## A Study on Skin Dose Changes with Changes in Body Weight from Tomotherapy for Head and Neck Cancer

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#### Abstract

**Background/Objectives**: When receiving radiation treatment in form of tomotherapy, most head and neck cancer patients show symptoms of weight loss caused by stomatitis and esophagitis, and skin burns. Weight loss may lead to a closer distance between the skin and the target, causing a change in the measured skin dose. This study was conducted to analyze such changes during the radiation treatment period. **Methods/Statistical Analysis**: The study also analyzed whether factors such as patient gender, age, diagnosis type, and treatment regimen, including surgery or chemotherapy in addition to radiotherapy, might influence the weight changes in patients, and collected values for changes in skin dose using thermoluminescence dosimeters. **Findings:** The study considered 20 patients with head and neck cancer, and all of these patients showed weight loss and an increase in measured skin dose. In addition, the gender or age of the patients had no direct relationship with their weight changes. Patients who hadn't undergone surgery prior to concurrent chemotherapy and radiation therapy displayed the least amount of weight loss. As the amount of weight loss became larger, so did the skin dose that was measured during tomotherapy (*p*<.05). **Application/ Improvements:** It appeared that greater weight loss led to an increase in measured skin dose, From this study, it is implied patients with large weight loss may benefit with an adjustment of their radiotherapy parameters while maintaining their target doses.

Keywords: Chemotherapy, Thermoluminescence Dosimeter, Tomotherapy, Surgery, Weight Loss

## 1. Introduction

Currently, the major treatment methods for head and neck cancer include surgery, radiation treatment, and chemotherapy. Advanced cancer is frequently observed in the head and neck cancer cases, and that's why more than two treatments are usually conducted concurrently for head and neck cancer patients. In general, radiation or anticancer radiation treatments were added after the surgery. Recently, however, because of the potential damage to vital organs such as larynx, the 'organ preservation' treatments are being applied to obviate serious functional effects. Such concept of treatment is to decide

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again upon surgery or radiation treatment according to the tumor's therapeutic response to chemotherapy, or to conduct the concurrent chemotherapy and radiation therapy first, and later decide on further surgery. Head and neck cancer is never a pushover in terms of the quality of life. By thinking about typical head and neck cancer such as oral cancer, larynx cancer, and tongue cancer, one may easily understand why. The head and neck cancer appears in the parts that are closely related to the function of eating, breathing, and speaking. Although the 5-year survival rate of the head and neck cancer is 80% and 90% in first and second stage, which is quite high, if not cured adequately in the early stages, the quality of life might decline significantly<sup>1</sup>. As such, for head and neck cancer, it is important to cure cancer at the same time as preserving the function of organs. This is why radiation treatment is a popular treatment method for the head and neck cancer, particularly for initial laryngeal cancer, and nasopharyngeal cancer. Radiotherapy is also selected for rhino pharynx cancer, which is inoperable as being located close to the bottom part of the brain, and tonsillar cancer, for which the treatment should preserve the swallowing function. Recently, the side effects of radiation treatment have decreased significantly due to improvements in the radiation-delivery technology<sup>2</sup>. Similar to surgery, radiation therapy has side effects such as treatment aftereffects or sometimes accidents caused by anesthesia or there may be development of scars post treatment. The most common side effect of radiation treatment of head and neck cancer is the destruction of salivary glands caused when the cancer cells are exposed to radiation. In order to reduce or prevent this for as much as possible, the intensity of radiation should be properly controlled<sup>3</sup>. Although in the initial stages of head and neck cancer, sole radiation treatment is sufficient, for the advanced cancer, radiation treatment is conducted as an auxiliary treatment for surgery (operation)<sup>4</sup>. Radiation therapy may also be combined with anticancer drug regimen such as chemotherapy. For instance, for a patient with severe laryngeal cancer who will most likely lose his or her voice if treated by surgery, the oncologists may try using an anti-cancer drug and conduct radiation treatment in case there would be a positive response. However, if a negative response appears with the anti-cancer drug, surgery would be attempted as the default treatment. If with drug and radiation combination, a positive response were seen, the patient would be able to live without losing their voice. The result of research on concurrent chemotherapy and radiation therapy was first published around 10 years ago, and now this mode of therapy has become a generally applicable treatment as initial therapy. It is known that the concurrent chemotherapy and radiation therapy increases the treatment effect by 10% compared to radiation treatment alone<sup>5</sup>. Thus, the radiation treatment is a vital therapy in head and neck cancer treatment along with drug therapy and surgery<sup>6</sup>. The radiation tomotherapy for head and neck cancer accompanies skin burn even though there is no change in weight. Nevertheless, most patients experience weight loss, and this study will verify how such weight changes affect the exit skin doses measured.

## 2. Object and Methods of Study

#### 2.1 Object of Study

In this study, the skin dose was measured with the thermoluminescence dosimeter for 20 head and neck cancer patients who had received tomotherapy at the Tomotherapy Room of the Proton Therapy Center at the K Cancer Center between April and November of 2015. Since the skin burns usually appear around the patient's neck for head and neck cancer cases, patients whose treatment area included the neck were selected. The average age of 20 patients was 59.6 years, and the patient group was composed of 4 female and 16 male patients.

#### 2.2 Methods of study

#### 2.2.1 Measurement of Patient Body Weight

Usually, radiation tomotherapy of head and neck cancer requires 30 treatment sessions and 6 weeks of treatment period. The patients who receive the tomotherapy also have an interview once a week with the doctor in charge. During the first day of radiation tomotherapy, the body weight of patient is measured then the dose is measured in the course of the treatment. The weight of patient is measured once again on the last day of the radiation therapy, before conducting the treatment. For our study, we have calculated the reduction ratio between the weight measured on the first day of the treatment and the weight measured on the last day of the treatment.

#### 2.2.2 Patient's Skin dose Measurement

When a head and neck cancer patient decides to receive tomotherapy and once the treatment plan is established, the attachment spot of thermoluminescence dosimeter should be determined in advance by checking the dose distribution diagram. Three ThermoLuminescence Dosimeter (TLD) elements each and three thermoluminescence dosimeters were used for the neck region. On the first day of tomotherapy, the skin dose measurement protocol is explained to the patient, and a picture of the thermoluminescence dosimeter attached to a certain spot is taken. To reduce error, the measurement is repeated on the second day, a day before the last day of the treatment, and on the last day of the treatment in the same manner with attachment of the dosimeters at the same spot as on the first day Figure 1.



Figure 1. TLD position

For the three thermoluminescence dosimeters, TLD1 is attached on the upper right part of the patient's neck, TLD2 is on the upper left part of the patient's neck, and TLD3 is on the bottom left part, as it cannot be attached to the middle area if a patient had operation on neck before the radiation treatment and had an airway tube inserted and attached to the middle part of the neck.

#### 2.2.3 Statistical Analysis

The patient might lose weight because of tomotherapy. However, there might be other factors that may cause weight loss. Therefore, we analyzed the correlation between the weight loss seen and the object's general features (gender, age), diagnosis, surgery and the specific anti-cancer therapy. A statistical program SPSS version 20 (SPSS Inc., Chicago, IL, USA) was used and the level of significance was set below a *p*-value of 0.05.

## 3. Results

# 3.1 Weight Change in Relation to Gender of the Patient

All 20 patients whose skin doses were measured showed a weight loss. The weight loss ratios of 9 patients were below 10%, for 10 patients between 10% and 20%, and for one patient above 20%. For the 20 patients, there were 16 male and 4 female patients. Among the 16 male patients, the weight loss ratio of 7 patients was below 10%, 9 patients between 10% and 20%, and no one had lost the greater than 20% weight. Among the 4 female patients, 2 had lost less than 10% weight, one patient had lost the weight by 10% to 20%, and there was a patient who had lost the weight by a ratio greater than 20%. The weight loss result for each gender was not statistically significant, and reflected that the gender of a patient did not affect weight changes seen ( $p \ge .05$ ), Table 1.

Table 1.	Body weight change by gender (unit:
persons,	%)

Gender	W	eight chan	Total			
	10<	10≥, <20	20<	Total	p-value	
Male	7(35%)	9(45%)	0(0%)	16(80%)	407	
Female	2(10%)	1(5%)	1(5%)	4(20%)	.407	

# 3.2 Weight Change in Relation to Age of the Patient

Among the 20 patients whose skin dose were measured, 4 of them were under 50 years old, 7 of them were above 50 and under 60 years old, 3 of them were above 60 and under 70 years old, and 6 were above 70 years old. Among the 4 patients under 50 years old, one had lost less than 10% weight, 2 had lost more than 10% and less than 20%, and one patient had lost the weight by a ratio greater than 20%. Among the 7 patients above 50 years old and under 60 years old, 5 patients had lost weight by less than 10%, 2 patients had lost weight by more than 10% and less than 20%, and no one had lost weight by more than 20%. Among the 3 patients above 60 and under 70 years old, a patient had lost weight by less than 10%, 2 patients had lost weight by more than 10% and less than 20%, and no one had lost weight by more than 20%. Lastly, among the 6 patients above 70 years old, 2 patients had lost weight by less than 10%, 4 patients had lost weight by more than 10% and less than 20%, and again, no one had lost more than 20% of their original weight. As the weight changes according to age were not statistically significant, it meant that the age of a patient did not affect weight change seen in the patient ( $p \ge .05$ ), Table 2.

#### 3.3 Weight Change in Relation to Head and Neck Cancer Surgery and Chemotherapy

Among the 20 patients whose skin doses were measured, 4 patients had undergone both surgery and chemotherapy, 7 patients had only undergone surgery, 7 patients had undergone only chemotherapy, and 3 patients did not have both treatments. All of 3 patients who had both surgery and chemotherapy showed weight change of less than 10%. Five of the 7 patients who had only undergone surgery showed weight loss of less than 10%, and 2 of them showed weight loss of more than 10% and less than 20%. Among the 7 patients who only had chemotherapy,

A	Weight change			Total	
Age	10<	10≥, <20	20<	Iotai	p-value
50<	1(5%)	2(10%)	1(5%)	4(20%)	
50≥, <60	5(25%)	2(10%)	0(0%)	4(35%)	127
60≥, <70	1(5%)	2(10%)	0(0%)	3(15%)	.12/
70<	2(10%)	4(20%)	4(0%)	6(30%)	

Table 2.Body weight change by age (unit:persons, %)

6 patients had lost weight by more than 10% and less than 20%, and a patient had lost weight by more than 20%. Among 3 patients who didn't have both treatments, surgery and chemotherapy, a patient had lost less than 10% weight and 2 patients had lost weight by more than 10% and less than 20%. From our analysis, conducting surgery and chemotherapy at the same time did affect weight change in the patient, and this was statistically significant (p<.05), Table 3.

# 3.4 Skin dose Change in Relation to Weight Change

If the average rate of increase in skin doses were 12%, 10%, and 7.89% for the three sites on the neck, the weight loss ratio was less than 10%. The average rate of increase in skin dose was 16.6%, 17.1%, and 15.9% in case the weight loss ratio being more than 10% and less than 20%. Lastly, the average rate of increase in skin dose was 31%, 43%, and 29%, which is a dramatic increase, in case of the only patient who showed the weight loss of over 20%. As this result is statistically significant, it means that the weight change for a patient affected the skin dose change and the radiation exposure to the normal tissues (p<.05), Table 4.

## 4. Discussion

Radiation treatment is widely used independently or as a part of concurrent therapies for patients with various malignant tumors. However, exposure to large amounts of ionized radiation causes local, acute, and chronic radiation dermatitis on the radiation treatment area or the surrounding skin. Recently, it has been shown that concurrent chemotherapy and radiation therapy prior to the surgery brings the best results among various concurrent treatments for advanced head and neck cancer<sup>7</sup>. In this study, we analyzed 4 groups of patients based on the treatment area and the clinical stage of the patient. Among

Table 3.	Body weight change by surgery and
chemothe	rapy (unit: persons, %)

C	Chemo	W	eight chan	ge	Tatal	Maara (0/)	p-value
Surgery	therapy	10<	10≥, <20	20<	Total	Mean(%)	
0	0	3(15%)	0(0%)	0(0%)	3(15%)	4.67±1.53	
0	Х	5(25%)	2(10%)	0(0%)	7(35%)	7.29±2.98	001
X	0	0(0%)	6(30%)	1(5%)	7(35%)	14.14±4.26	.001
X	Х	1(5%)	2(10%)	0(0%)	3(15%)	10.33±3.06	

Table 4. Skin dose by body weight change (unit:persons %)

Skin dose	Weight change (%)	Mean (%)	p-value
	10<	12±7.8	
TLD Mesurement1	10≥, <20	16.6±4.7	
	20<	31	
	10<	10±3.7	
TLD Mesurement2	10≥, <20	17.1±4.8	.001
	20<	43	
	10<	7.9±7.0	
TLD Mesurement3	10≥, <20	15.9±7.8	
	20<	29	

those 4 groups, the patients who did not have surgery but only chemotherapy before radiation treatment had the highest weight loss ratio. On the other hand, the patients who had both surgery and chemotherapy showed the lowest weight loss ratio. Such a result shows that the concurrent chemotherapy and radiation therapy minimizes weight loss in patients, and this result was statistically significant (p<.05).

Radiation treatment for head and neck cancer generally has a daily prescription dose of 220~250 cGy, and with 25 ~ 30 treatment sessions for 6 weeks, it is a total of 6,400~6,600 cGy of irradiation. Over the course of time, slight, moderate or severe radiation dermatitis first appears on skin in the neck area, which is closest to the irradiated target<sup>8</sup>. Radiation dermatitis, caused during the course of radiation treatment, is a common side effect causing discomfort to the affected patients. Slight radiation dermatitis symptoms are dehydration and cornification of skin. Since the treatment target of head and neck cancer is close to mouth and esophagus, a patient starts to feel discomfort while eating from stomatitis and esophagitis, and starts losing weight from reduced food intake<sup>9</sup>. Tomotherapy for head and neck cancer, which was conducted during this study, also caused weight loss in patients, even though the amount of weight change varied. This effect was statistically significant, and it appeared that the changes in weight of the patient affected the exit skin doses (p<.05).

Tumor eradication should be the priority when it comes to the radiation treatment in head and neck cancer cases. However, during the treatment, doses to normal tissues should be minimized<sup>10</sup>. This study has shown that concurrent chemotherapy and radiation therapy has an influence on the weight loss in patients, and such weight changes correlated with skin dose changes. The weight change during head and neck cancer tomotherapy might lead to unnecessary exposure of normal organs (tissues) to radiation. Weight loss causes loosening of aqua plaster that is applied to the patients during the treatment process, making it necessary to consider of an adaptive plan during the treatment. The limitations of this study were the considerable period of time that was required for the radiation regimen and sample size is not enough to fully explain various results of patients' changes. We expect to conduct a further study with a longer observation period and a larger number of patients.

## 5. Conclusion

This study followed 20 patients with head and neck cancer who had received tomotherapy, and was able to correlate their weight change with the measured skin dose using TLD. In detail, we obtained the following results: There was no direct relationship between the general features (gender or age) of a patient and the weight loss. Concurrent chemotherapy and radiation therapy affected the weight change of a patient, and this observation was statistically significant. The weight change of a patient during head and neck cancer tomotherapy affected the skin dose, and it was statistically significant.

In conclusion, since the weight change of a patient during the tomotherapy of head and neck cancer might cause unnecessary dose on normal organs, tissue and skin, it is necessary to consider of an adaptive plan in the course of the treatment, based on the weight change over the period of the radiation treatment.

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