Section: Radiation Oncology

Original Research Article

A PROSPECTIVE STUDY OF ASSESSMENT OF LUMPECTOMY CAVITY DISPLACEMENT IN POST-ONCOPLASTY CARCINOMA BREAST PATIENTS RECEIVING ADJUVANT RADIATION AT TERTIARY CANCER CENTER

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Received *: 06/08/2025*
Received in revised form *: 22/09/2025*
Accepted *: 10/10/2025*

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DOI: 10.70034/ijmedph.2025.4.157

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2025; 15 (4); 881-887

ABSTRACT

Background: Accurate localization of the tumor bed is critical for adjuvant radiotherapy following breast-conserving or oncoplastic surgery, as most local recurrences occur at or near the original tumor site. Reliance on the surgical scar for boost localization is unreliable in oncoplastic procedures due to tissue rearrangement. Preoperative imaging combined with intraoperative tumor bed clips offers a more precise method of delineation. **Objectives:** To evaluate the role of preoperative CT-simulation and intraoperative clip placement in improving tumor bed localization and radiation planning in breast cancer patients undergoing oncoplastic breast-conserving surgery.

Materials and Methods: This prospective study was conducted at MNJ Institute of Oncology and Regional Cancer Centre, Hyderabad, over a period of 2 years, including 20 patients with diagnosed or suspected carcinoma breast. Initial T staging was assessed at presentation, and patients suitable for breast conservation were taken for oncoplastic surgery. Preoperative CT-simulation was performed in eligible patients. During surgery, intraoperative clips were placed in the tumor bed by the surgical oncologist. Radiation oncologists later used these clips, along with preoperative CT images and clinical findings, to delineate the lumpectomy cavity for adjuvant radiotherapy. Patients received standard treatment of 50 Gy to the whole breast followed by a 10 Gy boost to the tumor bed.

Results: Intraoperative clip placement combined with preoperative CT-simulation allowed accurate identification of the original tumor location, minimizing reliance on surgical scars, which often did not correlate with the tumor site in oncoplastic surgery. This method enabled more precise boost planning and reduced the risk of geographic miss.

Conclusion: In breast-conserving and oncoplastic surgery, intraoperative clip placement, supplemented by preoperative CT-simulation, provides a reliable method for tumor bed localization, ensuring accurate radiotherapy boost delivery. This approach enhances local control and cosmetic outcomes by reducing unnecessary irradiation of normal breast tissue.

Keywords: Oncoplastic breast-conserving surgery, intraoperative clips, tumor bed localization, adjuvant radiotherapy, CT-simulation.

INTRODUCTION

Breast carcinoma represents a significant health challenge globally, particularly affecting lower-middle-income countries such as India. It is the most common cancer among women worldwide, with approximately 1.4 million new cases each year. Despite advancements in detection and treatment, breast carcinoma remains a leading cause of cancer-related deaths among women, claiming over 400,000 lives annually. Breast cancer (BC) is the commonest malignancy among women globally. It has now surpassed lung cancer as the leading cause of global cancer incidence in 2020, with an estimated 2.3 million new cases, representing 11.7% of all cancer cases.[1] Epidemiological studies have shown that the global burden of BC is expected to cross almost 2 million by the year 2030.[2]

Breast cancer deaths in the South-East Asia region are expected to increase to 61.7% by 2040.[3] Breast cancer is the most common cancer in India, surpassing Cancer Cervix, accounting for 28.2% of all female cancers, with an estimated 216,108 cases by 2022.[4] The age-standardized incidence rate of female breast cancer has increased by 39.1% from 1990 to 2016, and this trend has been seen in every state of India over the past 26 years.[5] Data at our institute, MNJ institute of Oncology and Regional Cancer center has shown that about 20-25% of all cancers registered are female breast cancer, 1% of male breast cancer. Addressing this challenge requires comprehensive strategies focusing on early detection, treatment accessibility, awareness campaigns, and equitable healthcare delivery. The Incidence of Carcinoma Breast has doubled in India over the last few decades. The increasing incidence could be attributed to the increasing working women population which may increase the probability of exposure to various risk factors.

Female gender is the strongest breast cancer risk factor. Approximately 99% of breast cancers occur in women and 0.5–1% of breast cancers occur in men according to the WHO Breast cancer statistics of 2024. The treatment of breast cancer in men follows the same principles of management as for women. The standard of care for Breast Carcinoma is multi-modality which is surgery (either breast conservation surgery or modified radical mastectomy) (or) chemotherapy depending on the stage at diagnosis. This may be followed by Radiotherapy to decrease the chances of locoregional recurrence. The patient may need to take hormonal therapy and/or HER2/neu directed targeted therapy depending on the hormone receptor status of the patient. Majority of the cases have either neoadjuvant chemotherapy followed by Modified radical mastectomy followed by adjuvant chemotherapy and referred to the Radiaiton Oncologist Adjuvant radiotherapy.

Several studies have provided evidence supporting the use of post- mastectomy radiation therapy to prevent local-regional recurrence. The reason behind this is the possibility of residual disease remaining undetected at the surgical site and in the nearby lymph nodes, which could serve as a source for metastasis. Therefore, targeting these areas with radiotherapy is believed to offer therapeutic advantages for patients by potentially reducing this risk. The standard radiotherapy protocol is administering a total dose of 50 Gy over 25 fractions, typically spread across 5-6 weeks, which includes provision for a posterior axillary boost. This may also include lumpectomy cavity boost of additional 10Gy over 5 fractions.

Many top centers around the world nowadays practice a sound established, hypo fractionated protocol for post-mastectomy radiation therapy (PMRT) which reduces the total number of fractions and in turn the treatment duration. When it comes to the protocol, prescription dose which is 5000 Gy delivered over 25 fractions with 2Gy per fraction is being practiced and has been considered as a fair standard dosage over the world after several trials.

Breast conservation surgery (BCS) is the upcoming standard for breast cancer patients. It has cosmetic advantages, which can help the patient psychologically. Oncoplasty is a procedure where BCS is performed along with reconstruction procedures. This surgery is mostly dependent on the skill and expertise of the surgeon.

There are not many studies or articles about the challanges faced by radiation oncologists in terms of adjuvant radiation therapy post-oncoplasty, factors influencing the decision of where to prescribe the treatment after oncoplasty. This prospective study is inspired based on the increasing number of oncoplasty procedures being done and no set guidelines for the radiation oncologist to follow regarding the Adjuvant Radiation therapy. There are not many patients willing to undergo Oncoplastic breast conservation surgery (OBCS), due to the fear of recurrence in the remaining breast. They moslty prefer to go for complete removal of the involved breast due to this fear and also peer pressure. These issues need to be clearly addressed and explained to the patient keeping in mind their fears regarding the chances of recurrences, the advantages of OBCS, the need for regular followup and the ways to tackle local recurrences, if and when they do occur.

MATERIALS AND METHODS

A prospective study conducted at the Department of Radiation oncology at MNJ institute of Oncology and Regional Cancer Center, Hyderabad. A period of 2 years from the date of approval.

Inclusion Criteria

- Age >18 years and <80 years.
- Informed consent
- Patients who underwent oncoplastic breast conservation surgery.
- Early breast cancer (T1 to T3; N0 to N1).

Exclusion Criteria

- Metastatic breast cancer.
- Patients with contraindications to radiation treatment.
- Patients with co-morbidities like hypertension, diabetes mellites, coronary artery diseases, respiratory diseases, epilepsy etc.,
- History of any previous radiation treatment (or) chemotherapy.
- History of synchronous (or) metachronous cancers.
- Oncoplastic surgery done at other institutes due to lack of communication and planning with the surgical oncologists.

Methodology:

Patients eligible according to the inclusion criteria for a minimum of 20. After obtaining an informed consent, patients who have been diagnosed with Breast Carcinoma and come under the inclusion criteria are being considered for the study.

The diagnosis of the patient is with a trucut biospy confirmation after which the next step of management is decided upon. Immuno-histochemistry is done to know the hormonal receptor status of the patient to decide upon the chemotherapy management. The next step may either be Oncoplastic surgery upfront (or) a course of neo-adjuvant chemotherapy depending on the T staging and the immuno-histochemistry status of the patient. The patients who underwent neo-adjuvant chemotherapy first, would receive either four (or) sometimes complete eight cycles of the chemotherapy regimen.

The standard chemotherapy regimens received by the patient include four cycles of Adriamycin and Cyclophosphamide followed by four cycles of Taxol. Trastuzumab can be added to the regimen along with taxol depending on the HER- 2/neu receptor status of the patient. Both the patients who are going through the neo-adjuvant chemotherapy route (or) directly undergoing oncoplastic surgery will get a CT-simulation scan done pre-operatively. This will help in guiding the radiation oncologist in locating the tumor cavity post-oncoplasty.

A pre-operative CT-simulation is necessary because, post-oncoplasty, either done by replacement technique (or) a displacement technique, there is difficulty in locating the tumor cavity (or) tumor bed. The pre-operative CT- simulation and intra- operative tumor bed clips are used as guidance by the radiation oncologists to locate the tumor cavity.

The pre-operative CT-simulation will be taken with the patient in supine position on a breast board, hands of the patient above the head and holding the grip rod depending on the comfort of the patient. The head of the patient will be turned to the opposite side of the breast involved. The simulation will then be taken from the mandible to the umbilicus in 3mm slices.

After the patient undergoes the oncoplastic surgery, the patient will either continue the remaining chemotherapy cycles (or) will be receiving adjuvant radiation to the whole involved breast with (or) without chest wall according to the initial staging of the patient and with boost to the tumor cavity location.

The standard adjuvant radiation dose received by the patient is 50Gy to the whole breast with (or) without the chest wall along with 10Gy boost to the tumor cavity at 2Gy/fraction in 5-6 weeks overall treatment time. When the patient comes to the radiation oncologist for adjuvant radiation, a CT-simulation for treatment purpose is taken. The treatment CT-simulation will be done in the same position as the one done pre-operatively. This will help in locating the tumor by exactly matching the pre-operative and post-operative CT-simulations.

After locating the tumor cavity with the help of pre-operative CT-simulation and intra-operative clips placed by the surgeon, by following the RTOG contouring guidelines, the breast to be treated, the cavity location, the organs at risk will be contoured, which in the case of Breast Carcinoma include the heart, the lungs and the contralateral breast as well. Standard radiotherapy doses will be planned keeping in mind the dose constraints that need to be followed for the organs at risk.

Dose constraints for organs at risk

.ORGAN AT RISK	DANISH GUIDELINE DOSIMETRIC PARAMETER
HEART	V20Gy = 10% V40Gy = 5%
IPSILATERAL LUNG	V20Gy = 25% (no SCNI) V20Gy = 35% (with SCNI)
SPINAL CORD	DMAX 45Gy
BRACHIAL PLEXUS	DMAX 54Gy

During the radiation treatment, patients will be monitored for any acute reaction, including dermatitis in Breast Carcinoma patients. The grading of severity of dermatitis is done by following the RTOG guidelines for grading dermatitis. Once the patient has completed radiation treatment, the patient will be continued on hormonal therapy and/or trastuzumab depending on the hormonal status of the patient. Else, the patient will be asked to come for follow-up every two months following the completion of radiation treatment for assessment of the treated breast and for general examination of the contralateral breast, the bilateral axilla and the supraclavicular fossa as a routine.

For the assessment of the cavity displacement, the pre-operative CT- simulation and post-operative / pre-treatment CT-simulation scans must be matched to see whether the cavity has displaced (or) not and if it has displaced, by how much in cm. The center of the tumor in pre-operative simulation and center of

the tumor cavity in post-operative simulations has been marked and they are both fused by aligning the bone prominences like the vertebral body and the ribs for matching both the scans as much as possible. This allows us to compare the centers of the tumor and cavity in both the scans and to see how much the center of the tumor has displaced in the post-operative scan.

After the mean displacement has been calculated for all the 20 patients, the displacement of cavity in each patient has been correlated with different factors like age, staging, whether (or) not neoadjuvant chemotherapy has been given, Hormonal receptor status and corresponding graphs and scatter plots have been done.

RESULTS

A total of 20 patients were included in this prospective study. The plan of management of each patient was decided by a surgical oncologist and a radiation oncologist.

Table 1: Lumpectomy cavity displacement

	Age	Lumpectomy cavity displacement (cm)
N	20	20
MISSING	0	0
MEAN	48.15	1.1090
MEDIAN	50.00	1.1050
STANDARD DEVIATION	8.061	0.43773
MINIMUM	35	0.48
MAXIMUM	60	2.39

The mean cavity displacement was calculated for these 20 cases together which was 1.1090 with a standard deviation of 0.43773.

Table 2: Age of the patients in sample size

Age (years)	Number of subjects	Percentage
</=45	9	45.0%
46 and above	11	55.0%
Total	20	
Diagnosis and laterality		
CA Left Breast	12	60%
CA Right Breast	8	40%
T staging		
T1	3	15.0%
T2	13	65.0%
T3	4	20.0%

The total 20 patients were divided into two age groups namely those below and equal to 45 years old which was 45% of the total sample size and those that are 46years old and above, which was 55% of the total sample size. There were 60% of the sample size with left breast cancer and 40% of the sample size with right breast cancer. There were 15% of cases with T1 stage, 65% of cases with T2 stage and 20% of cases with T3 stage.

Table 3: ER status of the patients

ER status	Number of subjects	Percentage
Positive	13	65%
Negative	7	35%
PR status		
Positive	10	50%
Negative	10	50%
HER2/neu status		
Positive	6	30%
Negative	14	70%
Neoadjuvant chemotherapy status.		
Yes	14	70%
No	6	30%

The total sample size was divided based on the positivity and negativity of hormonal Estrogen receptor (ER). There were 65% of patients with Estrogen receptor positive and 35% of patients with estrogen receptor negative. There were 50% of patients with progesterone receptor positive and 50% of patients with progesterone receptor negative. There were 30% of patients with HER2/neu receptor positive and 70% of patients with HER2/neu receptor negative. 70% of the total sample received neoadjuvant chemotherapy and 30% of the sample size didn't receive neoadjuvant chemotherapy.

Table 4: Cavity displacement in T staging

Staging	Lumpectomy Cavity Displacement		P Value (Anova)
	Mean	Standard Deviation	
T1	0.76	0.313	0.236
T2	1.12	0.483	
T3	1.34	0.165	

The mean cavity displacement in every T stage has been calculated along with the standard deviation and p value has been calculated using ANOVA (Analysis of Variance). This is used to compare means of more than two groups. A p value of <0.05 has statistical significance. And in this case, the p value is 0.236 which is insignificant.

POST-HOC TESTS

A post–hoc analysis refers to a statistical analysis that is specified after a study has been concluded and the data has been collected. They are also called multiple comparison tests.

Table 5: Multiple comparisons of T staging

Multiple comparisons						
Dependent variable						
Staging		mean	standard error	signifi- cance	.95% confidence interval	
					Lower bound	Upper bound
T1	T2	-0.35513	.0.27228	.0.210	-0.9296	0.2193
T2	T1	0.35513	0.27228	0.210	-0.2193	0.9296
	T3.	-0.21904	0.24306	0.380	-0.7319	0.2938

Multiple comparisons of different T stages have been done and the mean difference, standard error and p value of significance and 95% confidence intervals have been calculated for each comparison. None of the calculated p value is significant, indicating that the displacement in lumpectomy cavity is not correlated significantly with T staging of the breast cancer patient.

Table 5: Status of breast cancer and lumpectomy cavity displacement

Diagnosis	Lumpectomy Cavity Displacement		P Value (T - Test)
	Mean	Std. Deviation	
Ca Left Breast	1.00	0.363	0.186
Ca Right Breast	1.27	0.514	
ER status			
Positive	1.08	0.498	0.675
Negative	1.17	0.325	
PR status			
Positive	0.98	0.545	0.188
Negative	1.24	0.265	
HER2/neu status			
Positive	1.27	0.286	0.283
Negative	1.04	0.480	
Neoadjuvant chemotherapy			
Positive	1.12	0.316	0.819
Negative	1.07	0.683	

The mean values of lumpectomy cavity displacement seen in both sides of the breast cancer and their standard deviations have been calculated and the p value has been calculated with t-test indicating that the lumpectomy cavity displacement is not correlated significantly with the laterality, ER receptor status, PR status, HER2/neu receptor status and neoadjuvant chemotherapy of the breast cancer.

Table 6: Age and cavity displacement

Age (Years)	Lumpectomy Cavity Displacement		P value (t- test)
	Mean	Std. Deviation	
</= 45	1.32	0.507	0.049
46 and above	0.94	0.294	

The mean cavity displacement and standard deviations have been calculated in the two age groups of less than or equal to 45years old and those that are 46 years old and above. The p value has been calculated with t-test, which is 0.049 which is statistically significant. Therefore, we can say that lumpectomy cavity displacement is correlated significantly with the age of the breast cancer patient with more mean displacement seen in patients less than or equal to 45years of age.

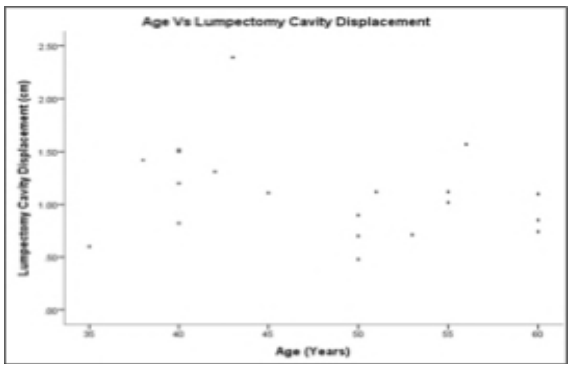

Figure 1: Correlation analysis between the age group

The correlation analysis between the age group of the patient and lumpectomy cavity displacement revealed a weak correlation between the two factors. Values at or close to zero indicate no linear relationship or a very weak correlation. In this case, the pearson correlation coefficient is –0.267.

According to the post-hoc analysis, the displacement of lumpectomy cavity was seen in every case with a mean displacement of 1.1090 in 20 patients.

There was no significant correlation between the different variables (T staging, hormonal receptor status, whether neoadjuvant chemotherapy was given) and the displacement of lumpectomy cavity.

It is observed that the p value was statistically significant i.e., 0.049, with t- test between the age groups of the patient and the mean lumpectomy cavity displacement, but the correlation analysis showed a weaker correlation between the two. Correlation analysis can only be done between numerical variables.

This displacement can be due to many reasons including subjective differences in the identification of post-operative lumpectomy cavity location i.e., maybe different for two radiation oncologists since contouring the cavity is subjective. One of the reasons can be due to the reconstruction technique used in oncoplasty procedure. Whether a displacement technique is being used, where the surrounding tissue may be displaced to fill-in the lumpectomy cavity (or) the replacement technique, where different types of skin pedicles may be used to fill-in the cavity.

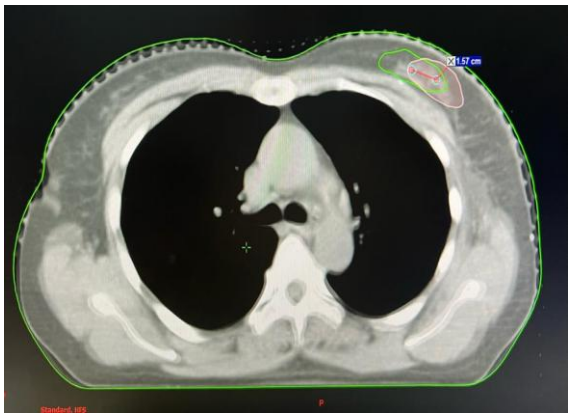

Figure 2: measuring the displacement of tumor and cavity centers

DISCUSSION

Our study, conducted in the MNJ Institute of Oncology and Regional Cancer Centre over two years with 20 breast cancer patients (either newly diagnosed or suspected), focuses on a workflow integrating preoperative CT-simulation, intraoperative surgical clips in the tumor bed, and subsequent radiation planning for breast-conserving therapy (or oncoplastic surgery). The key rationale is that accurate localization of the tumor bed (post-surgery) is critical for delivering a tumor-bed boost during adjuvant radiotherapy, particularly after oncoplastic surgery where scar location may not reflect the original tumor location.

Oncoplastic breast-conserving surgery (OPS) adds complexity to boost planning. Traditional methods (scar location, palpation, clinical landmarks) often fail because the tumor resection and tissue rearrangement may shift the bed or mask it. As Tse et al,[6] (2020) emphasize in their consensus statement on tumor bed localization, OPS complicates the identification of the original lumpectomy cavity, making reliance on surgical clips, imaging, and operative records essential.[1] Similarly, Morse et al,[7] (2024) commented on the interplay of oncoplastic reconstruction and adjuvant radiotherapy, noting that target delineation is more challenging and interobserver variability increases in OPS cases.[2] Therefore, our approach—placing clips intraoperatively and combining them with preoperative CT simulation—is aligned with best practices in the literature.

Our use of intraoperative clips in the tumor bed is well supported by literature. Riina et al,[8] (2020) evaluated the effectiveness of intraoperative clip placement and concluded that clips do improve accuracy of boost targeting after oncoplastic surgery, reducing geographic miss rates. They found that without clips, localization is often inaccurate and lead to inadequate coverage.

Moreover, de Freitas et al,[9] (2018) in "What a difference a clip makes!" reported that using radiographically visible markers significantly improved concordance and reduced normal tissue irradiation when planning boost volumes. Their data support our assumption that clips are crucial, especially when surgical scars may mislead. However, even with clips, there remains variability. The literature notes that the number, positioning (superficial, deep, radial directions), and documentation of clips matter (Kirby et al., 2013),[10] Muvvala et al,[11] (2020) compared various methods (scar-based, self-localization, pre-op CT, etc.) against clip-based delineation, and concluded that clip-based plus CT is the standard technique for boost delineation because other methods showed poor concordance. Our study design—using both preoperative CT simulation and intraoperative clips—mirrors this hybrid approach.

Furthermore, a recent 2025 study (Yeh et al.),[12] evaluated the use of stabilized hyaluronic acid gels as an adjunct to surgical clips to improve delineation in tumor bed delineation, especially when clips are sparse or displaced. That study underscores the need for redundancy in marking techniques.

Our requirement that patients suitable for oncoplastic breast conservation undergo preoperative CT-simulation is also validated by literature. Preoperative imaging helps localize the tumor within the breast in the treatment position, which can guide surgical planning and later registration. When used in conjunction with intraoperative clips, the registration between preoperative and postoperative planning CT helps accurately define the boost target. Muvvala et al,[11] compared pre-op CT delineation vs clip-based delineation and found better overlap when CT was used to complement clip information. A key caveat is that the postoperative cavity (seroma) can shift, contract, or evolve over time, which may limit accuracy if CT is delayed. Because of this, many centers aim to perform CT simulation soon after surgery to capture the original geometry. The sequence you describe—CT simulation early and clips placed intraoperatively—is logical to minimize anatomical changes.

As our sample is small (n=20), statistical power is limited, but our methodology is consistent with comparative studies that evaluate overlap metrics (e.g., overlap indices, geographic miss). In practice, studies like Fawzy et al,[13] (2019) comparing multiple methods of bed delineation highlight that only clip-based + imaging techniques reliably minimize geographic miss. Variation among radiation oncologists in contouring the lumpectomy cavity is well documented, especially in OPS settings. The more reliable the markers (clips, imaging), the lower the variability (Landis et al., 2007).[14] The justification for delivering a boost (e.g., 10 Gy in our protocol) is supported by radiotherapy trials and reviews which demonstrate that most local recurrences happen in or near the original tumor bed, and boosting lowers recurrence risk (Roldán et al. 2022).[15] Accurate boost delineation is thus critical. Given the complexity and risk of geographic miss in OPS, our approach is justified and likely to lead to better local control outcomes and reduced toxicity.

CONCLUSION

On locating and contouring the tumor location, it has been observed that the pre- operative tumor location and the tumor bed location corresponding to the intra-operative clips may not be in the exact same location. There has been a slight shift of the post-operative tumor cavity location from the pre-operative tumor location. This has been correlated with different factors like age of the patient, T staging of the patient on initial diagnosis, the status of hormone receptors and the Neo-adjuvant chemotherapy status. Whether (or) not these factors had any significant impact on the cavity location displacement. On further analysis, it has been found that there is no significant correlation of the cavity location with any of the above-mentioned factors.

Limitations: There are not many studies (or) papers on this topic and it is a novel study in a way. The small sample size is also a limitation since not many patients are willing for breast conservation surgery, but favor mastectomy. Due to the small sample size, coming to a proper conclusion about the correlation of cavity displacement with different variables couldn't be done.

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