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● *Technical Innovations and Notes*

COMPARISON OF PLASTIC AND ORFIT® MASKS FOR PATIENT HEAD FIXATION DURING RADIOTHERAPY: PRECISION AND COSTS

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Purpose: Two widely used immobilization systems for head fixation during radiotherapy treatment for ear-nose-throat (ENT) tumors are evaluated.
Methods and Materials: Masks made of poly vinyl-chloride (plastic) are compared to thermoplastic masks (Orfit®) with respect to the accuracy of the treatment setup and the costs. For both types of material, a cut-out (windows corresponding to treatment fields) and a full mask (not cut out) are considered. Forty-three patients treated for ENT tumors were randomized into four groups, to be fixed by one of the following modalities: *cut-out plastic mask* (12 patients), *full plastic mask* (11 patients), *cut-out Orfit® mask* (10 patients), and *full Orfit® mask* (10 patients).
Results: Reproducibility of the treatment setup was assessed by calculating the deviations from the mean value for each individual patient and was demonstrated to be identical for all subgroups: no differences were demonstrated between the plastic (s = 2.1 mm) and the Orfit® (s = 2.1 mm) group nor between the cut-out (s = 2.0 mm) and not cut-out (s = 2.1 mm) group. The transfer chain from simulator to treatment unit was checked by comparing portal images to their respective simulation image, and no differences between the four subgroups (s = ±3.5 mm) could be detected. A methodology was described to compare the costs of both types of masks, and illustrated with the data for a department. It was found that Orfit® masks are a cheaper alternative than plastic masks; they require much less investment expenses and the workload and material cost of the first mask for each patient is also lower. Cut-out masks are more expensive than full masks, because of the higher workload and the additional material required for second and third masks that are required in case of field modifications.
Conclusions: No substantial difference in patient setup accuracy between both types of masks was detected, and cutting out the masks had no impact on the fixing capabilities. A first Orfit® mask will typically be a cheaper alternative than a plastic mask for most departments (lower fixed and variable costs). The higher material cost of the subsequent Orfit® masks, compared to the plastic masks, offset the lower investment expenses.

Immobilization devices, Radiotherapy, Head and neck tumors, Quality assurance, Costs.

INTRODUCTION

In the radiation treatment of head and neck tumors, where irradiations are predominantly carried out with curative intent, high geographic precision is needed. Geographic misses can be responsible for local failure and for increased doses to normal tissues such as the spinal cord or the eye (6, 7). Different systems have been developed to immobilize the patient's head by fixing it to the table couch, and have been shown to improve treatment accuracy (4, 5, 8, 9, 11, 12).

In the present study, two widely used systems, *poly vinyl-chloride* (PVC) (plastic) and *thermoplastic* (Orfit®) masks, are compared with respect to the accuracy of the patient position on the table couch and the costs. Because the material of the mask increases the dose to the skin, it was stated in earlier studies (2, 10) that masks had to be cut out to preserve the skin-sparing effect of the high-energy photons. Because it was expected that cutting out the masks could affect their rigidity and, thus, their fixing capability, both modalities are investigated.

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The aim of the present study is to assess whether the plastic masks, in use in our department since 1979, are the best choice or whether the newer Orfit® (1) masks are an acceptable alternative, as they appear less labor intensive to produce, although the material is more expensive.

METHODS AND MATERIALS

Fixation technique

Two fixation systems are compared: plastic and Orfit®. With each technique, the patient is first placed in an adequate irradiation position on the simulator and an optimal wooden head support, used on a lucite tray, fixed on the table is used.

For all patients, holes are cut out of the fixation masks for nose and mouth (Orfit® masks are precut by the supplying firm), but for some patients, the treatment fields are also cut out after the first treatment session whereby care is taken to save the central cross of each field as well as the field edges to allow correct positioning. Hence, for both immobilization techniques a cut-out and a not cut-out mask are studied. Two categories of patients were included in the study: (a) patients treated with two small opposed fields, and (b) patients treated with three fields (two lateral and one supraclavicular). For the second group, a field size modification (field reduction or slip[1]) is performed after 36 Gy. All patients were treated on a 6 MV linear accelerator, supplied with a check and confirm system. Lasers (indicating the field center) and the light field are drawn on the mask during simulation and are used for daily positioning on the treatment couch.

Plastic masks. These masks are made of transparent PVC, about 1.5 mm thick, and are molded in several steps. In the plaster room, the patient is put in the same position as on the simulator and a negative plaster of Paris cast is made by a nursing aid. This activity requires an amount of plaster bandages (42 strips of 60 cm per patient), some plastic foil (3 m/patient), and vaseline to protect the patient, and takes about 30 min. Subsequently, the nursing aid prepares a positive plaster mold from the first cast, by filling the plaster cast with detergent and plaster (consisting of 10 liter of water, 12 kg of plaster powder, and some salt to speed up the drying process). The manufacturing of this positive mold takes about 5 min. These plaster casts are stored until the end of the treatment for each patient, because some patients will require a second and third mask (e.g., for modified or boost fields). Storing this plaster casts, for which stack shelves must be available, has the advantage that this part of the manufacturing process does not need to be repeated in case additional masks are needed. Afterwards, a plastic mask is produced on the basis of this positive mold by the nursing aid. This process involves the following steps. The plaster mold first has to be removed from the negative mold and irregularities are removed with a plaster saw and sand paper. Then a PVC plate of about 1.5 mm (50 × 60 cm) is put over the plaster head to manufacture the plastic mask by means of a vacuum oven technique. After this, the mask can be finalized: the superfluous plastic on the sides is removed with a band saw, holes for the nose and the mouth are cut out (with the aid of a small drill), the sides are smoothened by means of a dentist's drill, and the two fixation plates are added (requiring a small drill and a small heater). This process takes 30 min. Finally, just before simulation, the patient is put in the correct position, the mask is adjusted to the patient (5 min for the simulator technician), and fixed to the head support by four fixation points (two at each side of the head), which takes about 5 min for the nursing aid. During simulation, the field edges and central cross are drawn immediately on the mask. For those masks that are cut out, after the first approved treatment session, an additional workload of 5 min for the nursing aid is involved.

To manufacture these masks, some building space is required. A plaster room of 10 m^2, part of the molding room (5 m^2), and storage space for the plaster masks of the patients under treatment (5 m^2) must be available.

If additional masks are needed, there is only a small workload involved for not cut out masks: the removal of the marks on the mask (1 min 30 s for the simulator technician) and the patient positioning (cf. supra). For cut-out masks, a new plastic plate is required and the workload involves the manufacturing of the plastic mask (30 to 35 min), the positioning of the patient, and the adjustment and fixation of the mask.

Orfit® masks. Orfit® masks are made of a thermoplastic material, about 1.5 mm thick, and are molded directly on the patient's face, just before simulation. On the simulator, the patient is prepared by a nursing aid who puts a protection stocking over the patient's face (1 min). Subsequently two nursing aids warm up the thermoplastic material in a water heater (50 s). Then the material is molded immediately on the patient's face by two nursing aids and one medical doctor or a treatment technician (2 min 30 s). Because the simulation can proceed during the drying process, the latter does not require any additional workload.[2] In contrast to the plastic masks, the most recent model of the Orfit® masks offers the possibility to fix not only the head of the patient (by fixation at both sides of the head) but also the shoulders (by fixation at both sides of the shoulders). During simulation, some tape must be stuck to the mask to facilitate the drawing

[1] A slip is a deplacement (1 cm) of the junction between the two lateral and the supraclavicular fields after 36 Gy to decrease the risk of an overdosage in the region of junction.

[2] If the mask would be prepared in a separate session, the waiting time for the drying process (5 min) should be incorporated in the cost calculation.

of the field edges and central cross (1 min 30 s, by the simulator technician). If the treatment fields are cut out (with a pair of scissors), this takes about 7 min for the nursing aid. In case the patient needs a second and third simulation (e.g., for modified or boost fields), this whole process needs to be repeated, except when the mask is not cut out (no additional manufacturing involved). In this case, only the tape must be removed and new tape must be applied (4 min 30 s for the simulator technician). Using plastic masks is more demanding for the patients than Orfit® masks, because the latter can easily be manufactured during one patient visit just before the simulation. With plastic masks, the patient has to come to the simulator twice (one visit for the mask, one for simulation).

Measurements and analysis

The study consists of two parts: first, a check of the reproducibility of the patient position in the radiation beam, and second, a calculation of the cost for implementing each of the two systems in daily practice.

Reproducibility of the position of the patient. To assess the reproducibility of the treated volume, repetitive portal images were taken on 43 patients, all treated for ENT tumors and fixed at random with a plastic or an Orfit® mask. To investigate a possible decrease in fixing capability when cutting the fields in the mask, half the number of masks was cut out, the other half was not. The patients were randomized into one out of four arms: cut-out Orfit® mask (10 patients), full Orfit® mask (10 patients), cut-out plastic mask (12 patients), and full plastic mask (11 patients).

To assess *day-to-day variations* in treated volume, portal images of the right lateral field were taken three times a week. In about 85% of the sessions, portal films[3] were taken, and in 15%, online images were acquired with a Scanning Liquid Ionization Chamber System.[4] Several of the images had to be dropped for analysis because it was not possible to measure the craniocaudal (44 images out of 559 = 8%) and/or anteroposterior (six images out of 559 = 1%) distances due to, for instance, the absence of recognizable anatomical structures (small fields) or due to poor image quality. Measurements were performed on a total of 515 images, with an average of 12 (range 8–16) images per patient. Distances between anatomical structures and field edges were measured. The mean distances were calculated for each individual patient. The deviations from these mean distances were calculated to assess the day-to-day variability in the patients' position. Two hundred seventy-seven measurements were performed for the plastic cut-out group (138 AP+139 CC), 245 for the plastic not cut-out group (130 AP+115 CC), 232 for the Orfit® cut-out group (121 AP +111 CC), and 226 for the Orfit® not cut-out group (120 AP+106 CC).

An evaluation was also made of the *transfer chain* from simulator to treatment unit by comparing the distance measured on the simulation film to the mean of the distances measured on the corresponding series of portal images. This comparison was made for all right lateral fields. If a field size modification had been performed, the modified field was included in the study and was considered as a new case (38 cases). Deviations in anteroposterior and craniocaudal directions were considered.

On the simulation films of the supraclavicular fields (56 films), distances were measured in lateral and craniocaudal direction and compared to the corresponding portal film, made at the first treatment session (because no repetitive images were taken). Some fields had to be omitted if no simulation data were available at the time of the study. Plastic masks (33 films) were compared to Orfit® masks (23 films). At the first treatment session, none of the masks was cut out; that is why, for the supraclavicular fields, no comparison could be made between a cut-out and a not cut-out version.

All measurements were performed on images taken at a focus film distance (FFD) of 145 cm. The magnification factor to the patient's midline level was taken into account and a correction was applied to the measured distances.

Cost calculations. On the basis of the equipment needs, the workload and the material that is required for each type of mask, the cost of Orfit® and plastic masks can be compared. The workload and the use of material were estimated on the basis of a detailed registration of each item for a number of patients. Because it became clear after a few registration sessions that neither the material used nor the workload varies substantially from patient to patient, this detailed registration was not performed for all patients included in the sample.

All price and wage data are valid for 1993 and were obtained from the Leuven University Hospital administration. They are converted into ECU, at a rate of 1 ECU = 40 Belgian Franks (BF).[5]

The total costs for both types of masks will be reported in two separate categories, fixed and variable costs. The former do not change with the number of masks, while the latter increase with the number of masks. These costs are reported as the "unit cost" per mask. More details on the cost calculations are reported in the appendix.

RESULTS

Reproducibility of the position of the patient

The *reproducibility* of the position of the patient on the treatment couch is represented in Figs. 1 and 2. The

[3] Kodak X-omat Verification films, Kodak, Rochester, NY.
[4] NKI, Amsterdam.
[5] 1 ECU = 1.2 $, November 1994.

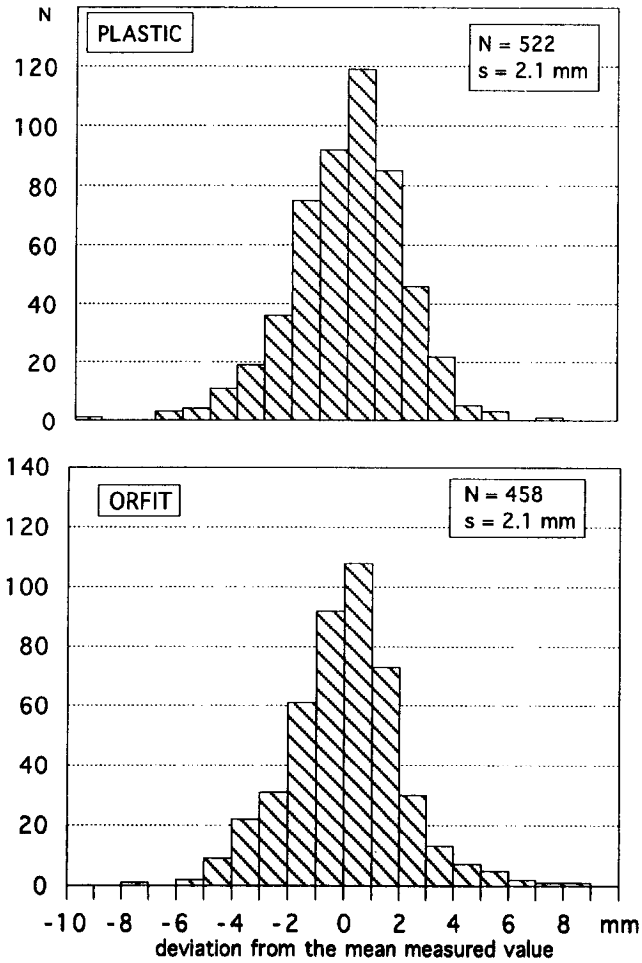

Fig. 1. Reproducibility. The deviation from the mean measured value in mm in anteroposterior and craniocaudal direction are plotted for PLASTIC (top) and ORFIT® (bottom). The number of measurements (N) and the standard deviation (s) are given.

variations in position from day to day are equal for patients fixed with Orfit® or plastic masks (Fig. 1). Cutting out the masks has no influence on the patient immobilization: no difference was demonstrated between the cut-out and the not cut-out group (Fig. 2). When looking at the results of the four subgroups independently, no difference could be detected (Table 1). The standard deviation is about 2 mm (1.7–2.4 mm) for each group, indicating a narrow distribution with only few large deviations. No day-to-day variation of more than 1 cm was detected. When considering anteroposterior and craniocaudal deviations separately, craniocaudal deviations show a slight predominance. The number of positioning errors larger than 4 mm is 4.1% for the plastic masks and 6.2% for Orfit® masks in anteroposterior direction and 6.7 and 6.0% respectively in craniocaudal direction. The number of patients with one or more films showing a deviation in anteroposterior direction of more than 4 mm is seven out of 23 (30%) for the plastic masks and nine out of 20 (45%) for the Orfit® masks. In craniocaudal direction, this becomes respectively 12 out of 23 (52%) for plastic and 8 out of 20 (40%) for Orfit®.

The check of the *transfer chain* shows that only a limited number of systematic errors of more than 5 mm occur (s < 4 mm), and that no error of more than 1 cm was detected (Table 2).

For the lateral fields, no substantial difference was demonstrated between the plastic (x = 0.2 mm, s = 3.1 mm) and the Orfit® masks (x = -1,2 mm, s = 3.2 mm) (Fig. 3), nor between the cut-out (x = −0.6 mm, s = 3.3 mm) and the not cut-out (x = −0.3 mm, s = 3.1 mm) group (Fig. 4). When considering the supraclavicular fields however, a small difference between Orfit® (n = 23) and plastic (n = 33) is demonstrated: the standard deviation for plastic being slightly higher than for Orfit®: 4.5 mm vs. 3.8 mm.

Cost calculations

The fixed and variable costs of both types of masks are reported in Tables 3 and 4, respectively. To allow a detailed

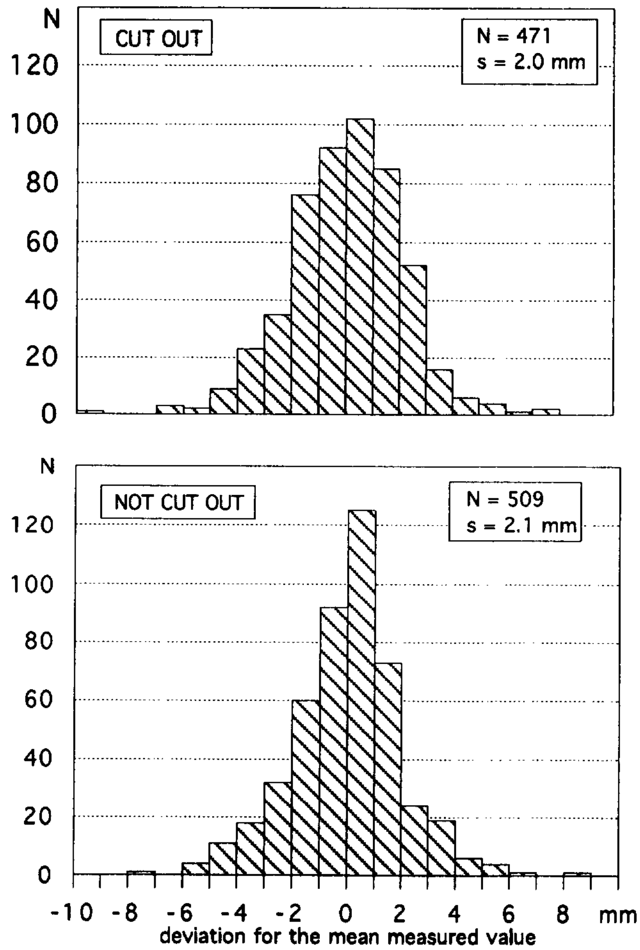

Fig. 2. Reproducibility. The deviation from the mean measured value in mm in anteroposterior and craniocaudal direction are plotted for the CUT-OUT (top) and the NOT CUT-OUT (bottom) subgroups. The number of measurements (N) and the standard deviation (s) are given.

Table 1.

Mask type	Anteroposterior				Craniocaudal			
	n	s	> 4 mm*	pat†	*n*	s	> 4 mm*	pat†
Plastic cut out	138	2.2 mm	7/138 (5.1%)	5/12	139	2.4 mm	14/139 (10%)	9/12
Plastic not cut out	130	1.7 mm	4/130 (3.1%)	2/11	115	1.8 mm	3/115 (2.6%)	3/11
Orfit cut out	121	1.9 mm	4/121 (3.3%)	3/10	111	1.8 mm	3/111 (2.7%)	2/10
Orfit not cut out	120	2.2 mm	11/120 (9.2%)	6/10	106	2.3 mm	10/106 (9.4%)	6/10

n: number of measurements; s: standard deviation.
* Number of deviations of > 4 mm.
† Number of patients with at least 1 deviation of > 4 mm.

comparison with the precision results, the cost of the cut-out vs. full masks is presented separately.

Clearly, cut-out masks are more expensive than full masks because of the higher workload and the additional material required for additional masks.

Obviously, Orfit® masks are cheaper for the radiotherapy department than are plastic masks; not only are the fixed costs much lower, but so are the variable costs in most cases. Working with plastic masks requires a nonnegligible investment of over 82,000 ECU, for additional space and equipment. For Orfit® masks, an investment of less than 1,500 ECU is sufficient. This major difference in initial investments is naturally also translated into the level of annual fixed costs (over 13,000 ECU vs. only 170 ECU).

Plastic masks do not only require heavier investments, but they moreover imply higher unit cost for labor and material than Orfit® masks. For full masks whereby the treatment fields are not cut out, this holds for the first mask, as well for the possible second and third masks for the same patient. This implies that the average cost per patient is lower for Orfit® than for plastic masks.

For masks whereby the treatment fields are cut out, it is still the case that the first plastic mask is more expensive than a first Orfit® mask. But if the patient needs several masks, the Orfit® alternative will ultimately be more expensive than the plastic version, because for cut-out Orfit® masks, the whole manufacturing process (included the thermoplastic material) must be repeated for each mask.

Table 2.

Mask type	*n*	x	s	> 5 mm*
Plastic cut out	55	0.3 mm	3.9 mm	6 (11%)
Plastic not cut out	47	0.5 mm	3.1 mm	4 (8.5%)
Orfit cut out	40	−1.3 mm	3.2 mm	4 (10%)
Orfit not cut out	44	−1.0 mm	3.5 mm	7 (16%)

n: number of measurements (right lateral field, modified fields, supraclavicular fields). x: mean value, s: standard deviation.
* Number of deviations of > 5 mm.

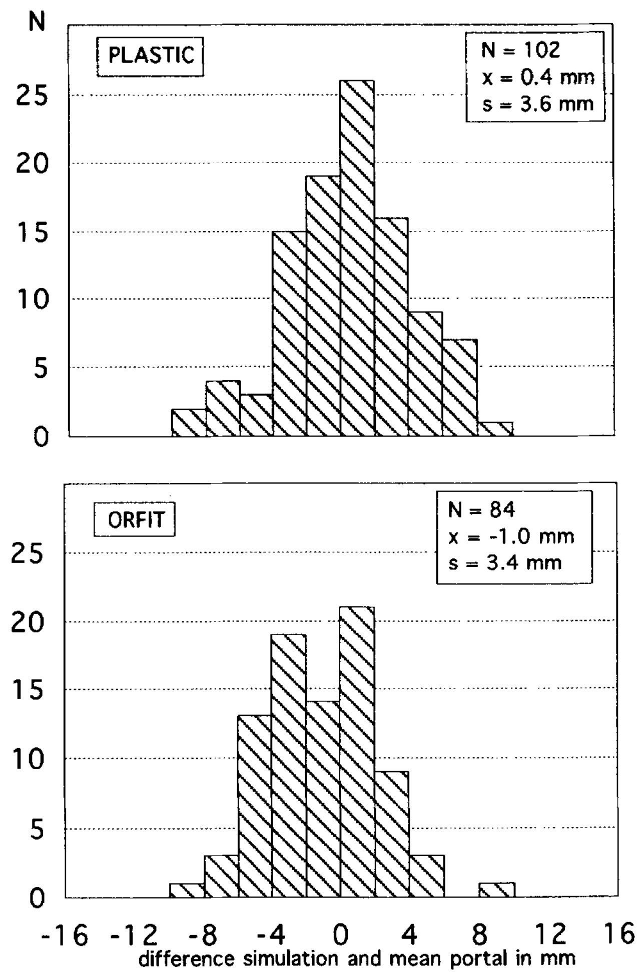

Fig. 3. Check of the transfer chain. Simulation films and the portal films of the right lateral fields and the supraclavicular fields are compared to each other. The difference between the simulation and portal films (in mm) are plotted for PLASTIC (top) and ORFIT® (bottom) The number of measurements (N), the mean value ($\bar{x}$), and the standard deviation (s) are given.

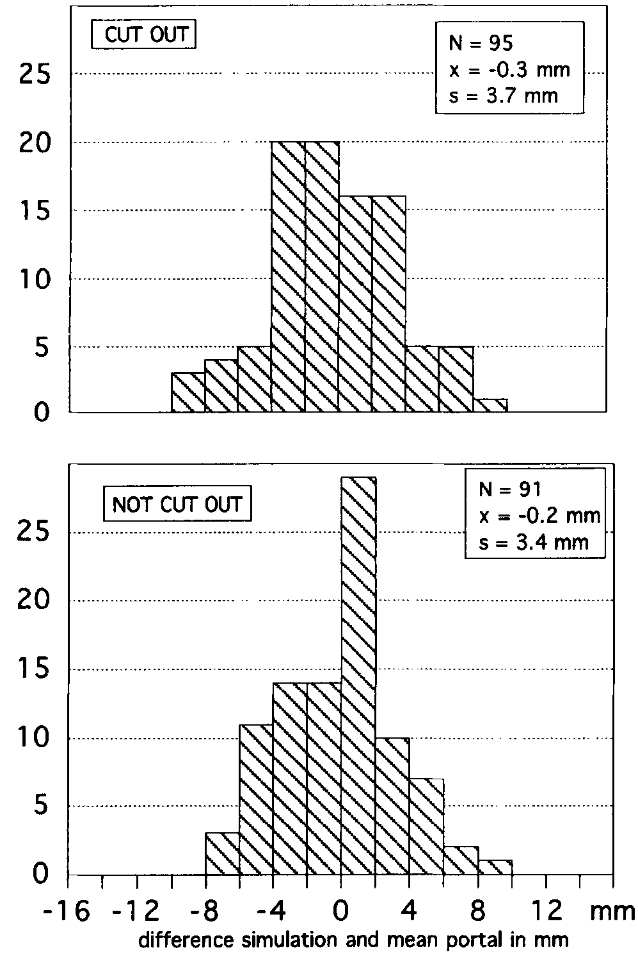

Fig. 4. Check of the transfer chain. Simulation films and the portal films of the right lateral fields and the supraclavicular fields are compared to each other. The difference between the simulation and portal films (in mm) are plotted for CUT-OUT (top) and NOT CUT-OUT (bottom) subgroup. The number of measurements (N), the mean value ($\bar{x}$), and the standard deviation (s) are given.

DISCUSSION

Reproducibility of the patient's position

There is certainly a need for a good fixation of the patient's head during radiotherapy for head and neck tumors, because without any fixation of the head, involuntary movements are unavoidable and it becomes extremely difficult to reproduce the same position for all the sessions. Fixation cannot only prevent geographical misses, it also allows for a decrease in the safety margins for normal tissues at risk such as the spinal cord or the eye if necessary. Moreover, the rather unaesthetic and easily vanishing marks on the patient's face can be definitely avoided, because all marks indicating the field center, field edges, and laser positions can be drawn directly on the mask.

Table 3. Fixed costs for immobilization masks in ECU

Type of mask	Initial investment expenses	Annual fixed costs
Plastic masks		
space	41 250	8 578
equipment	41 261	4 744
Total	82 511	13 322
Orfit® masks		
equipment	1 412	169

1 ECU = 1.2 $.

Table 4. Variable costs for immobilization masks in ECU

Type of mask	Not cut out mask	Cut out mask
Cost of first mask		
Plastic mask	85.22	86.7
Orfit® mask	67.49	69.56
Additional cost for each subsequent mask		
Plastic mask	2.52	21.7
Orfit® mask	2.22	69.56
Average cost per patient*		
Plastic mask	88.37	113.82
Orfit® mask	70.26	156.51

1 ECU = 1.2 $.

* Assuming that 25% (50%) of the patients need two (three) masks.

A good fixation system should fulfill a great number of requirements: (a) the patient position on the table couch has to be strictly reproducible; (b) the mask should be patient-friendly, well-tolerated, and be responsible for only minimal additional skin reaction; (c) material as well as labor cost should be as low as possible; (d) the mask should be easily applicable in daily routine and allow all necessary beam arrangements, including dorsal and oblique fields, to be applied.

Because fixation of the patient's head during radiotherapy for head and neck tumors has been proved to improve treatment accuracy substantially, different immobilization devices have been developed.

Verhey *et al.* described the combination of thermoplastic masks and a biteblock and demonstrated a mean motion of 2 mm (s = 1.4 mm). Gill and Thomas developed a frame for stereotactic radiotherapy that provides a rigid fixation (3D displacement of 0.5 mm, s = 0.4 mm). Although this system seems to be very reliable, the cost and labor are probably only acceptable if used for stereotactic purposes. In our department, individual plastic masks have been used for years. They are rigid and transparant and are demonstrated to have an excellent fixing capability (s: 2.1 mm). The more flexible and less transparent Orfit® masks, however, are demonstrated in this study to provide an identical precision in immobilization of the patient's head (s: 2.1 mm). Although not transparent enough to visualize skin lesions, which can be a serious disadvantage, the maxi-perforations in the Orfit® masks offer a sufficient visibility to assure the correct positioning of the patient's head in the mask.

Concerning the movements of the shoulders, the fixation provided with the Orfit® masks was demonstrated to increase the precision. Another advantage of the fixation of the shoulders is the tight fit of the mask at the level of the supraclavicular field, which makes the correct source–skin distance (SSD) setting a lot easier than for the plastic masks where frequently a gap between the skin and the mask is seen at supraclavicular level.

Although it was suspected that, in particular for Orfit® masks, cutting them out would affect their rigidity and allow head movements within the mask, no increase in day-to-day variations could be demonstrated. When comparing the subgroups of patients, the standard deviation of the group where the mask was cut out was higher than the standard deviation of the not cut-out group for plastic, but for Orfit®, the opposite was shown. This contradictory observation can be explained by the presence of some large random errors in a few individual patients, at random in each subgroup. These errors are, thus, neither attached to one given patient nor to a specific technique but are scattered among several patients over the different fixation modalities. Although with respect to precision no difference between cut-out and not cut-out masks could be demonstrated, no information is available on differences in radiation induced skin reactions. Overall precision would be served by not cutting out the masks, allowing for the use of the same mask for modified, reduced, and/or boost fields, which is, in addition, financially advantageous. It should, however, be stressed that for ^{60}Co important increases in skin effect have been shown behind the mask (10) and Fiorino *et al.* (3) showed an increase in "skin dose" in a 6 MV field behind an Orfit® mask (skin doses vary between 40 and 50% behind a mask vs. 10–15% without a mask). Although no important increase in skin reaction has been observed in the patients, irradiated at 6 MV, in the present study, further investigations are prerequisite before making any definitive conclusions.

Cost

The cost data can be applied to calculate which type of masks will be the cheaper alternative for radiotherapy departments, and to support other decisions relating to fixation techniques (e.g., should storage capacity be built when plastic masks are used?). This point will be illustrated with the cost data obained for our department.

The cost calculations in Tables 3 and 4 reveal that using plastic masks involves higher total costs for our radiotherapy department than using Orfit® masks. This result is quite obvious for full masks, but it also holds for cut-out masks. The difference in annual fixed costs between both types of masks (i.e., cost disadvantage for plastic masks) is quite large, implying that it can only be outweighed by the difference in variable cost (i.e., cost advantage for plastic mask) if a large number of masks was produced. It can easily be calculated that the department should use cut-out masks in about 300 [derived from (13,322–169)/(156.5–113.82)] ENT patients annually, before the plastic masks involve lower total cost than the Orfit® masks, which is a number that is not often reached in practice (e.g., in our department, 225 out of 1,500 radiotherapy patients are treated for ENT tumors).

The cost calculations further illustrate that while using plastic masks it was a good decision to store plaster casts (which involves higher fixed costs), rather than make completely new masks (which involves higher variable costs). The annual cost of storage space (annual fixed costs for 5 m^2 of 1.430 ECU) is already lower than the cost for plaster molds (additional cost of 64 ECU per mask), once more than 22 masks are produced annually.

It should obviously be kept in mind that the final conclusions (e.g., the break point of 300 masks) may differ from departments to department, because their costs may vary, e.g., due to different overhead allocation methods, prices, and fixation techniques. This does not imply that our cost data are useless for other departments: because we provided details (volumes and unit prices) of all resources used, other departments can adapt our data to their specific situations, without too much difficulty.

CONCLUSION

For immobilization of the patients' head during head and neck cancer radiation treatment, Orfit® and plastic masks were found to be equivalent. Moreover, full and cut-out versions were demonstrated to provide a comparable fixation. Therefore, financial considerations should predominate in the choice of the most advantageous type of mask for a given department. This article described the methodology to compare the costs of both types of masks, a methodology that can easily be adapted to other departments. The data for our department showed that if full masks are used, Orfit® masks always involve lower costs than plastic masks. If cut-out masks are used, Orfit® remains the cheapest solution, when a limited number of patients (less than 300) needs masks per year. Only if more than 300 patients need a mask annually, would plastic be more advantageous, because the higher material cost of the Orfit® masks offsets the lower investment expenses.

It should, however, be stressed that the large financial advantage of using full masks (which predominantly holds for Orfit® masks) has to be counterbalanced by the possible loss in skin-sparing effect whenever the treatment field has not been cut out.

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APPENDIX: DETAILS ON COST CALCULATIONS

Data sources

The wage and price data are those that apply to the Leuven University Hospital in 1993.

Calculation of the fixed costs

The "initial investment expenses" refer to the purchase price of the space and equipment (durable goods) that are required to manufacture and use fixation masks in the radiotherapy department.

The "annual fixed costs" (AFC) refer to the annual cost of the equipment and space and include the amortization of the equipment, taking the opportunity cost of capital (5% real interest rate) into account, and the annual operating and maintenance expenses, which are expressed as a percentage of the purchase price. Hence, the AFC of a piece of equipment with purchase price P, n years of clinical lifetime, and x percent operating expenses, can be expressed as:

$$AFC = 0.05*P/[1 - (1.05)^n] + x*P$$

Calculation of the variable costs

The variable costs consists of (consumable) materials and labor costs. For each activity, the labor cost is calculated as the average gross hourly wage*labor time, for the qualification that executes the activity.

Overview of the cost calculations

Table A1. Fixed costs for plastic masks (in ECU)*

Component	Initial investment	Annual FC
Space	41,250	8,578
Extractor hood	7,500	1,471
Vacuum oven	27,405	2,250
Band saw	975	175
Plaster saw	882	158
Small drill	269	48
Dentist's drill	1,625	292
Heating system	250	45
Stacking space	1,540	200
Support + plate	142	18
Fixation plates	673	87
Total	82,511	13,322

* As of December 1994, 1 ECU = 1.2 $.
FC = fixed cost.

Table A2. Variable costs of plastic masks (in ECU)*

Component	Full mask	Cut out mask
Labor		
Neg. plaster cast	8.94	8.94
Pos. plaster mask	1.49	1.49
Plastic mask	8.94	10.42
Adjust. & fixation	3.44	3.44
Total labor	22.81	24.29

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Table A2. (*Cont'd*)

Component	Full mask	Cut out mask
Material		
Plaster bandages	50.67	50.67
Plaster powder	3.17	3.17
Plastic (pvc)	7.82	7.82
Others†	0.75	0.75
Total material	62.41	62.41
Total cost first mask	85.22	86.70
Cost per addit. mask	2.52	21.70
Average cost/patient‡	88.37	113.82

* As of December 1994, 1 ECU = 1.2 $.

† Including plastic foil, sand paper, vaseline, detergent, water, use of electricity; ‡assuming that 25% (50%) of the patients needs two (three) masks.

Table A3. Fixed costs for the Orfit® masks (in ECU)*

Component	Initial investment	Annual
Water heater	1,032	120
Support + plexi plate	380	49
Total	1,412	169

* As of December 1994, 1 ECU = 1.2 $.

Table A4. Variable cost of the Orfit® masks (in ECU)*

Component	Full mask	Cut out mask
Labor		
Prep. pat. & plas.	0.80	0.80
Molding	3.45	3.45
Tape on mask	1.37	1.37
Cutting out	0	2.07
Total labor	5.62	7.69
Material		
Orfit mask	59.75	59.75
Prot. stocking	1.55	1.55
Tape	0.45	0.45
Total material	61.75	61.75
Use of water heater	0.12	0.12
Total cost first mask	67.49	69.56
Cost per add. mask	2.22	69.56
Average cost/patient†	70.26	156.51

* As of December 1994, 1 ECU = 1.2 $.

† Assuming that 25% (50%) of the patients needs two (three) masks.