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Original research article

A comparative study between open-face and closed-face masks for head and neck cancer (HNC) in radiation therapy

Zaheeda Mulla[a,*], Rolina K. Alwassia[a,b], Essam Mohammad Senan[a], Shamel Soaida[c], Ahmed Ahmed Mohamed Ameen Mohamed[a,d], Hussain Almerdhemah[a], Hafiz Asif Iqbal[a], Hane Mohammad Muamenah[a]

[a] King Faisal Specialist Hospital & Research Centre (KFSHRC) - Jeddah, Oncology Department, Radiation Oncology Section, P.O Box 40047, 21499, Jeddah, Saudi Arabia
[b] King Abdul Aziz University Hospital, Department of Radiology Department, P.O Box 21589, Jeddah, Saudi Arabia
[c] Cairo University, Department of Clinical Oncology, Faculty of Medicine, Cairo, P.O Box 11562, Cairo, Egypt
[d] Sohag University Hospital, Department of Clinical Oncology, Sohag, P.O Box 82524, Egypt

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ABSTRACT

Aim: To determine the setup reproducibility in the radiation treatment of Head and Neck (HN) patients using open face head and shoulder masks (OHSM) with customized headrest (CHR) versus standard closed head and shoulder masks (CHSM) and to determine the patient's level of comfort and satisfaction for both masks.
Methods: Forty patients were prospectively randomized into two groups using simple random sampling. Group 1 was assigned with CHSMs, immobilized with a standard HR (SHR) while Group 2 was assigned with OHSMs, and immobilized with CHR. Cone beam computed tomography (CBCT) was taken the first 3 days, followed by weekly CBCT (prior treatment) with results registered to the planning CT to determine translational and rotational inter-fraction shifts and to verify accuracy. Mean (M) and standard deviation (SD) of the systematic and random setup errors of the 2 arms in the translational and rotational directions were analyzed, using Independent t-test and Mann–Whitney U test. Patient comfort was measured using a Likert questionnaire.
Results: The vertical, lateral, longitudinal and Z/roll rotational shifts were not significantly different between the two masks. X/yaw and Y/pitch rotational shifts were significantly greater in Group 2 versus Group 1, for both systematic ($p = 0.009$ and 0.046, respectively) and random settings ($p = 0.016$ and 0.020) but still within three degrees. Patients reported higher neck and shoulder comfort ($p = 0.020$) and overall satisfaction ($p = 0.026$) using the OHSM with the CHR versus the CHSM with the SHR during CT simulation.
Conclusion: Open masks provide comparable yet comfortable immobilization to closed masks for HN radiotherapy.

1. Introduction

Patient immobilization is essential in effective radiation therapy. A rigid body enables precise imaging and application of radiation beams, enabling accurate delivery of lethal doses of radiation to cancerous cells while sparing normal tissue and preventing side effects.

However, in the pursuit of effective immobilization methods, patients occasionally experience discomfort. For head and neck cancer patients, full head masks covering the face are needed while receiving radiation therapy, forcing patients to keep their eyes, nose and mouth closed.[1] Head and shoulder masks (HSM) covering the face, neck and shoulders were invented[2,3] to reduce setup variations at the shoulder level. Inadvertently, these contribute to the patient's discomfort, pain, claustrophobia, and even shortness of breath. The course of radiation therapy for most Head and Neck cancer (HNC) patients last for more than six weeks,[1] emphasizing the need for improved patient comfort during treatment. Mullaney et al.[4] have shown that immobilization devices are the key to anxiety, and can impact negatively patients' emotional status. A study by Clover et al.[5] has reported this to be one of patients' worst experiences during cancer trajectory.

The development of the new open face masks allows an alternative immobilization of the head and neck for claustrophobic

* Corresponding author at: Radiation Therapist, Section of Radiation Therapy, Department of Oncology, KFSHRC – Jeddah, P.O Box 40047, 21499, Jeddah, Saudi Arabia.
E-mail addresses: mulla.zaheda@gmail.com, zmulla68@kfshrc.edu.sa (Z. Mulla).

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Fig. 1. Standard duon closed head and shoulder mask.

Fig. 2. Five-point hybrid open head and shoulder mask.

patients.[1,3] Wiant et al.[3] found that open head and shoulder masks (OHSM) can steadily limit motion to a level comparable to closed head and shoulder masks (CHSM). While accurate and effective treatment is paramount in medical treatment, the patient's comfort and wellbeing is also important in the process.[4] It is possible that customized head rests (CHR) allow accurate positioning while maintaining patients' comfort during radiation therapy,[6] while standard head rests (SHR) provide similar treatment accuracy and comfort.[2,7] Nonetheless, there are limited studies available that specifically compare techniques and immobilization systems from the patient's perspective,[2] hence patient feedback is also an important consideration in maintaining patient's comfort.

2. Materials and methods

2.1. Patient selection

Forty patients using either three-dimensional (3-D) or Volumetric Arc Therapy (VMAT) for their HNC treatment were selected from October 2017 to August 2018. The patients were grouped randomly into two groups, the first group with a standard CHSM (Group 1) and the other group with an OHSM (Group 2). Written informed consent was obtained from all patients and the study received ethical approval from the hospital's research and ethics committee. Simple random sampling was done by the assistant clinical research coordinator using Microsoft Excel (Microsoft Corp., Redmond, WA, USA). All patients, whether claustrophobic or not, with or without mouth-bite, including intra-oral bolus or not, with or without tracheostomy, were randomly grouped to avoid confounding results.

2.2. Patient immobilization, simulation and treatment planning

The first group was immobilized with a standard 2.4 mm thickness DUON CHSM by Orfit and supported with a SHR (Fig. 1). The second group was immobilized with a 5 point hybrid HSM with pre-cut isosceles-trapezoid-shaped opening by Orfit (Fig. 2). The hybrid OHSM are 1.6 mm thickness Efficast and reinforced with 1.2 Nanor strips around the opening and locking edges, and were supported with a CHR using AccuForm Cushions. Both group setups were prepared in accordance with the ESTRO ACROP guidelines for positioning, immobilization, and position verification of HNC patients.

The immobilization devices were indexed and fixed to the couch with an indexer to minimize rotational and translational errors. The patients were positioned supine on the couch in the required treatment position and aligned straight using the sagittal lasers per ESTRO ACROP guidelines.[8]

Both masks were immersed in a water bath of 70 degrees Celsius for 5 min. For the OHSM, the mask was then molded with the superior and inferior edges of the pre-cut opening pressed against the forehead and chin, respectively, and the lateral opening edges against the cheek, with the rest of the mask molded over the head, neck and shoulders. The mask was centered on the nose for the CHSM and molded against the forehead, nose and chin, neck and shoulders.

After molding, contrast-enhanced Computer Tomography (CT) simulation scans were performed for each patient using the Siemens SOMATOM Sensation Open CT Scanner. The scan slices were 3 mm thick from the vertex to 5 cm below the sternal angle. The data was transferred to the treatment planning system (Monaco) in order to plan the treatment.

The planning computed tomography scan with the isocenter position was exported from the planning system to the treatment control station to be used as a reference.

2.3. Patient set up

All patients were treated using the Elekta Linear Accelerator with kV-CBCT. Prior to treatment, patients were set up with their respective HSM in the treatment position. Reference points on the thermoplastic mask were aligned to the in-room lasers, and then moved to the treatment isocenter using the shifts provided on the plan.

The patients underwent pre-treatment KV-CBCT scanning using the XVI (X-Ray volume imaging) system, which comprises the XVI clinical database, kV arm source and the kV detector panel. The KV arm source and the KV detector panel are located opposite each other on the gantry of the digital accelerator. The CBCT was done on the first 3 days of treatment followed up weekly. Patients had a different number of CBCTs according to their primary site and treatment prescription (see *Radiotherapy Dose and Energy* below). All CBCTs were included in the study.

2.4. Scan parameters

Using the pre-set head and neck scan protocol, 183 frames were acquired over a 200-degree clockwise arc (320 degrees to 160 degrees), yielding an imaging dose of 0.5 mGy. Kilovolt peak is at 100 kV, with 18.3 total milliamperes per second (mAs). The detector position is small and the collimation setting used is S20 to improve image quality as the reduction of the field of view (FOV) reduces scatter irradiation.

2.5. Recording, evaluation and correction

CBCT images were recorded using the XVI system with the Head and Neck Preset. The gantry rotated around the patient and multiple image projections (frames) were recorded by the kV panel detector and were reconstructed using an algorithm to give the three-dimensional volumetric computed tomography image set prior to radiotherapy. The therapists evaluated the registered images for localization of the target relative to the planned reference position. Each CBCT acquisition till end of registration took between

Table 1
Patient characteristic according to gender, histology and location.

Characteristic	Closed mask (20)	Open mask (20)	Total (40)	P-value
Mean age ± Standard deviation (SD)	50.3 ± 11.9	54.3 ± 17.1	52.3 ± 14.7	.048* t
Gender	16 (40%)	10 (25%)	26 (65%)	.047* x
Male	4 (10%)	10 (25%)	14 (35%)	
Female				
Histological type				
Squamous cell carcinoma	10 (25%)	12 (30%)	22 (55%)	
Rhabdomyosarcoma	1 (2.5%)	0 (0%)	1 (2.5%)	
Pleomorphic Adenoma	1 (2.5%)	1 (2.5%)	2 (5%)	
Carcinoma in Situ	2 (5%)	0 (0%)	2 (5%)	.397 x
Undifferentiated	1 (2.5%)	3 (7.5%)	4 (10%)	
Undifferentiated non-keratinizing	2 (5%)	2 (5%)	4 (10%)	
Leiomyosarcoma	0 (0%)	1 (2.5%)	1 (2.5%)	
Non keratinizing-SCC	2 (5%)	0 (0%)	2 (5%)	
Acinic cell carcinoma	1 (2.5%)	0 (0%)	1 (2.5%)	
Location				
Tongue	5 (12.5%)	6 (15%)	11(27.5%)	
Lip	1 (2.5%)	0 (0%)	1 (2.5%)	
Oral cavity	0 (0%)	1 (2.5%)	1 (2.5%)	
Left Cheek	0 (0%)	1 (2.5%)	1 (2.5%)	
Right Buccal	1 (2.5%)	0 (0%)	1 (2.5%)	
Larynx	3 (7.5%)	0 (0%)	3 (7.5%)	.435 x
Left Parotid	2 (5%)	1 (2.5%)	3 (7.5%)	
Nasopharynx	7 (17.5%)	7 (17.5%)	14 (35%)	
Lt maxillary sinus	1 (2.5%)	0 (0%)	1 (2.5%)	
Mandible	0 (0%)	1 (2.5%)	1 (2.5%)	
Glottis	0 (0%)	1 (2.5%)	1 (2.5%)	
Left Retromolar	0 (0%)	1 (2.5%)	1 (2.5%)	
Mandible and Tongue	0 (0%)	1 (2.5%)	1 (2.5%)	
History of claustrophobia				
Yes	1 (5)	1 (5)	2 (5)	1.000 x
No	19 (95)	19 (95)	19 (95)	
Baseline pain level §				
Before CT-scan	1.80 (1.01)	1.25 (0.55)	1.53 (0.85)	.121 M
Before Radiotherapy	1.95 (1.00)	1.55 (1.00)	1.75 (1.01)	.149 M

SD: Standard deviation; SCC: Squamous cell carcinoma; § pain level was assessed on a 1–5 scale where higher scores indicate worse pain; * statistically significant difference ($p < 0.05$); test used: t independent t-test, x chi square, M Mann–Whitney U test.

two to three minutes for each patient. The therapists performed the corrections online and were approved offline by the radiation oncologists within first 3 days of treatment.

2.6. Registration

The patient anatomy detected in the CBCT scans was automatically registered to the reference planning CT scan using voxel-based registration. The registration occurred within a region of interest 'clip box' with only bony matching used. Chamfer match algorithm was used for bony anatomy registration for fast identification of errors with the green-purple display and then to fine tune with other display options. Manual adjustments were made at the discretion of the radiation therapists.

Online shifts using automatic table displacement values were done between registration and radiotherapy. The translational and rotational set-up error in all 6 directions was recorded for each patient in an excel sheet. Note: for rotational errors greater than 3 mm, the patient was repositioned in a mask and re-verified with CBCT.

2.7. Radiotherapy dose and energy

Radiotherapy of 1.8–2.66 Gy per fraction was given once daily, 5 days a week, 15–35 fractions to a total dose of 45−70 Gy, according to the prescription for the primary site of treatment. The patients were treated with 6 MV photons.

2.8. Determination of inter-fraction errors

The inter-fraction errors were determined from the pre-treatment CBCT after patient setup and before correction or treatment. This is evaluated by the position of the spinal cord and mandible. The systematic errors were defined by those translational and rotational set-up errors of the CBCTs taken during the first 3 days of treatment and the random errors were defined by the translational and rotational set-up errors of the weekly CBCTs.

2.9. Patient comfort and satisfaction

Patient comfort and satisfaction were determined using a 5-item questionnaire, each item being a 5-point Likert scale and assessing the following dimensions while wearing the mask: pain level, tightness, perceived anxiety, neck and shoulders comfort feel, and general satisfaction about the mask. A 1–5 score was attributed to each dimension and scores were analyzed as a numerical variable. The questionnaire was administered to all patients from both groups at two time points: 1) at CT simulation time and 2) on the first day of radiotherapy. This double measurement approach was aimed at eliminating the bias of patients' reaction toward the initial immobilization.

2.10. Statistical analysis

Significant differences between translational and rotational shifts between masks were analyzed using the Independent t-test and Mann-Whitney U test. Proportional treatment accuracy was defined as the number of sessions meeting the given accuracy level (e.g., ±0.1 cm, which corresponds to shift ≤0.1 cm in the given plane) divided by the total number of sessions for the same patient. Thus, values of PA ranged between 0 and 1, where higher values stand for higher proportion of sessions meeting the given range of shift, thereby indicating higher treatment accuracy. The two groups were compared regarding PA using Mann–Whitney U test. Mean patient comfort and satisfaction scores for the 5 dimensions were computed and compared between the two groups using the Mann–Whitney U test. Data was managed and analyzed by using the Statistical Package for Social Sciences, Version 21.0 for Windows (SPSS Inc., Chicago IL, USA). Significance level was set for p-value <0.05.

3. Results

3.1. Patient characteristics

Table 1 depicts clinical characteristics of all the 40 patients as well as a comparison between the OHSM and CHSM groups. Age and gender distribution showed mean ± SD age = 52.3 ± 14.7 years and 26 (65%) males with statistically significant disparity between the two groups. Majority of the patients have squamous cell carcinoma (55%) with no significant difference between the two groups (p = 0.397). The most common radiation site represented in this study was the nasopharyngeal area (35%), followed by the tongue (27.5%), and no statistical difference in location between the two groups was observed (p = 0.435). Further, only one patient from each group reported history of claustrophobia and baseline pain levels were comparable in the two groups both before CT-scan and before RT.

The average number of prescribed fractions for included patients in this study with CHSM and the OHSM was 21.6 and 19.3, respectively.

3.2. Absolute shifts

Shifts in the X (Yaw) rotation axis are significantly greater in the OHSM versus CHSM group for both systematic (mean shift = 0.580 versus 0.268 degrees, p = 0.005) and random (0.730 versus 0.499 degrees, p = 0.016) settings, respectively. Likewise, shifts in the Y (Pitch) rotation axis are significantly greater in the OHSM versus CHSM group for both the systematic (mean shift = 0.567 versus 0.370 degrees, p = 0.046) and random (mean shift = 0.643 versus 0.461 degrees, p = 0.038) settings, respectively. However, differences in shifts in both X and Y rotations axes are below the 3-degree threshold and, as such, are not clinically significant. No statistically significant difference was observed between the two groups regarding the translational shifts (vertical, lateral and longitudinal planes), and Z (Roll) rotational axis (Table 2).

3.3. Proportional accuracy

In the X-axis (yaw), the proportion of accurate sessions was lower in the OHSM versus CHSM group at both ±0.1° (median PA = 0.111 versus 0.369, p = 0.001) and ±0.5° (0.354 versus 0.667, p = 0.002), respectively. The close masks provide higher accuracy at both the ±0.1° and ±0.5°. Likewise, in the Y-axis (pitch), treatment accuracy in the OHSM group was lower than in the CHSM group both at ±0.1° (median PA = 0.111 versus 0.317, p = 0.009) and ±0.5° (0.444 versus 0.556, p = 0.006), respectively. In the Z-axis (roll), the difference between OHSM and CHSM was only significant at ±0.1° (median PA = 0.156 versus 0.275, p = 0.005) (Table 3).

Conversely, OHSM has a tendency to be more accurate at ±0.05 cm in the lateral (0.317 versus 0.286), longitudinal (0.250 versus 0.191) and vertical (0.333 versus 0.286) planes, compared to CHSM, respectively; however, none of these differences reached statistical significance (p > 0.05) (Table 3, Fig. 3).

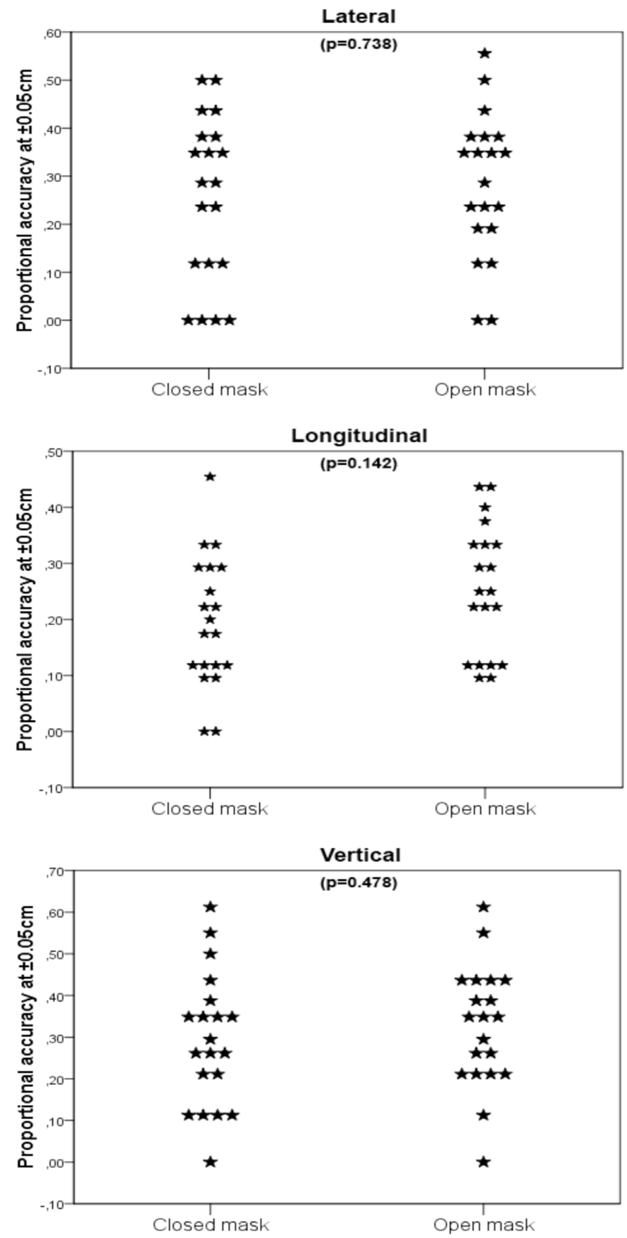

Fig. 3. Proportional accuracy of closed versus open masks in lateral, longitudinal and vertical planes at accuracy level ±0.5°.

3.4. Patient comfort and satisfaction likert results

Patients using OHSM reported experiencing less tightness and anxiety than those using CHSM, although these results were not statistically significant. On the other hand, the OHSM group reported better overall satisfaction and neck and shoulder comfort; however, this difference was statistically significant only at the time of CT (Fig. 4).

4. Discussion

The first aim of this study was to assess setup accuracy of OHSM versus the CHSM. While there was increased movement in using the OHSM in this study, the shifts did not exceed the submillimeter movement thresholds, concordant with previously published data.[1,3] This allows sufficient immobilization without trading off patient comfort. This is also consistent with Velec et al.,[9] where

Table 2
Mean absolute shifts between closed and open-face masks.

Setting	Plane	Closed mask		Open mask		*p*-value	
		Mean	SD	Mean	SD	Indepen-dent t-test	Mann–Whitney U test
Systematic Setting (average of first 3 days)	Lateral	0.126	0.102	0.155	0.096	.358	.231
	Longitudinal	0.152	0.058	0.120	0.046	.060	.072
	Vertical	0.179	0.095	0.142	0.079	.194	.231
	X (Yaw)	0.268	0.276	0.580	0.372	.005*	.009*
	Y (Pitch)	0.370	0.348	0.567	0.334	.076	.046*
	Z (Roll)	0.377	0.349	0.605	0.465	.087	.253
Random Setting (average of weekly sessions)	Lateral	0.120	0.040	0.132	0.146	.704	.341
	Longitudinal	0.137	0.036	0.125	0.029	.253	.289
	Vertical	0.107	0.053	0.097	0.037	.478	.779
	X (Yaw)	0.499	0.206	0.730	0.353	.016*	.052
	Y (Pitch)	0.461	0.184	0.643	0.282	.020*	.038*
	Z (Roll)	0.700	0.863	0.646	0.311	.792	.314
Overall Setting (combined Systematic and random-average)	Lateral	0.125	0.041	0.138	0.114	.644	.565
	Longitudinal	0.136	0.037	0.126	0.030	.368	.529
	Vertical	0.129	0.046	0.112	0.047	.266	.211
	X (Yaw)	0.453	0.221	0.644	0.308	.031*	.026*
	Y (Pitch)	0.442	0.155	0.605	0.260	.021*	.040*
	Z (Roll)	0.592	0.636	0.628	0.294	.822	.096

SD: Standard deviation;* statistically significant difference ($p < 0.05$).

Table 3
Proportional accuracy (PA) of settings in closed versus open mask using Mann–Whitney U test.

Plane	Shift	Proportion of sessions				p-value
		Closed mask		Open mask		
		Median	P90	Median	P90	
Lateral	Positive (right)	0.317	0.663	0.388	0.771	.547
	Negative (left)	0.444	0.693	0.354	0.697	.383
	Null	0.125	0.440	0.236	0.438	.659
	PA at ±0.05 cm	0.286	0.494	0.317	0.493	.738
	PA at ±0.1 cm	0.369	0.596	0.388	0.705	.327
Longitudinal	Positive (anterior)	0.500	0.721	0.556	0.778	.265
	Negative (posterior)	0.317	0.556	0.275	0.534	.096
	Null	0.153	0.330	0.125	0.371	.738
	PA at ±0.05 cm	0.191	0.333	0.250	0.426	.142
	PA at ±0.1 cm	0.317	0.541	0.375	0.564	.265
Vertical	Positive (superior)	0.364	0.625	0.369	0.770	.758
	Negative (inferior)	0.333	0.556	0.354	0.541	.968
	Null	0.250	0.361	0.268	0.494	.779
	PA at ±0.05 cm	0.286	0.541	0.333	0.544	.478
	PA at ±0.1 cm	0.422	0.700	0.388	0.775	.779
X (Yaw)	Positive	0.388	0.618	0.667	0.989	.001*
	Negative	0.236	0.763	0.111	0.617	.341
	Null	0.368	0.625	0.111	0.443	.001*
	PA at ±0.1°	0.369	0.625	0.111	0.443	.001*
	PA at ±0.5°	0.667	0.100	0.354	0.854	.002*
Y (Pitch)	Positive	0.250	0.760	0.222	0.735	.678
	Negative	0.354	0.848	0.571	0.989	.056
	Null	0.317	0.541	0.111	0.419	.009*
	PA at ±0.1°	0.317	0.541	0.111	0.419	.009*
	PA at ±0.5°	0.556	0.871	0.444	0.667	.006*
Z (Roll)	Positive	0.422	0.883	0.500	0.889	.689
	Negative	0.211	0.398	0.310	0.660	.211
	Null	0.375	0.541	0.156	0.426	.005*
	PA at ±0.1°	0.275	0.541	0.156	0.426	.005*
	PA at ±0.5°	0.578	0.748	0.438	0.798	.327

Test used: Mann–Whitney U test. P90: 90th centile. Values are median [P90]. PA: Proportional accuracy, which was computed as the number of sessions meeting the given accuracy level divided by the total sessions for the same patient; * statistically significant difference ($p < 0.05$).

the use of skin-sparing masks did not yield any significant inter-fractional errors.

According to Sharp et al.,[10] a smaller full head mask significantly reduced claustrophobic anxiety and skin toxicity among patients as compared to the bigger HSM while the results remained reproducible and errors negligible.[9] The use of a smaller three fixed point full head mask has a reduced claustrophobic effect and skin toxicity effect as compared to larger five fixed point HSM. However, Gilbeau et al.,[11] reported that the use of three fixed point masks yielded less reproducible results as compared to either four or five-point. Nonetheless, the enclosed claustrophobic anxiety and skin toxicity side effects of a full head mask persist for many patients. Mullaney

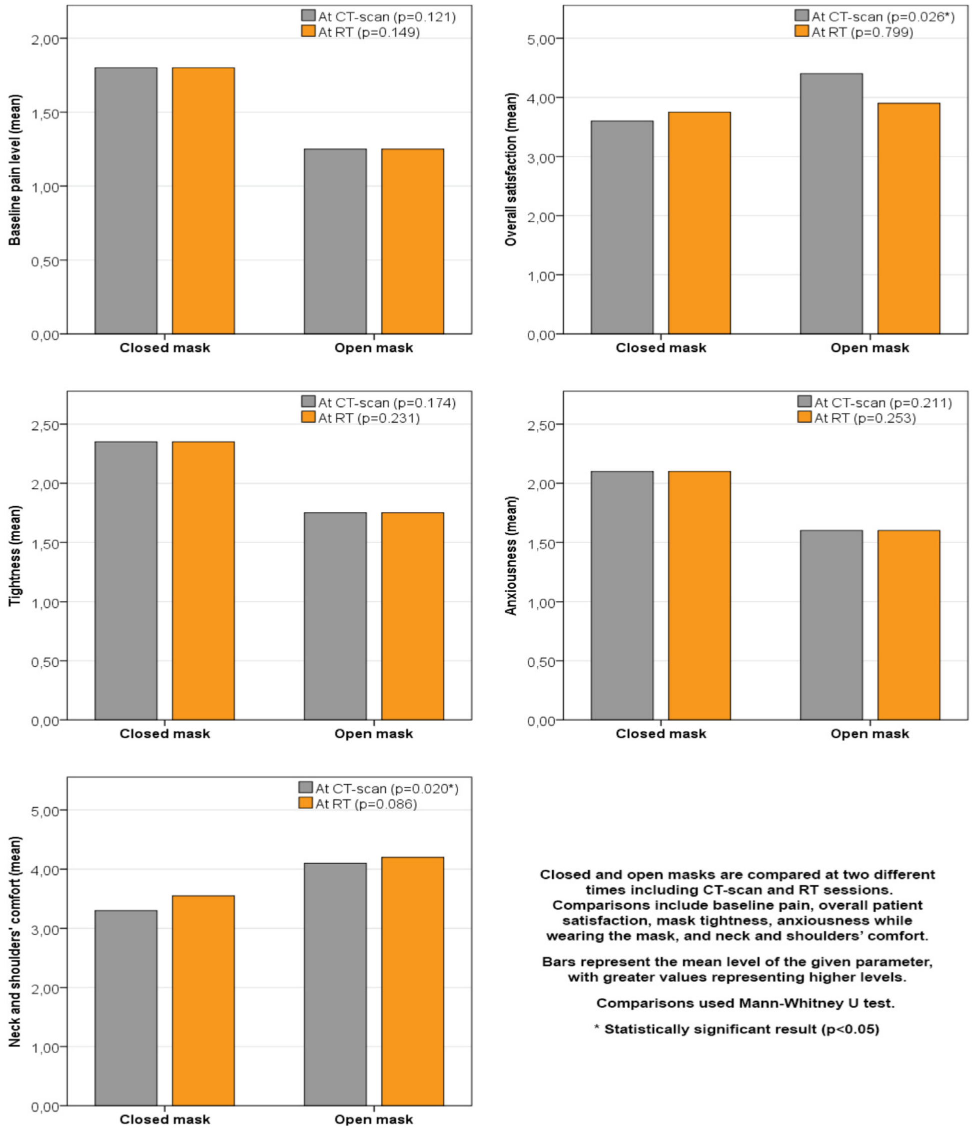

Fig. 4. Comparison of the patient's comfort and satisfaction Likert results during CT simulation and radiotherapy.

et al.[4] reported that immobilization devices, such as masks and headrests, can trigger anxiety among patients and could negatively affect the efficacy of treatment. Between the two claustrophobic patients, the one with the CHSM was extremely anxious, very dissatisfied with the mask (as she found it extremely tight), as well as extremely uncomfortable for her neck and shoulder position.

Patients experiencing anxiety may need additional medication to address anxiety[5] during treatment, thereby adding costs over their treatment, or even seek alternative treatment such as surgery, a more aggressive and invasive treatment just to avoid a prolonged stressful and anxious experience brought about by immobilization.[4] Li et al.[1] reported that open-faced masks can especially help those with mild to moderate claustrophobic anxiety. Subjects can move slightly more in open-face masks versus closed-masks due to the presence of sharp edges around the nose in closed masks. Open masks remain sturdy due to the reinforcing strips built on the mask.[1] The design of the open-faced mask allows it to be tolerated by claustrophobic patients during treatment and can be applied to more patients with improved comfort. A couple of studies pointed out that open-face masks also allow accurate high-resolution static image capture or real-time delta motion capture even with small facial movements, such as blinking.[1,3]

Equipment design affects reproducibility and patient response. Howlin et al.[2] reported that the use of standardized headrests (SHR) in conjunction with customized masks yielded accurate yet cost-effective results, as well as satisfactory patient feedback. This contrasted by Van Beek et al.[7] where the use of CHR yielded similar reproducibility compared to SHR. However, this study used SHR with the CHSM setup whereas CHR was used in the OHSM setup. The reproducibility from using OHSM combined with SHR, as well as the reproducibility among different types of open-masks could be considered in future studies.

Given the restrictive nature of immobilization devices, patients may experience powerlessness, depression and/or anxiety throughout treatment.[4,5] However, patient positioning and immobilization is essential in delivering accurate treatment and in preventing adverse side effects from accidental dosing. Patient input is also important in delivering effective treatment. The patients in the study reported increased neck and shoulder comfort as well as overall satisfaction with the OHSM during CT simulation. While these statistically significant results were only present during CT simulation, it is noted that patients are usually more anxious on the initial stages of radiotherapy, especially when immobilization strategies are determined.[5] This initial step can be formative for the patient; anxiety triggered by the temporary fixation of the head and neck can reduce compliance towards the procedure. In addressing such cases, their psychosocial wellbeing can be better pinpointed in the form of more specific patient self-reports,[5] impact mitigation on treatment, and in future equipment design.[4] Providing these can empower the patient and help lessen patient anxiety and its disruptive complications in the care process. Detailed questionnaires could be integrated in treatment that patients who are likely to disrupt treatment due to adverse psychosocial effects (e.g. depression, anxiety) can be identified and addressed early on, reducing the cost and time brought about by the disruption of treatment.

As for impact mitigation, small modifications on the masks, such as eye openings and refitting the mask to reduce neck pressure, were reported to lessen the impact of anxiety on a claustrophobic patient undergoing treatment.[4] Having "panic buttons" for patients to hold during treatment can help communicate their anxiety before it can escalate and disrupt treatment.[4] In this regard, any study regarding immobilization adjustments for mitigating patient anxiety with respect to existing guidelines (such as ESTRO ACROP) would be recommended.

Some of the limitations of the study were that the intra-fraction errors were not reported. The analysis was not a pure comparison between open versus closed face masks as CHR was used only in the OHSM, hence the difference in patient-reported outcomes such as comfort and pain could also be related to the type of headrest used. Use of similar headrests between open and closed masks could be done in a future prospective study to make it a pure comparison between masks.

5. Conclusion

Open masks with CHR provide comparable yet comfortable immobilization to closed masks with SHR for HN radiotherapy.

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None declared.

Conflict of interest

None declared.

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