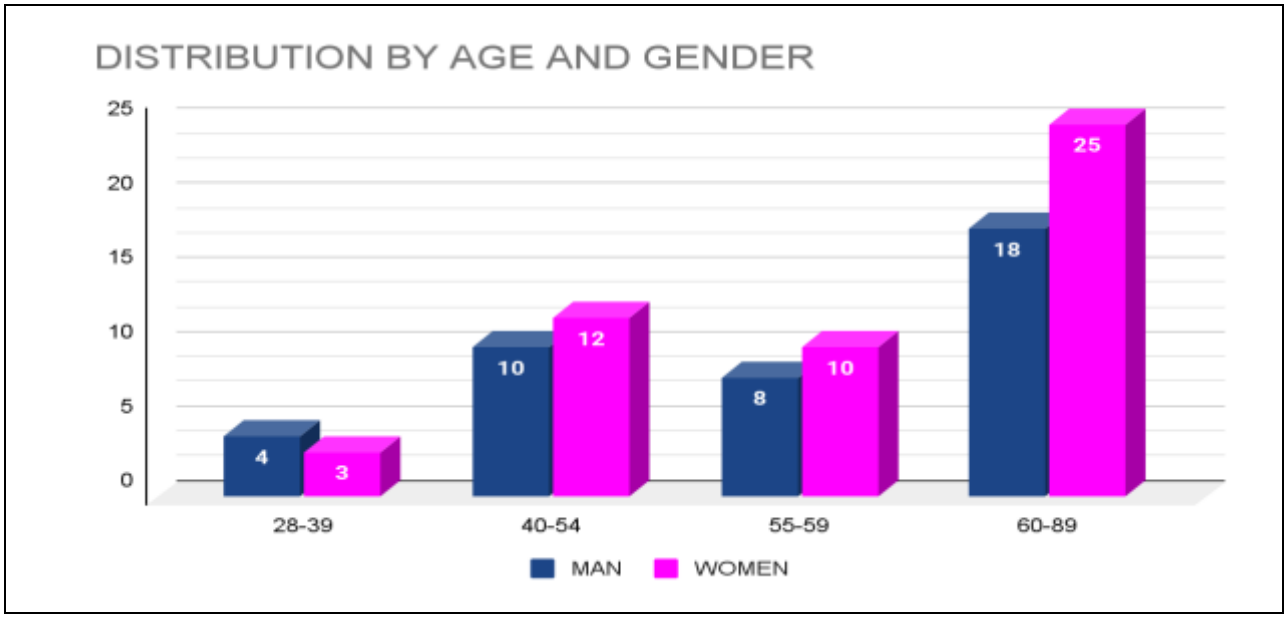

Figure 3: Distribution of the cohort by age and gender.

The majority of irradiation targets were metastases. The most frequent location was the brain, which accounted for 59.1% of treated cases (Table 1). These brain metastases primarily originated from primary breast tumors (30 patients) and lung tumors (20 patients).

The second most common location was the bones, which constituted 22.7% of irradiation sites, mainly from prostate and breast cancers. Other treated locations included the lung (5.7%), adrenal gland (3.4%), pituitary gland (3.4%), and prostate (2.3%). It is worth noting that 94% of patients were treated for a single lesion, while 6% received irradiation for at least two metastases simultaneously.

STEREOTACTIC IRRADIATION SITES	PRIMARY TUMORS	TOTAL NUMBER
BRAIN	- **BREAST (30)** - **LUNG (20)** - MENINGIOMA (4) - THYROID (1)	**55**
BONE	- **PROSTATE (10)** - LUNG (6) - BREAST (6)	**22**
LUNG	- **LUNG (3)** - RECTUM (1) - COLON (1)	**05**
PROSTATE	- PROSTATE	**02**
PITUITARY GLAND	- PITUITARY ADENOMA	**02**
LYMPH NODES	- CERVICAL CANCER	**02**
LIVER	- RECTUM	**01**

Table 1: Distribution of stereotactic irradiation sites and primary tumors.

Doses and treatment characteristics:
The median gross tumor volume was 32.38 cm^3 (ranging from 0.2 to 499.5 cm^3), which attests to the technique's ability to treat a variety of lesion sizes.

The average total dose delivered was 28.43 Gy. Total doses varied considerably depending on the case, ranging from 13 Gy in 1 fraction to 60 Gy in 8 fractions. The average treatment spread was 7 days, illustrating the rapidity of this modality's execution.

Efficacy and toxicity profile:
Patient follow-up was performed 6 months post-treatment. The results revealed a very satisfactory clinical and radiological response rate: 83.7% of patients showed complete regression of their initial symptoms accompanied by lesion stability. Only 7.6% of patients showed signs of tumor progression. It is important to note that 8.7% of the cohort were lost to follow-up during the study (Figure 4).

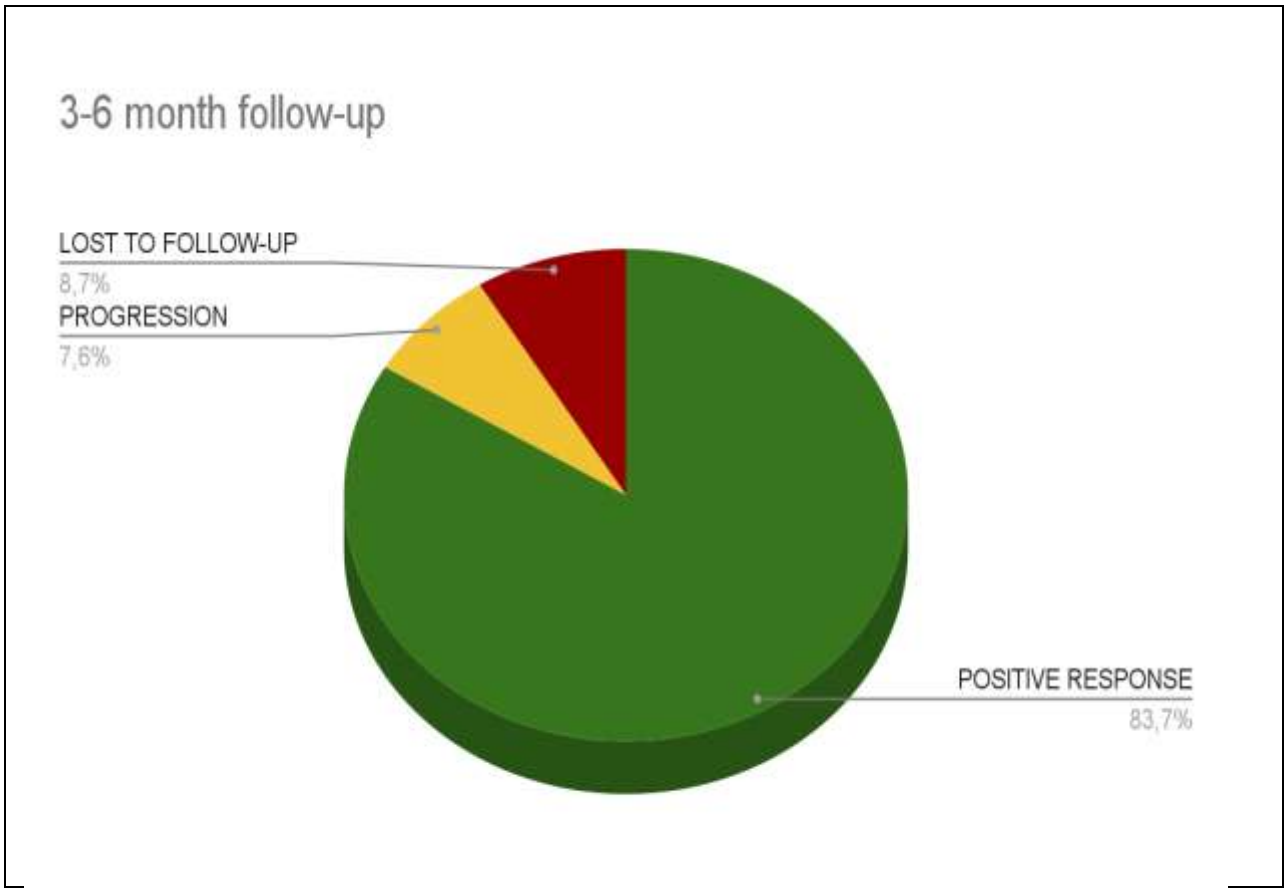

Figure 4: 3-6 month follow-up.

In terms of safety, the acute toxicity profile was excellent. We recorded no re-irradiation in our series, and the observed acute toxicities were rare. Only one patient reported a bronchial toxicity of a cough. No acute neurological or digestive toxicity was observed, which highlights the high degree of tolerance for this treatment.

Discussion:-

Our study, the first to evaluate the institutional results of stereotactic radiotherapy at the National Oncology Institute (INO) in Rabat, clearly demonstrates the clinical efficacy of this technique and its excellent safety profile. The data from our cohort of 92 patients aligns closely with results published in international literature, which confirms the validation and successful implementation of this advanced technique in Morocco.

The local control and symptomatic regression rate observed in our series is 83.7% at six months post-treatment. This figure is entirely comparable to the high control rates reported in international multicenter studies. For example, the study by Ahmed et al. [4] reports a local tumor control rate of 91.2%, and other series document similar rates [5, 6].

The predominance of brain metastases in our cohort (59.1%) is also in line with the major role of stereotactic radiosurgery in the treatment of these lesions, for which it represents a non-invasive alternative to surgery.
A particularly notable aspect of our study is the excellent safety profile. The absence of severe acute toxicity, with only one case of mild bronchial cough and no neurological or digestive toxicity, confirms the high degree of tolerance for stereotaxy.

Our acute toxicity profile is very favorable and similar to that of other studies [7, 8], which reported no acute toxicity. This is a crucial point, as preserving the quality of life is a major therapeutic objective, especially in patients with potentially limited life expectancy. The ability to deliver ablative doses to precise targets while sparing adjacent healthy tissues is a fundamental characteristic of this technique.

However, it is important to note the limitations inherent in our study. Its retrospective nature and its execution within a single institution limit the generalizability of our results. Furthermore, the size of our cohort is modest compared to large international clinical trials such as the study by Gerszten et al. [9], with 393 patients.

The six-month follow-up, while appropriate for an early evaluation, does not allow for a conclusion on long-term tumor control or the development of late toxicities. Finally, the proportion of 8.7% of patients lost to follow-up could potentially bias the final evaluation of efficacy.

Despite these limitations, our study constitutes a crucial validation of the integration of stereotactic radiotherapy into the Moroccan oncology landscape. It demonstrates that high-quality care, with clinical outcomes and a toxicity profile equivalent to international standards, can be provided in our context. This data paves the way for larger, prospective, and multicenter studies, which are essential to confirm these first promising results.

Conclusion:-

Our study, the first to evaluate stereotactic radiotherapy at the National Oncology Institute (INO) in Rabat, confirms the feasibility and efficacy of this advanced technique in the Moroccan context.
The clinical results are particularly encouraging, with a high response and local control rate (83.7%) at six months, directly comparable to international standards.

This success, combined with an excellent safety profile marked by the absence of significant acute toxicity, attests to the added value of stereotaxy. It represents a non-invasive and effective therapeutic option, crucial for improving the outcomes and quality of life of patients with tumors or metastases.

These conclusions are of capital importance, as they demonstrate our institution's ability to implement and operate a high-tech radiotherapy program with leading results. Our work serves as a proof of concept for the region, paving the way for a broader use of stereotaxy in Morocco and underscoring our center's commitment to elevating the level of oncological care.

For the future, it will be essential to conduct prospective studies on larger cohorts and establish a longer-term follow-up to assess durable tumor control and late toxicity. A multicenter collaboration between the different radiotherapy departments in the country would help to consolidate these initial results and strengthen national clinical research in oncology.

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