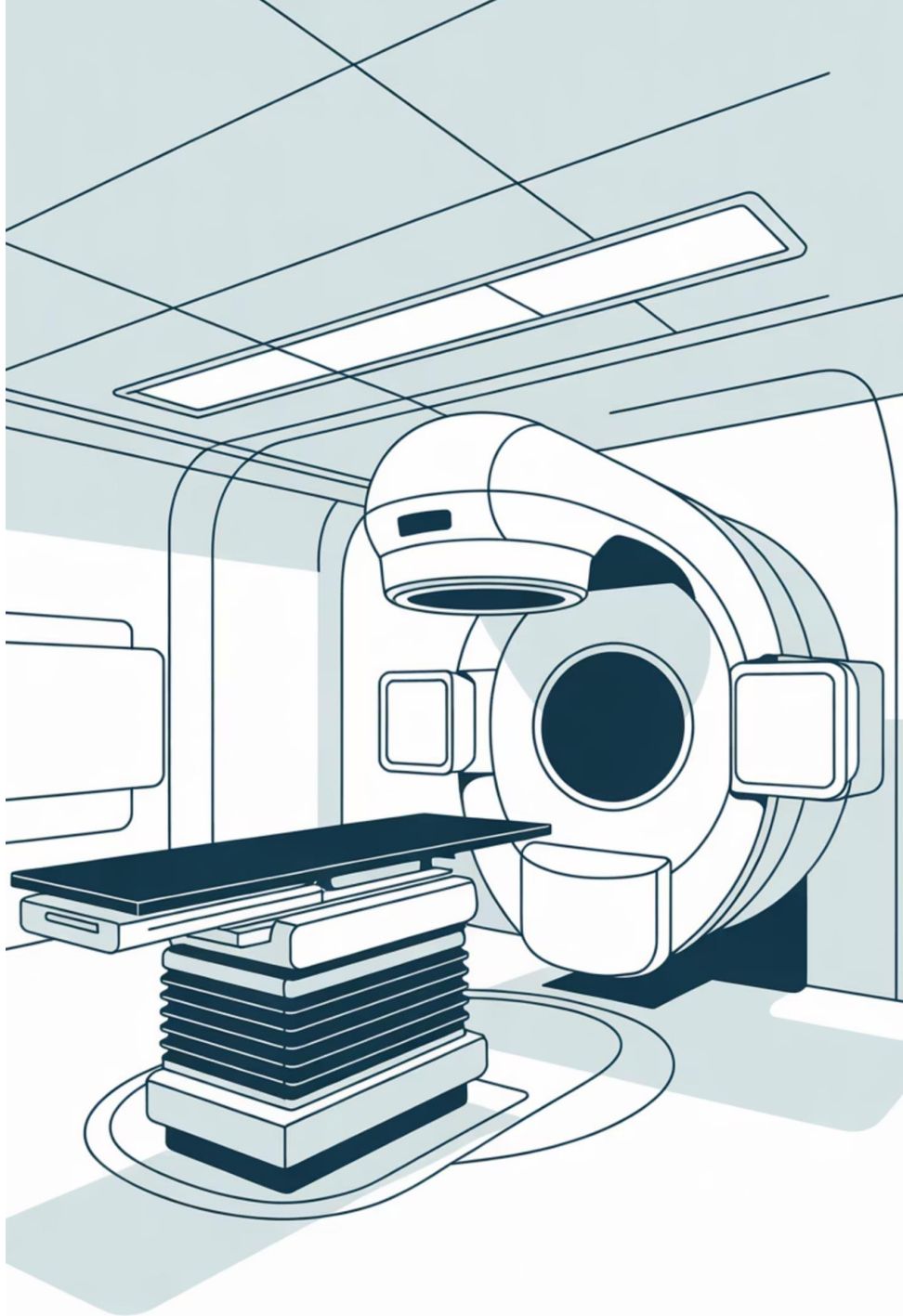
Narodowy
Instytut
Onkologii
im. Marii Skłodowskiej-Curie
Państwowy Instytut Badawczy
Oddział w Gliwicach

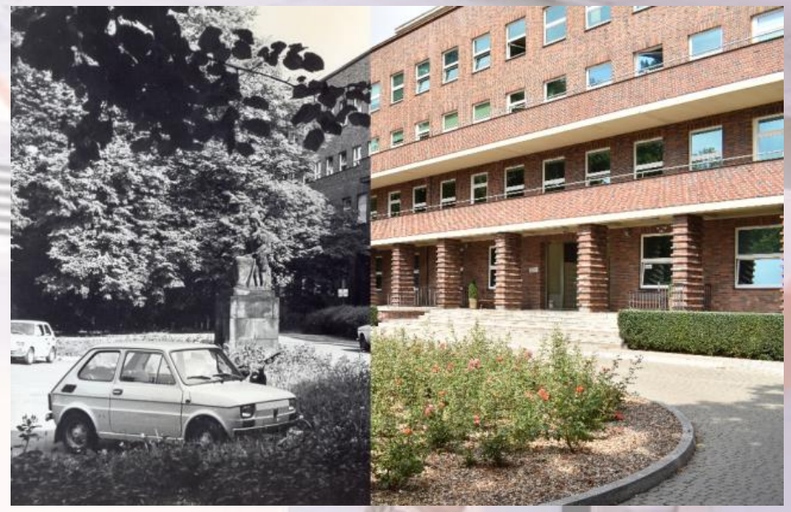
Application of Open Face Masks and Surface Guided Radiation Therapy (SGRT) in Patients Undergoing Stereotactic Radiotherapy for Head and Neck Regions

Bodusz Dawid, Nachlik Michał, Bugowska Magdalena, Kołosza Zofia, Cortez Alexander, Rutkowski Tomasz, Wydmański Jerzy

Radiotherapy Department, Maria Skłodowska-Curie National Research Institute of Oncology, Gliwice Branch



Narodowy Instytut Onkologii
im. Marii Skłodowskiej-Curie
Państwowy Instytut Badawczy
Oddział w Gliwicach

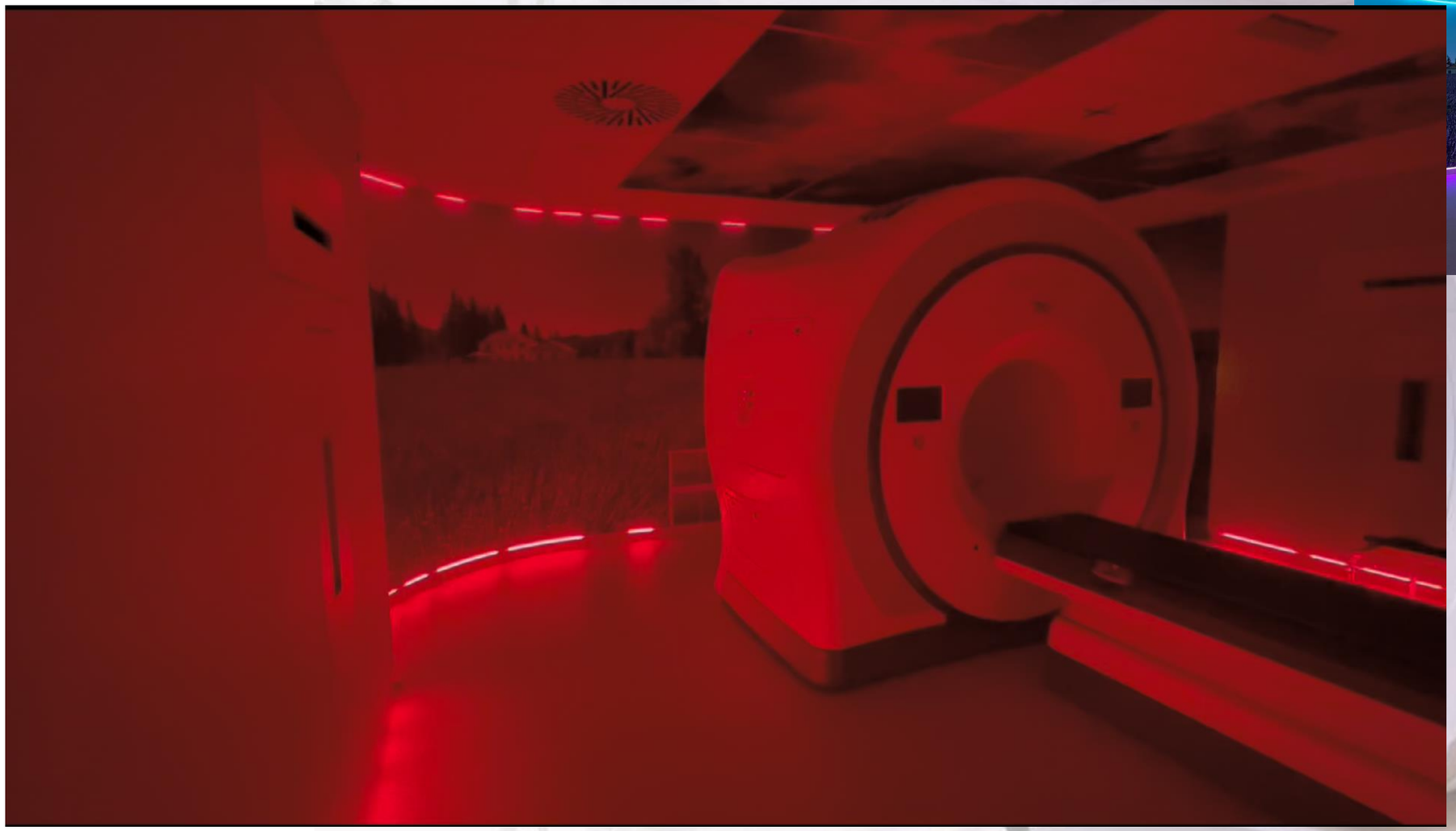


11 Linacs (6 with AlignRT):
7 x TrueBeam
1 x Edge
1 x Radixact
1 x CyberKnife M6
1 Ethos
2x IORT units
1 x Hyperthermia

Team:
74 RTTs
34 rad.onc.
6 nurses

Patients:
7 000 /year
~300 /day

Narodowy
Instytut
Onkologii
im. Marii Skłodowskiej-Curie
Państwowy Instytut Badawczy
Oddział w Gliwicach



Background

The Challenge

Precise and reproducible patient positioning is critical in high-precision radiotherapy, particularly in stereotactic techniques requiring submillimetric accuracy. Traditional thermoplastic masks, while effective in reducing patient movement, often limit visual access to the patient's face, hindering real-time verification and patient comfort.

The Innovation

Open face immobilization systems provide partial facial exposure, improving patient tolerance—especially for claustrophobic individuals—while maintaining necessary immobilization for stereotactic precision. When combined with SGRT, a non-ionizing, camera-based tracking technology, these systems enable real-time monitoring of patient surface anatomy.

The integration of SGRT with open face masks is gaining clinical relevance in stereotactic radiotherapy (SRT) for head and neck tumors, including skull base metastases, recurrent nasopharyngeal carcinoma, and parotid lesions. However, clinical validation and reproducibility across multiple fractions remains under investigation.

Objective

Setup Accuracy

Evaluate positioning precision with open face masks and SGRT in stereotactic treatments

Intrafraction Stability

Assess patient stability during treatment delivery

Treatment Efficiency

Determine optimal role in routine clinical practice

This study aims to evaluate the application of open face masks in conjunction with SGRT in stereotactic treatments of head and neck regions. The findings may help define the optimal role of these technologies in routine clinical practice and contribute to the refinement of positioning protocols in stereotactic head and neck radiotherapy.

Narodowy Instytut Onkologii
im. Marii Skłodowskiej-Curie
Państwowy Instytut Badawczy
Oddział w Gliwicach

Material and Methods

Group of Patients

51

Qfix Group

Patients with Qfix open-face masks (Sept 2021 - Feb 2023)

100

Klarity Group

Patients with Klarity open-face masks (March - Dec 2024)

42

„Control" Group

Patients with closed-face Orfit masks

1,393

Total Measurements

Alignment measurements collected across all groups

The study included patients undergoing **radiotherapy for cranial lesions** using open-face thermoplastic masks from two different manufacturers. In both open-face groups, bite-blocks were used in a subset of patients to enhance immobilization. All treatments were performed on the same therapeutic unit for consistency.

Treatment machine workflow

IGRT Treatment Procedure

Patient Setup with SGRT

Initial positioning of the patient using SGRT

CBCT Verification

Confirming patient alignment with CBCT

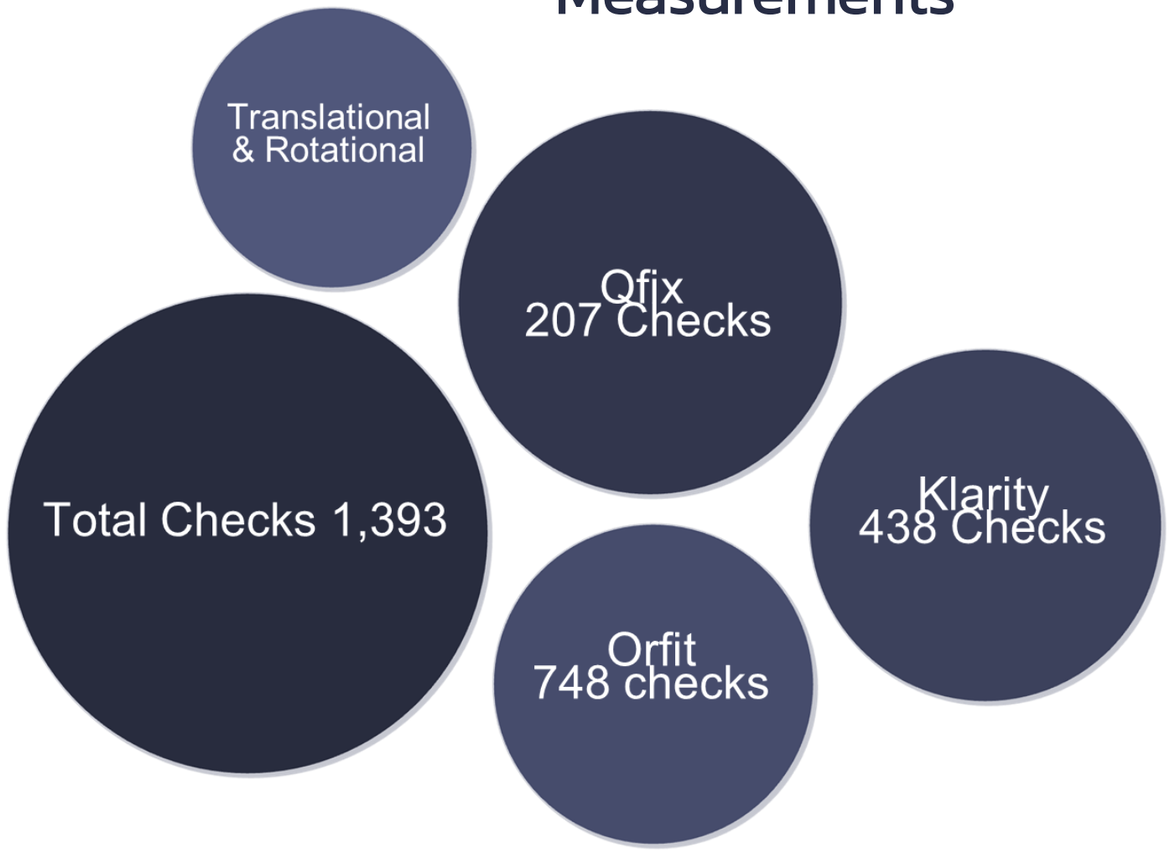
Patient Position Correction

Adjusting patient position based on CBCT results

Treatment Delivery with SGRT Monitoring

Administering treatment while monitoring with SGRT

Measurements



SGRTwith AlignRT

For patients immobilized with open-face masks, positioning was guided using the AlignRT system (VisionRT, UK), which provides real-time surface monitoring based on stereoscopic camera tracking. After the patient assumed the treatment position and the mask was secured, the SGRT system captured the current surface and compared it with a pre-defined reference surface from CT simulation.

01

Surface Capture

System captures patient's facial surface in treatment position

02

Real-Time Comparison

Displays translational and rotational displacements versus reference

03

Manual Corrections

Adjustments made to meet tolerance thresholds (±1 mm and ±1°)

04

CBCT Verification

Cone beam CT performed for final verification

05

Continuous Monitoring

Intrafraction monitoring with automatic beam hold if motion exceeds thresholds

In these groups, **neither skin markers nor laser positioning systems were used**. The system was capable of initiating automatic beam hold if patient motion exceeded predefined thresholds during treatment.

SRS Immobilization System

www.Qfix.com

Encompass™ SRS Immobilization System

Both types of open-face masks used in this study were compatible with the Encompass™ SRS Immobilization System (Qfix, USA), a high-precision, non-invasive immobilization platform designed for stereotactic radiotherapy in the head and neck region.

- Provides rigid fixation while maintaining unobstructed facial access
- Custom-molded thermoplastic mask secured to rigid frame
- Minimizes movement in all three spatial dimensions
- Frame indexed to treatment couch for high reproducibility

SRS Immobilization System – Qfix

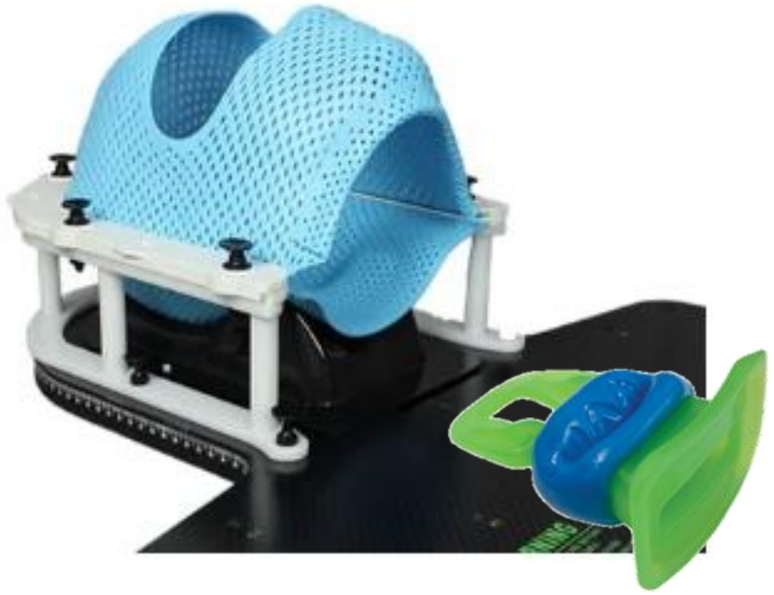
www.Qfix.com

Encompass™ SRS Immobilization System

Both types of open-face masks used in this study were compatible with the Encompass™ SRS Immobilization System (Qfix, USA), a high-precision, non-invasive immobilization platform designed for stereotactic radiotherapy in the head and neck region.

- Provides rigid fixation while maintaining unobstructed facial access
- Custom-molded thermoplastic mask secured to rigid frame
- Minimizes movement in all three spatial dimensions
- Frame indexed to treatment couch for high reproducibility

SRS Immobilization System – Klarity



Encompass™ SRS Immobilization System

Both types of open-face masks used in this study were compatible with the Encompass™ SRS Immobilization System (Qfix, USA), a high-precision, non-invasive immobilization platform designed for stereotactic radiotherapy in the head and neck region.

- Provides rigid fixation while maintaining unobstructed facial access
- Custom-molded thermoplastic mask secured to rigid frame
- Minimizes movement in all three spatial dimensions
- Frame indexed to treatment couch for high reproducibility

www.klaritymedical.com

Statistical Analysis

Software & Significance

All statistical procedures performed with STATISTICA software (version 13.3). Two-tailed tests applied throughout with significance threshold at $\alpha = 0.05$.

Descriptive Statistics

For each spatial displacement variable (Vrt, Lng, Lat, Pitch, Roll, Rtn), descriptive statistics generated separately for every immobilisation system. Normality examined using Shapiro-Wilk test.

Non-Parametric Methods

As most variables deviated from Gaussian distribution, non-parametric methods selected for group comparisons. Kruskal-Wallis test applied with Dunn's post-hoc tests and Bonferroni adjustment.

Comparison Methodology

System Comparison

Kruskal-Wallis analysis across three systems (Qfix, Klarity, Orfit) for each displacement variable

Effect Size

Magnitude quantified with eta-squared (η^2): 0.01 small, 0.06 medium, ≥0.14 large

Post-Hoc Testing

Pairwise comparisons using Dunn's test with Bonferroni adjustment

Bite-Block Analysis

Mann-Whitney U test to assess bite-block impact within each open-face system

Results

Narodowy Instytut Onkologii
im. Marii Skłodowskiej-Curie
Państwowy Instytut Badawczy
Oddział w Gliwicach

Residual Set-Up Deviations After SGRT Correction

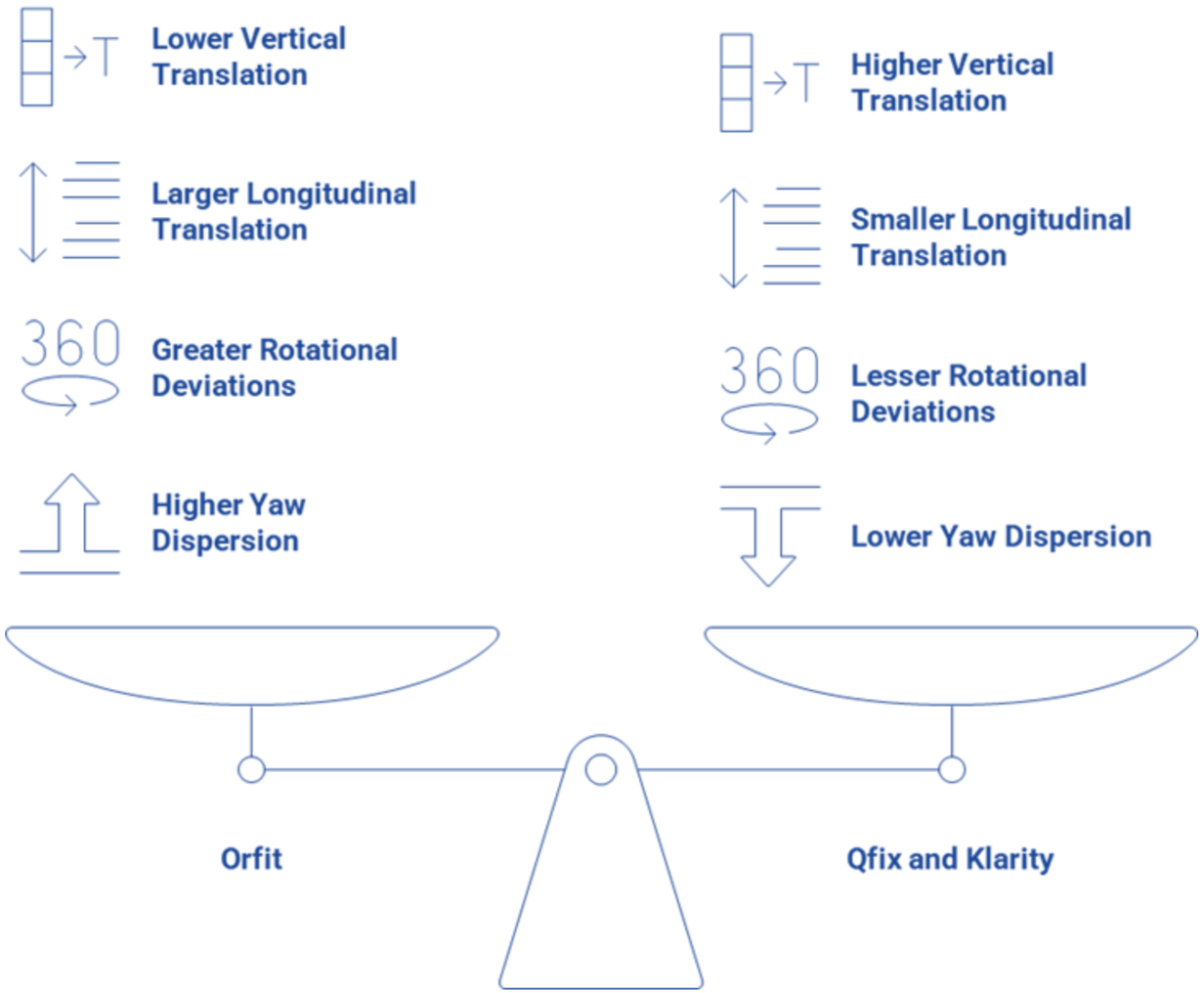
Axis / Metric	Qfix (n=207)	Klarity (n=438)		Orfit (n=748)
Translations (cm)				
Vertical - Median (IQR)	0.30 (0.17–0.39)	0.25 (0.11–0.35)	≥	0.18
Vertical - Mean ± SD	0.27 ± 0.17	0.27 ± 0.50	≥	0.28 ± 0.28
Longitudinal - Median (IQR)	0.03 (–0.10–0.08)	–0.08 (–0.19–0.04)		0.17
Longitudinal - Mean ± SD	–0.01 ± 0.17	–0.15 ± 1.79	<	0.30 ± 0.71
Lateral - Median (IQR)	0.03 (0–0.08)	0.01 (–0.05–0.08)		0.19 (0.09–0.34)
Lateral - Mean ± SD	0.04 ± 0.08	0.03 ± 0.40		0.29 ± 0.37
Rotations (°)				
Pitch - Median (IQR)	0.70 (0.20–1.40)	0.20 (–0.80–0.90)		1.30
Pitch - Mean ± SD	0.74 ± 0.96	0.04 ± 1.36		1.41 ± 0.96
Roll - Median (IQR)	0.40 (0.10–0.80)	0 (–0.70–0.60)		0.80
Roll - Mean ± SD	0.40 ± 0.65	–0.02 ± 0.99		1.02 ± 0.86
Yaw - Median (IQR)	0.20 (0–0.60)	0.05 (–0.60–0.60)		0.80
Yaw - Mean ± SD	0.30 ± 0.76	–0.01 ± 1.02		1.02 ± 0.81

Residual Set-Up Deviations After SGRT Correction

Axis / Metric	Qfix (n=207)	Klarity (n=438)
Translations (cm)		
Vertical - Median (IQR)	0.30 (0.17–0.39)	0.25 (0.11–0.35)
Vertical - Mean ± SD	0.27 ± 0.17	0.27 ± 0.50
Longitudinal - Median (IQR)	0.03 (–0.10–0.08)	–0.08 (–0.19–0.04)
Longitudinal - Mean ± SD	–0.01 ± 0.17	–0.15 ± 1.79
Lateral - Median (IQR)	0.03 (0–0.08)	0.01 (–0.05–0.08)
Lateral - Mean ± SD	0.04 ± 0.08	0.03 ± 0.40
Rotations (°)		
Pitch - Median (IQR)	0.70 (0.20–1.40)	0.20 (–0.80–0.90)
Pitch - Mean ± SD	0.74 ± 0.96	0.04 ± 1.36
Roll - Median (IQR)	0.40 (0.10–0.80)	0 (–0.70–0.60)
Roll - Mean ± SD	0.40 ± 0.65	–0.02 ± 0.99
Yaw - Median (IQR)	0.20 (0–0.60)	0.05 (–0.60–0.60)
Yaw - Mean ± SD	0.30 ± 0.76	–0.01 ± 1.02

Axis / Unit	Comparison	Δ-median	Adjusted P	Effect Size	Interpretation
Translations (cm)					
Vertical	Qfix vs Orfit	+0.12	0.011	0.12	small
Vertical	Klarity vs Orfit	+0.07	0.046	0.10	small
Longitudinal	Qfix vs Orfit	–0.14	<0.001	0.62	large
Longitudinal	Klarity vs Orfit	–0.25	<0.001	0.67	large
Lateral	Qfix vs Orfit	–0.16	<0.001	0.63	large
Lateral	Klarity vs Orfit	–0.18	<0.001	0.66	large
Rotations (°)					
Pitch	Qfix vs Orfit	–0.60	<0.001	0.49	medium–large
Pitch	Klarity vs Orfit	–1.10	<0.001	0.56	large
Roll	Qfix vs Orfit	–0.40	<0.001	0.52	large
Roll	Klarity vs Orfit	–0.80	<0.001	0.58	large
Yaw	Qfix vs Orfit	–0.60	<0.001	0.55	large
Yaw	Klarity vs Orfit	–0.75	<0.001	0.59	large

Comparing Systems



Qfix vs Klarity Dispersion in Yaw

P-value

A Kruskal-Wallis test confirmed **significant between-group heterogeneity** in each degree of freedom ($P < 0.001$; $\eta^2 = 0.08–0.19$). Post-hoc Dunn tests demonstrated that **both open-face systems out-performed the closed-face** reference for every axis (adjusted $P < 0.01$). **No significant differences were detected between Qfix and Klarity in vertical or lateral axes.**

Influence of Bite-Block Use

Analyzing the distinct effects of intra-oral bite-blocks on the translational and rotational accuracy of Qfix and Klarity open-face masks during stereotactic radiotherapy.

Qfix System

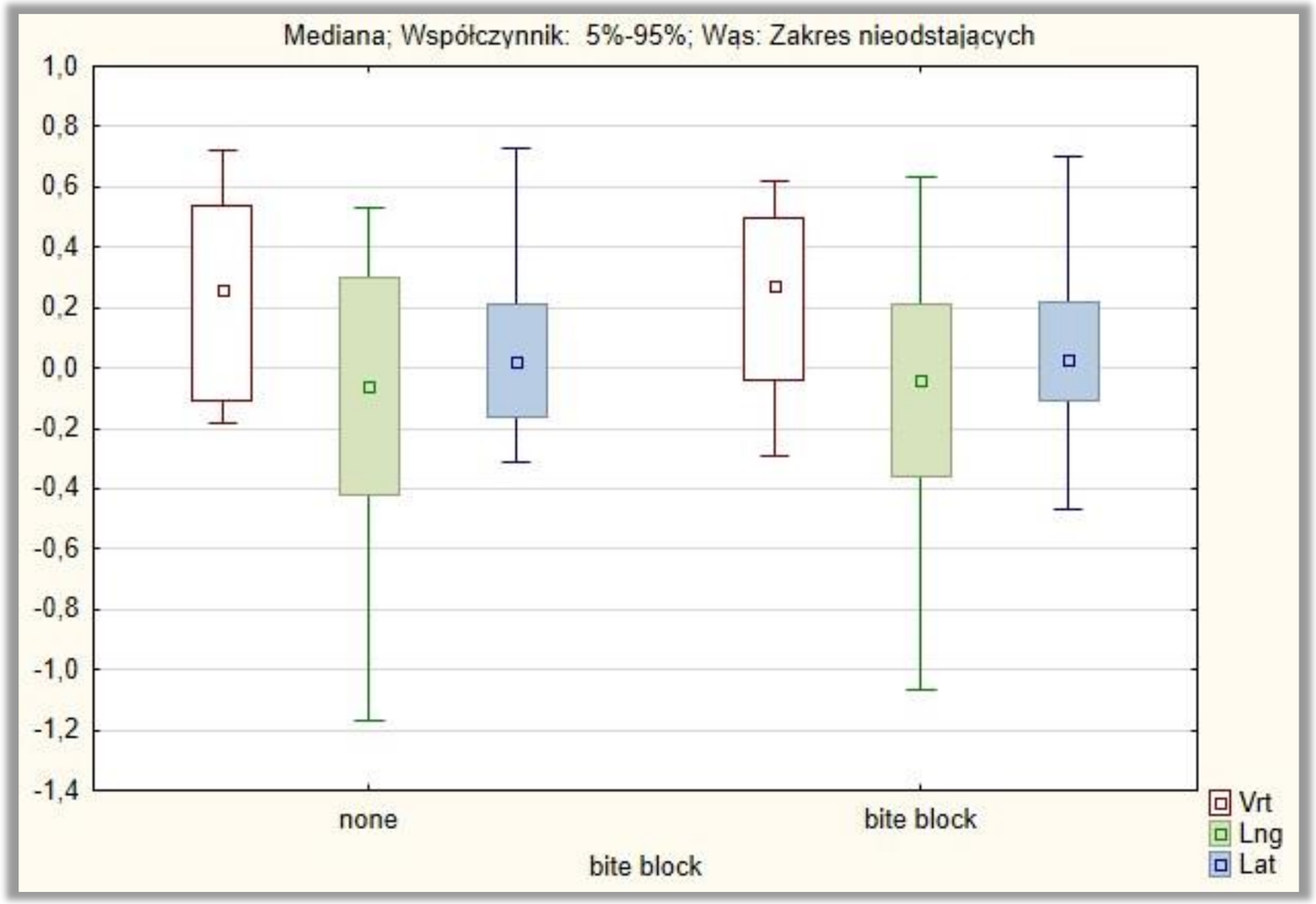
- **No measurable impact on translational** accuracy across all axes.
- Modest, **significant improvement in yaw** (rotational stability).
- Pitch and roll deviations remained unaffected.
- small but significant reduction in median vertical displacement (0.29 → 0.25 cm, U = 4,081, P = 0.014)

Klarity System

- Moderate **reduction in pitch error** (rotational control) (median 0.50° vs –0.20°, U = 12,288, P < 0.001).
- Weaker but significant decrease in roll.
- Translational dimensions and yaw were essentially unaltered.

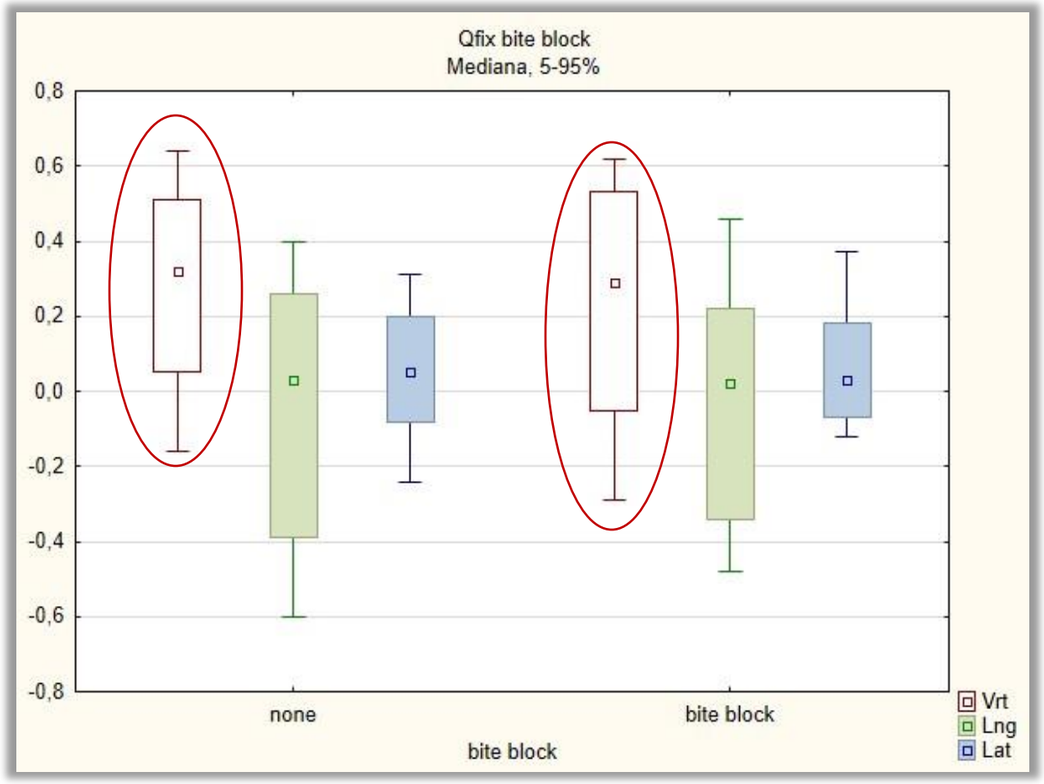
These findings suggest bite-blocks provide limited translational advantages but can selectively enhance rotational control, particularly for pitch in Klarity masks.

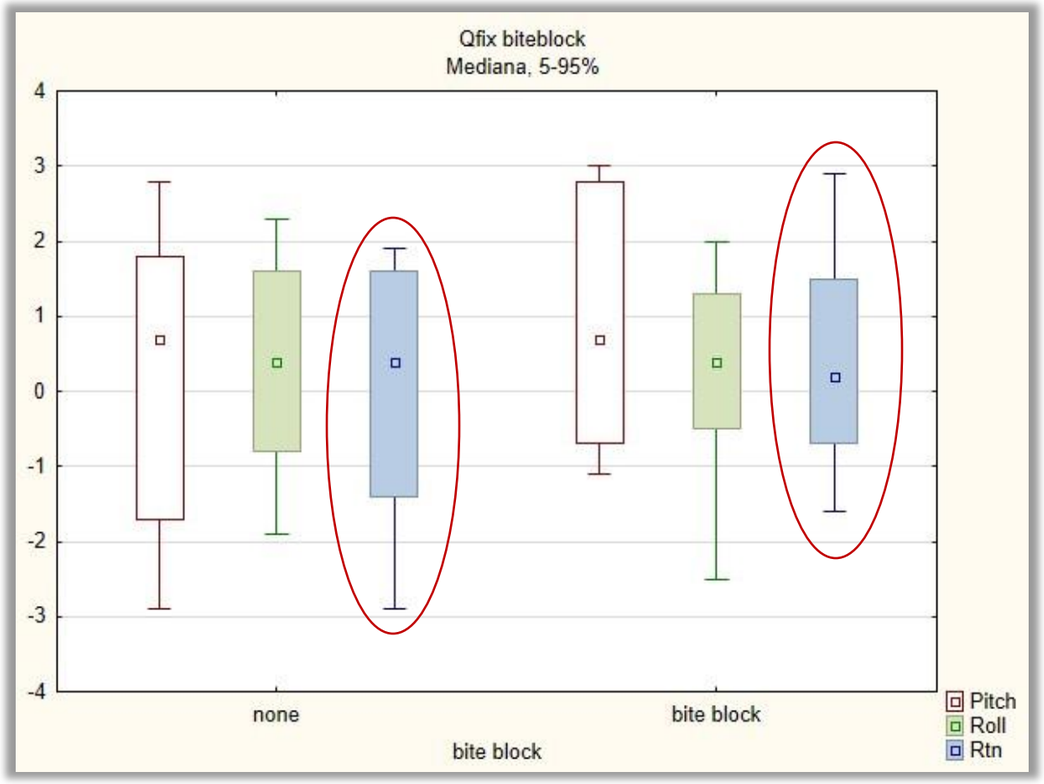
Influence of Bite-Block Use



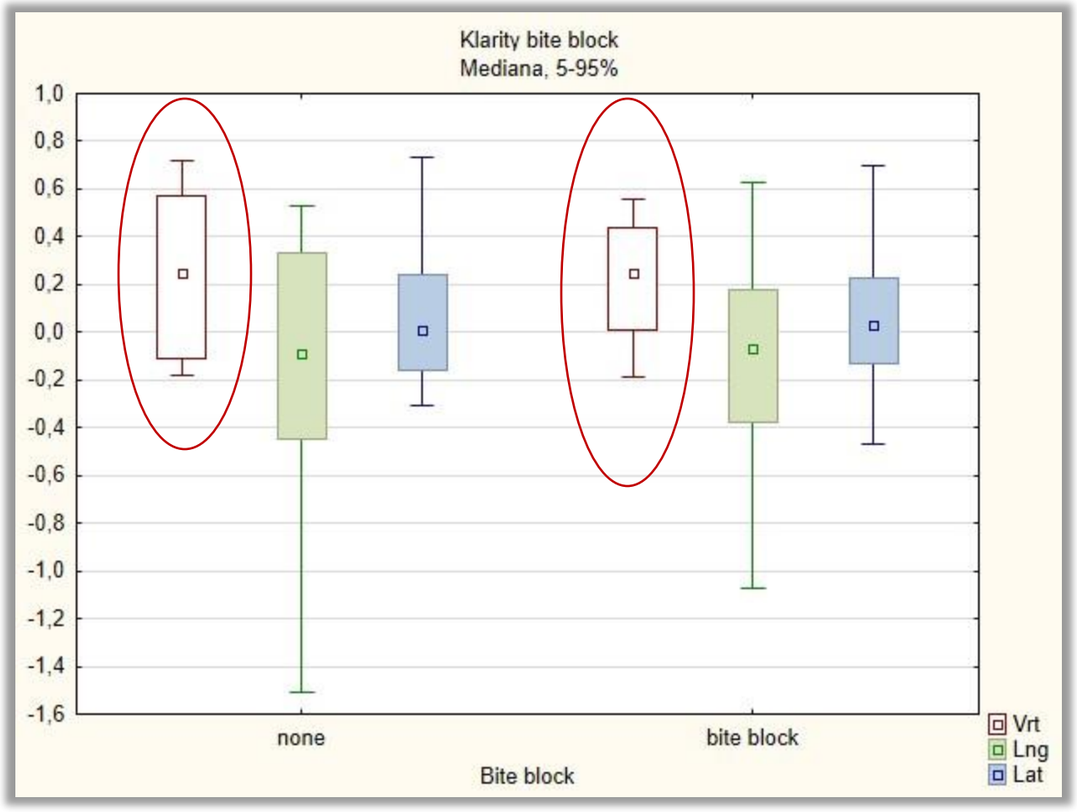
No influence
Whole group
(Qfix+Klarity)

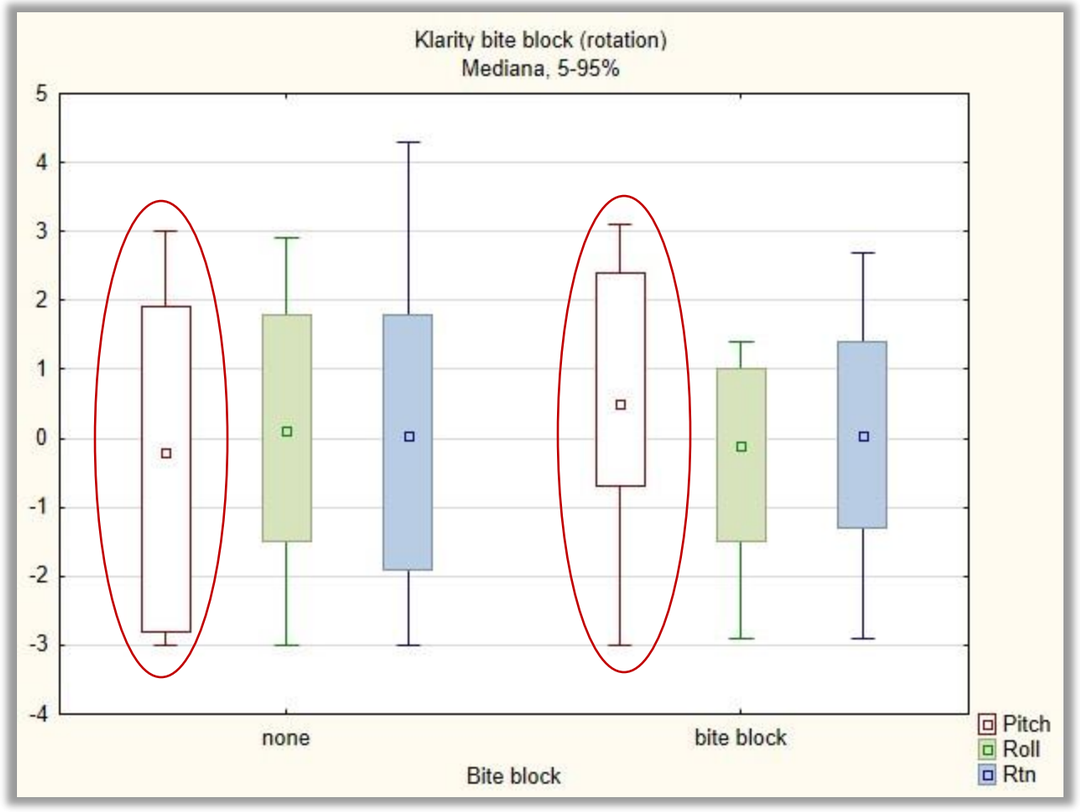
Influence of Bite-Block Use





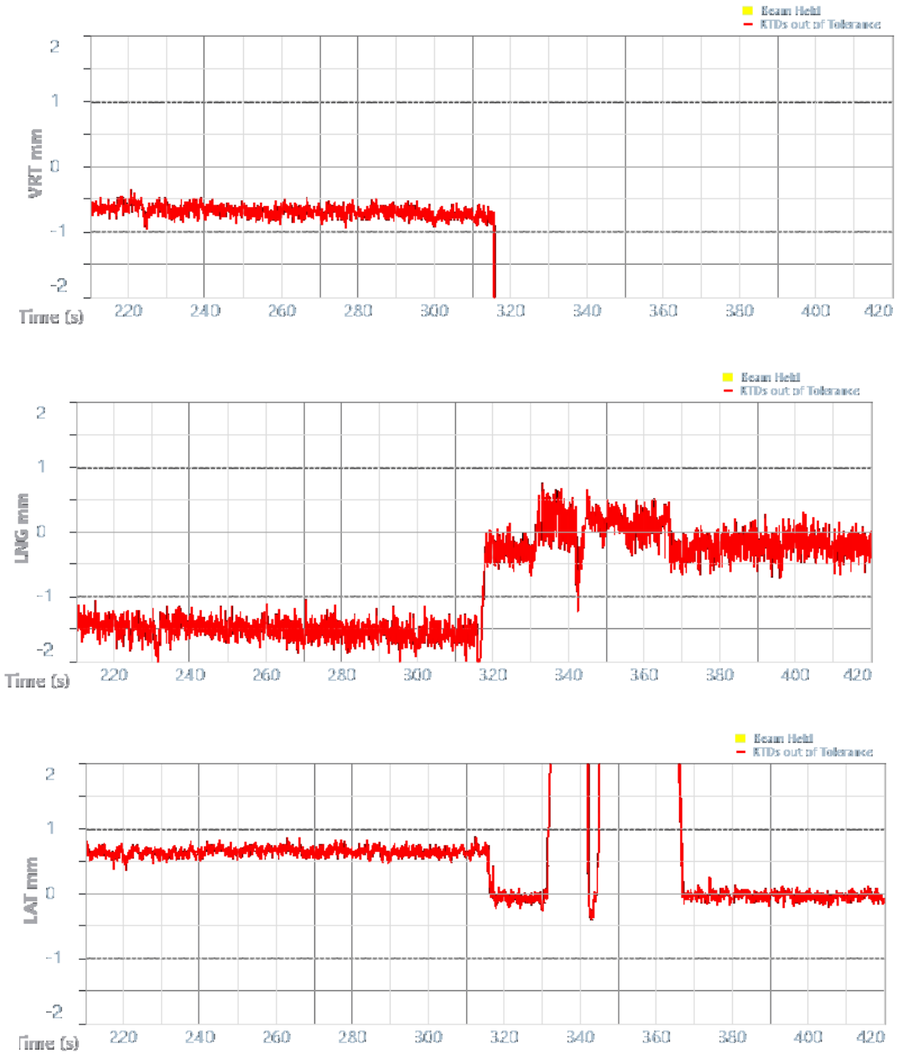
Influence of Bite-Block Use





Intrafraction motion

	Mean (mm/ °)	Max (mm/ °)	SD (mm/ °)
VRT	0,5	0,5	0,0
LNG	0,7	2,0	0,4
LAT	0,5	0,5	0,0
MAG	0,6	2,0	0,3
YAW	0,5	0,2	0,0
PITCH	0,5	1,0	0,1
ROLL	0,5	0,5	0,0



Narodowy
Instytut
Onkologii
im. Marii Skłodowskiej-Curie
Państwowy Instytut Badawczy
Oddział w Gliwicach

Brief summary

The present analysis confirms that open-face immobilisation in conjunction with surface-guided radiation therapy (SGRT) provides sub-centimetre translational and sub-degree rotational precision for frameless cranial stereotactic radiotherapy (SRT).

0.30

Translation Precision

Median residual translations ≤ 0.30 cm for open-face systems

1.0

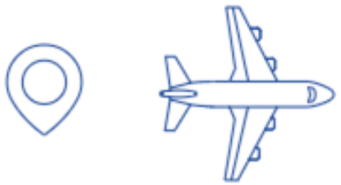
Rotational Precision

Rotations ≤ 1° consistently outperforming closed-face masks

These values are fully compatible with the < 0.3 cm / < 1° tolerances typically recommended for intracranial SRT and compare favourably with the 0.2–0.4 cm / 0.4–0.8° ranges reported in recent open-face SGRT series.

What about time?

IGRT Treatment Procedure



Patient Setup with SGRT

Initial positioning of the patient using SGRT

CBCT Verification

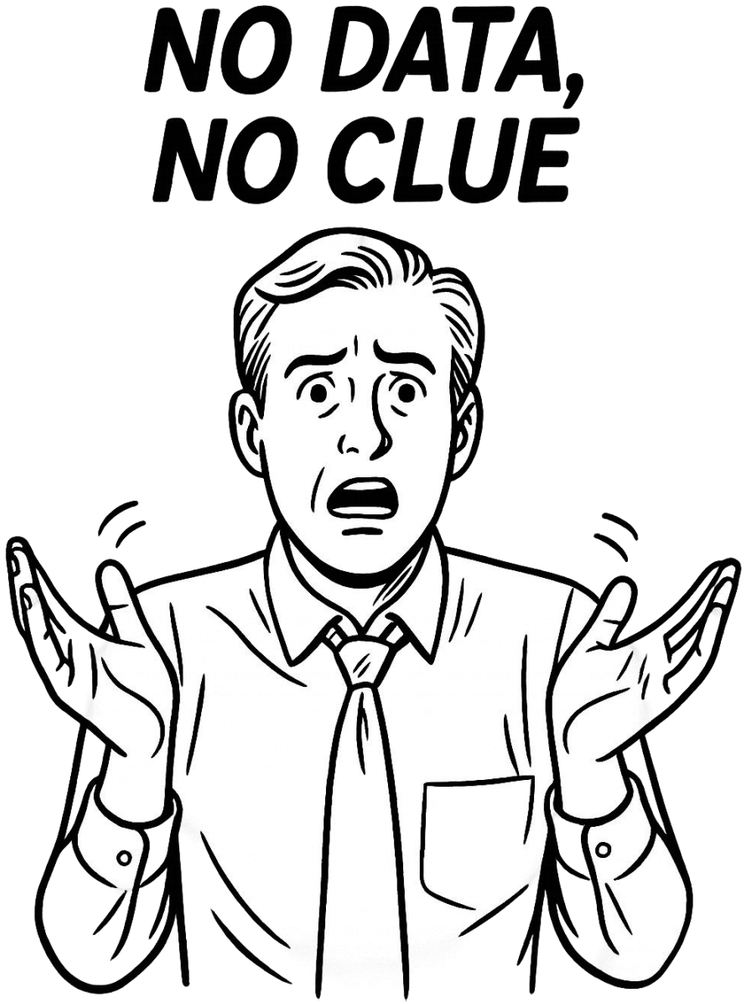
Confirming patient alignment with CBCT

Patient Position Correction

Adjusting patient position based on CBCT results

Treatment Delivery with SGRT Monitoring

Administering treatment while monitoring with SGRT



What about time?

IGRT Treatment Procedure

Patient Setup with SGRT

Initial positioning of the patient using SGRT

CBCT Verification

Confirming patient alignment with CBCT

Patient Position Correction

Adjusting patient position based on CBCT results

Treatment Delivery with SGRT Monitoring

Administering treatment while monitoring with SGRT

NO MORE TIME NEEDED FOR SET-UP

Radiat Oncol. 2022 Jun 4;17(1):104. doi: 10.1186/s13014-022-02077-4.

Initial clinical experience of surface guided stereotactic radiation therapy with open-face mask immobilization for improving setup accuracy: a retrospective study

Shun Zhou [# 1], Junyu Li [# 1], Xianggao Zhu [# 1], Yi Du [2 3], Songmao Yu [1], Meijiao Wang [1], Kaining Yao [1], Hao Wu [1 4], Haizhen Yue [5]

Results: The absolute values of median (maximal) CBCT couch shifts were 0.4 (1.3) mm in VRT, 0.1 (2.5) mm in LNG, 0.2 (1.6) mm in LAT, 0.1(1.2) degree in YAW, 0.2 (1.4) degree in PITCH and 0.1(1.3) degree in ROLL. The couch shifts and AlignRT RTD values exhibited highly agreement except in VRT and PITCH (p value < 0.01), of which the differences were as small as negligible. We did not find any case of patient repositioning that was due to out-of-tolerance setup errors, i.e., 3 mm and 2 degree. The surface guided setup time ranged from 52 to 174 s, and the mean and median time was 97.72 s and 94 s respectively.

Conclusions: The proposed surface guided SRT procedure with open-face mask immobilization is a step forward in improving patient comfort and positioning accuracy in the same process. Minimized initial setup errors and repositioning rate had been achieved with reasonably efficiency for routine clinical practice.

Comparative Study J Appl Clin Med Phys. 2022 Apr;23(4):e13536. doi: 10.1002/acm2.13536. Epub 2022 Jan 20.

Intra-fractional motion error during HyperArc stereotactic radiosurgery on patients with brain metastases: Comparison of open and full-face clamshell-style immobilization devices

Shingo Ohira [1 2], Riho Komiyama [1], Naoyuki Kanayama [1], Yoshihiro Ueda [1], Shoki Inui [1], Masayoshi Miyazaki [1], Masahiko Koizumi [2], Koji Konishi [1]

Results: For Encompass, the mean values of IME in the translational setup were 0.1, 0.2, and 0.0 mm in the anterior-posterior, superior-inferior, and left-right directions, respectively, and the mean values of IME about rotational axes were -0.1, 0.0, and 0.0° for the Pitch, Roll, and Yaw rotations, respectively. For DSPS, the mean values of IME in the translational setup were 0.2, 0.2, and 0.0 mm in the anterior-posterior, superior-inferior, and left-right directions, respectively, and the mean values of IME about rotational axes were -0.1, -0.1, and 0.0° for the Pitch, Roll, and Yaw rotations, respectively. No statistically significant difference was observed between the IME of the two immobilization systems except in the anterior-posterior direction ($p = 0.02$). Moreover, no statistically significant correlation was observed between three-dimensional IME and treatment time. The margin compensation for IME was less than 1 mm for both immobilization devices.

Conclusions: The IME during STI using open- and full-face clamshell-style immobilization devices is approximately equal considering the adequate accuracy in patient positioning.

Phys Med. 2021 Dec 4;92:69-74. doi: 10.1016/j.ejmp.2021.11.012. Online ahead of print.

Assessment of intra-fraction motion during automated linac-based SRS treatment delivery with an open face mask system

Mariluz De Ornelas [1], Tejan Diwanji [2], Irene Monterroso [2], Elizabeth Bossart [2], Raphael Yechieli [2], Nesrin Dogan [2], Eric A Mellon [2]

Results: For 132 fractions with isocenter within a single target, the median shift magnitude was 0.40 mm with a maximum shift of 1.17 mm. A total of 398 targets treated for plans having multiple or single targets that lied outside isocenter, resulted in a median shift magnitude of 0.46 mm, with median translational shifts of 0.20 mm and 0.20° rotational shifts. A 1 mm PTV margin was insufficient in 18% of targets at a distance greater than 6 cm away from isocenter, but sufficient for 96% of targets within 6 cm.

Conclusions: The findings of this study support 1 mm PTV expansion due to intra-fraction motion to ensure target coverage for plans with isocenter placement less than 6 cm away from the targets.

Narodowy
Instytut
Onkologii
im. Marii Skłodowskiej-Curie
Państwowy Instytut Badawczy
Oddział w Gliwicach

Conclusions

Superior Precision

Open-face masks combined with SGRT achieve clinically superior set-up precision and can safely replace conventional laser-guided, closed-mask positioning.

System Equivalence

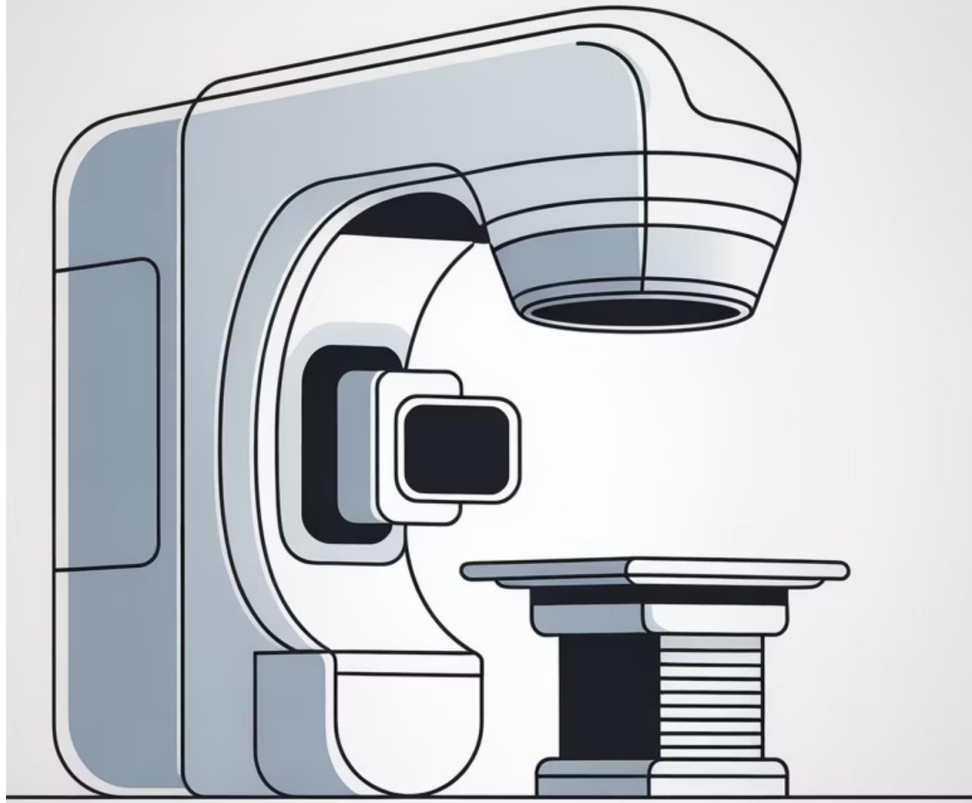
Qfix and Klarity masks are functionally equivalent and therefore interchangeable in clinical practice.

Selective Bite-Block Use

Bite-blocks selectively enhance rotational control. Routine use should be reserved for critical cases requiring sub-degree rotational margins.

Reduced Exposure

Open-face SGRT workflows reduce the need for skin tattoos and minimise additional imaging exposure.



Pragmatic Implications

Patient-Friendly Alternative

Incorporating open-face masks with SGRT provides a high-precision, patient-friendly alternative to closed-face, laser-based positioning.

Flexible System Selection

Because Qfix and Klarity perform equivalently, institutions can flexibly select either system based on practical considerations.

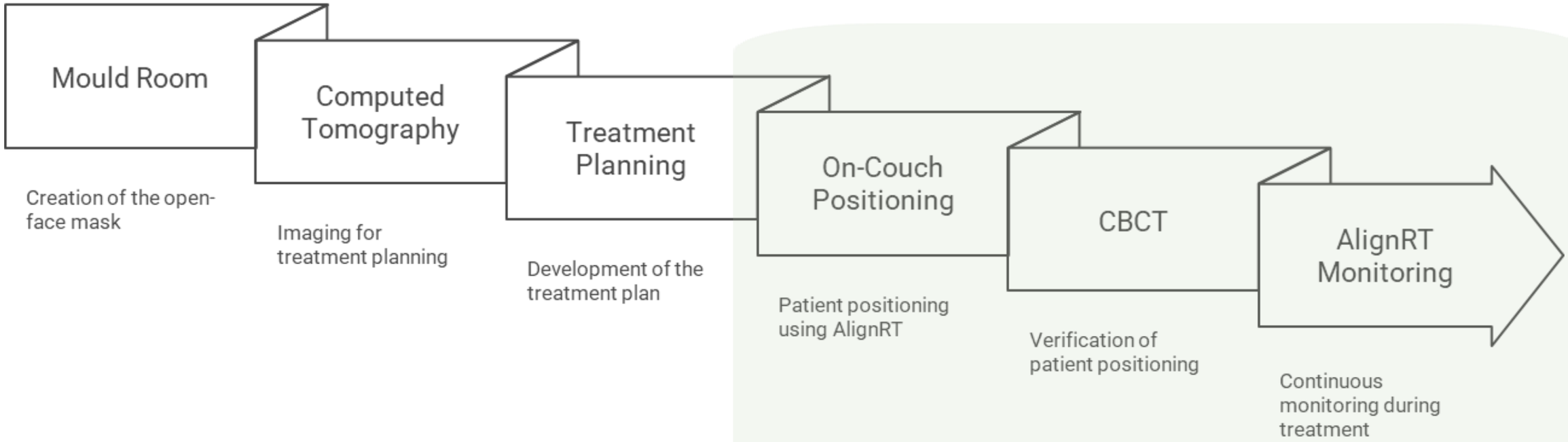
Strategic Bite-Block Use

Reserve bite-blocks for anatomically demanding cases where sub-degree rotational margins are critical.

Clinical Adoption

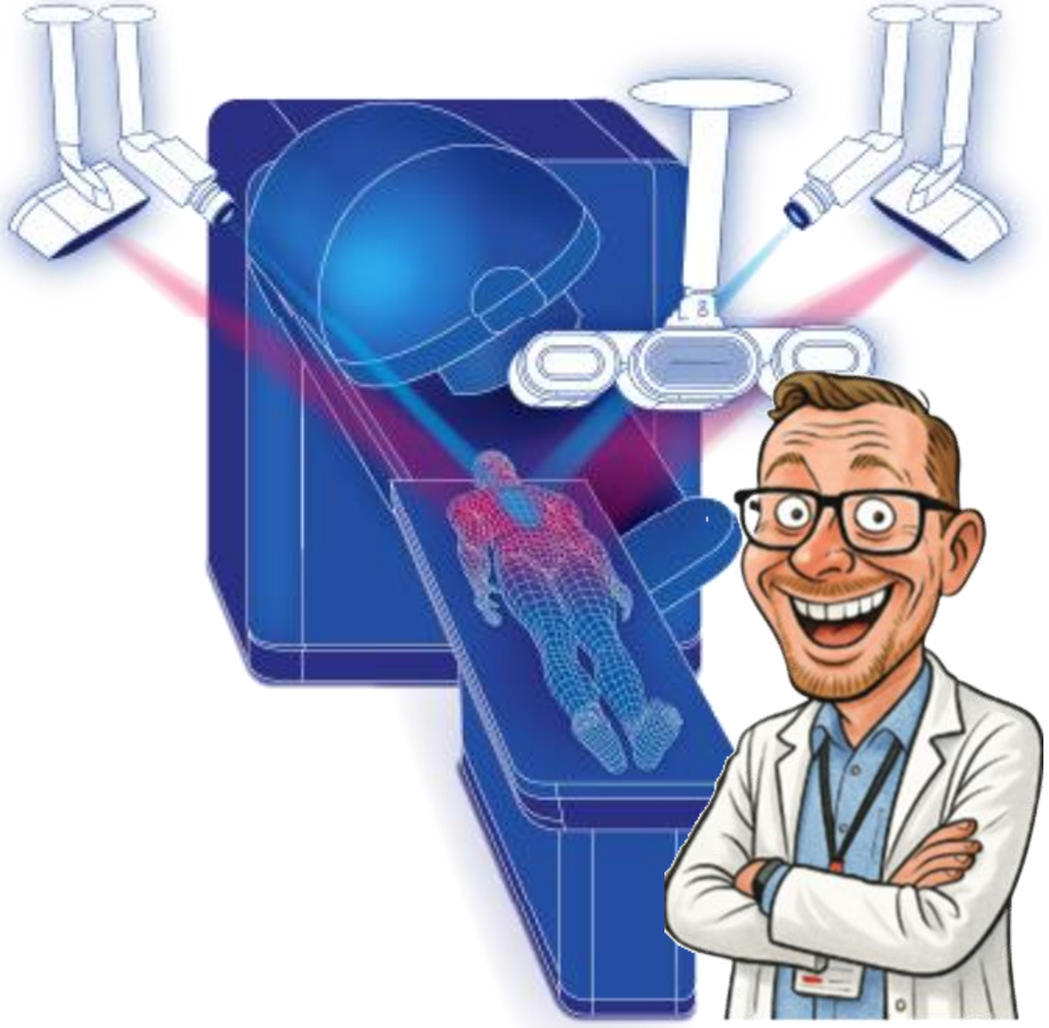
Routine clinical adoption of this workflow is supported, aligning with contemporary recommendations for frameless intracranial stereotaxy.

SRS Workflow with Open-Face Mask and AlignRT



It’s not magic, it’s AlignRT.

Narodowy Instytut Onkologii
im. Marii Skłodowskiej-Curie
Państwowy Instytut Badawczy
Oddział w Gliwicach



www.visionrt.com

Take-home ~~massage~~ message

- **A** Accuracy that matters
- **L** Less setup time
- **I** Improved patient comfort
- **G** Guaranteed precision
- **N** No additional imaging dose
- **R** Real-time safety
- **T** Trusted technology

Narodowy Instytut Onkologii
im. Marii Skłodowskiej-Curie –
Państwowy Instytut Badawczy
Oddział w Gliwicach

dr n. med. Dawid Bodusz

Email: dawid.bodusz@gliwice.nio.gov.pl
Adres: ul. Wybrzeże Armii Krajowej 15
44-102 Gliwice
www.gliwice.nio.gov.pl