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INTRODUCTION

Longitudinal imaging evaluation of brain tumor patients with MRI is a challenging endeavor, as there is considerable overlap between imaging findings of tumor progression and treatment related changes. There is felt to be a high degree of variation between individual interpreters, particularly in complex cases. Structured reporting systems, such as the recently described brain tumor reporting and data system (BT-RADS), attempt to maximize consistency between reading radiologists, although how successful they are at achieving this is unknown.

METHODS

Score	Title	Subscore	Description	Associated management recommendation
0	Not scored		New baseline, incomplete study, or otherwise unable to categorize	Continued follow-up, no change
1	Imaging improvement	1a - Improvement	Improvement in imaging findings suspected to reflect decreasing tumor burden and/or improving treatment effect	Continued follow-up, no change
		1b - Medication effect	Improvement in imaging findings potentially due to effect from medications such as increasing steroids or initiating Avastin	Continued follow-up, no change
2	No change		No appreciable change from the prior	Continued follow-up, no change
3	Imaging worsening	3a - Favor treatment effect	Worsening imaging findings favored to represent treatment effects, including radiation therapy and medications	Decreased time interval of follow-up
		3b - Indeterminate	Worsening imaging findings favored to represent an indeterminate mix of treatment effect and tumor worsening	Decreased time interval of follow-up
		3c - Favor tumor progression	Worsening imaging findings favored to represent increasing burden of tumor	Consider change in management vs. Decreased time interval of follow-up
4	Imaging worsening		Worsening of imaging findings highly suspicious for tumor progression	Consider change in management

Figure 1: Descriptions and associated management recommendations for each BT-RADS Score.

Patients with a diagnosis of a primary brain tumor with imaging presented at adult brain tumor board between October 2017 and September 2019 were reviewed. The most recent follow-up MRI was scored on an 8-point scale as described by BT-RADS, ranging from 0 to 4 with increasing suspicion for worsening disease, as described in the original radiologist report. Secondary review of MRI was performed by one of three neuroradiologists routinely participating in brain tumor conference. Interrater agreement between primary and secondary review were calculated using rates of exact agreement and linear weighted kappa.

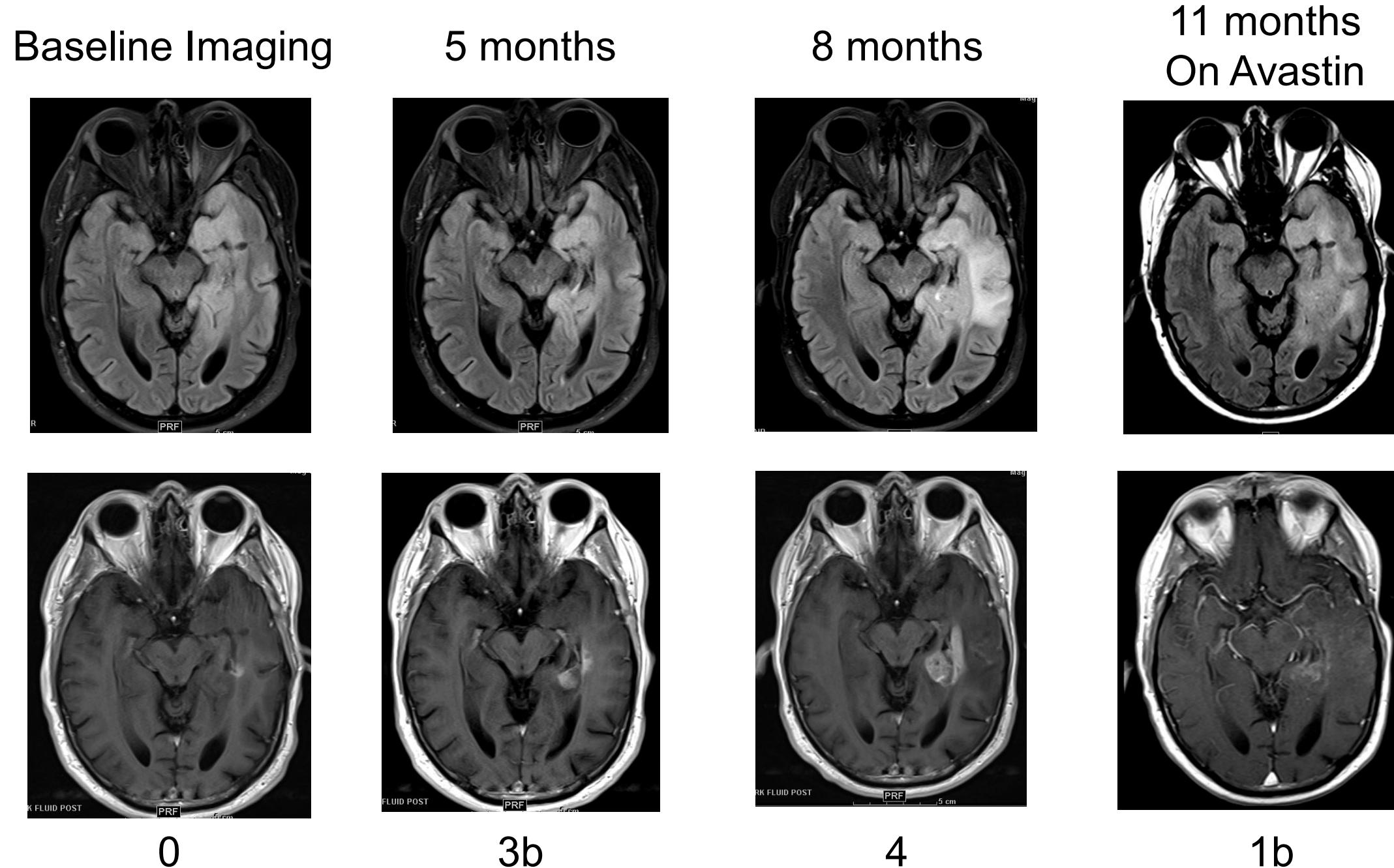


Figure 2: Example of applying BT-RADS scoring to a patient with a Grade II astrocytoma. The baseline post-surgical scan receives a score of 0. At 5 months post-op, the patient is more than 90 days past completing radiation treatment, and the tumor appears worse on imaging. Patient receives a score of 3b for an indeterminate mix of treatment effect and tumor worsening, and is recommended to decrease the time interval for follow up imaging. At 8 months post-op, imaging again appears worse compared to the previous scan. The patient is assigned a score of 4 because of suspicion for tumor progression and a change in management was recommended. The patient initiated Avastin therapy and received follow up imaging at 11 months post-op, which showed improvement. Due to this being the first study on Avastin, the patient was given a score of 1b because the improvement could be a possible medication effect (pseudoresponse).

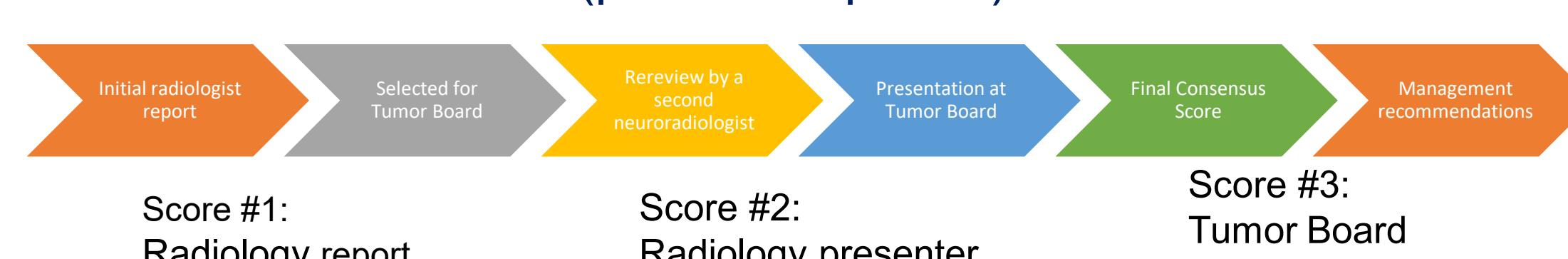


Figure 3: Flowchart for reviewing and scoring cases.

RESULTS

During the study period 212 studies from 130 individual patients were reviewed. Grade 4 astrocytoma (glioblastoma) was the most common diagnosis (63/130, 48.5%), followed by Grade 3 astrocytoma (16/130, 12.3%) and Grade 2 oligodendrogloma (12/130, 9.2%). The most frequently applied consensus score was 0 (65/212, 30.7%), most commonly applied to immediate post-operative images reviewed for treatment planning. Worsening imaging studies (3a-4) were reviewed more commonly, most likely because management changes were being considered.

Tumor Type	Number
Astrocytoma	90 (69.2%)
Grade 2	11 (8.5%)
Grade 3	16 (12.3%)
Grade 4	63 (48.5%)
Oligodendrogloma	22 (16.9%)
Grade 2	12 (9.2%)
Grade 3	10 (7.7%)
Other	18 (13.8%)
Gliosarcoma	4 (3.1%)
Presumed glioma (no biopsy)	6 (4.6%)
Anaplastic PXA	1
Medulloblastoma	1
Grade 1 Glioneuronal tumor	1
Fibrillary astrocytoma	1
Ependymoma	1
DIPG	1
Atypical lipomicrocytoma	1
Grade 1 glioma	1
Total	130

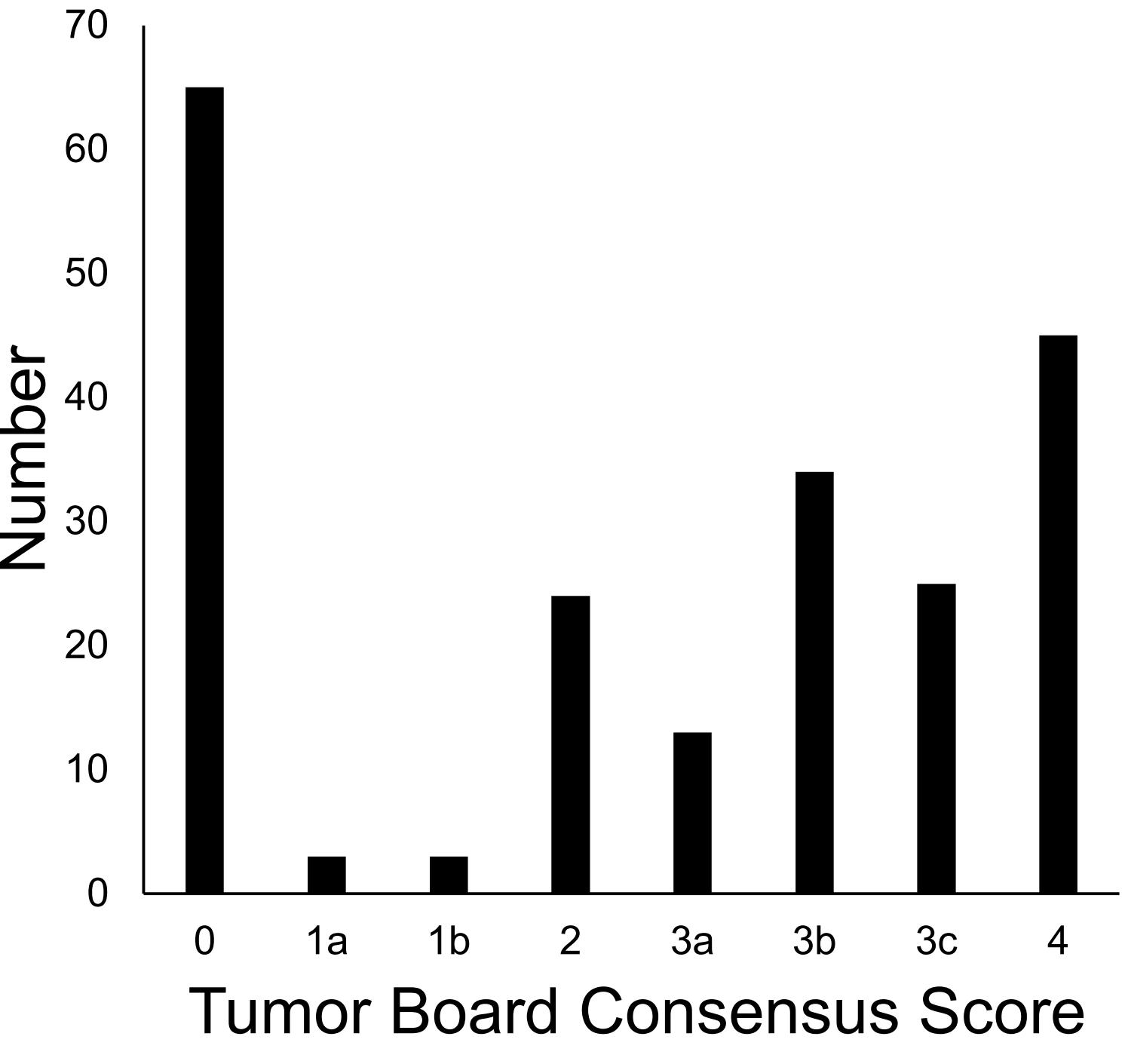


Figure 4. Histogram of consensus scores applied at tumor board showing relative frequency of each score applied.

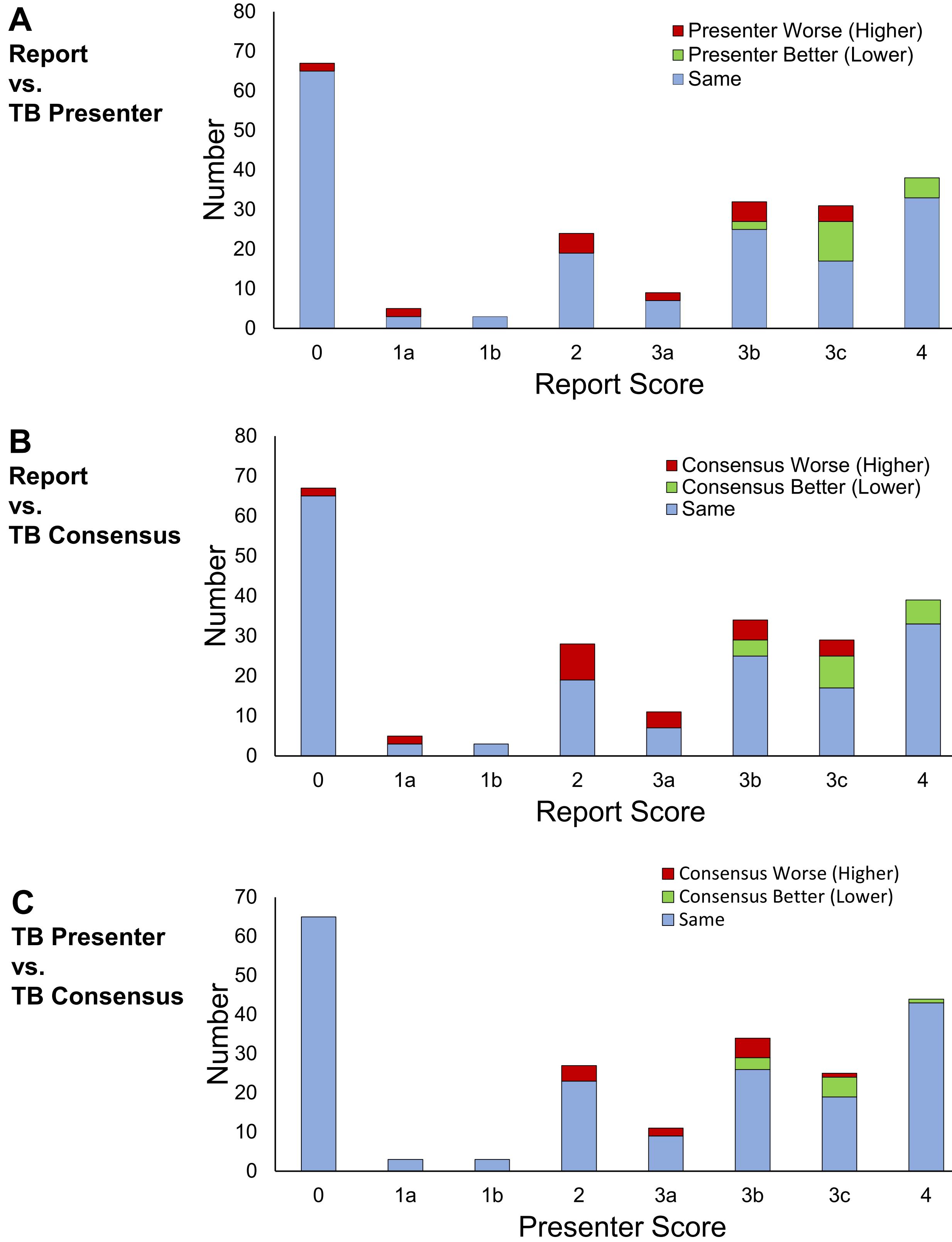


Figure 5. Comparison of scores between radiologist generating the report, the radiologist performing the secondary review, and the tumor board consensus. Comparison is shown for the report vs. the tumor board presenter (4A), the report vs. the tumor board consensus (4B), and the presenter vs. the consensus (4C).

RESULTS - Cont

The overall agreement rate between initial and secondary review was 82.2%, with kappa of 0.78 ± 0.06 . The agreement rate between the initial review and the consensus of the tumor board was 79.0%, with a kappa of 0.74 ± 0.07 . There was perfect agreement on studies with improvement (1a or 1b) with lower levels of agreement (63.6-82.4%) for studies with worsening imaging findings (3a-4).

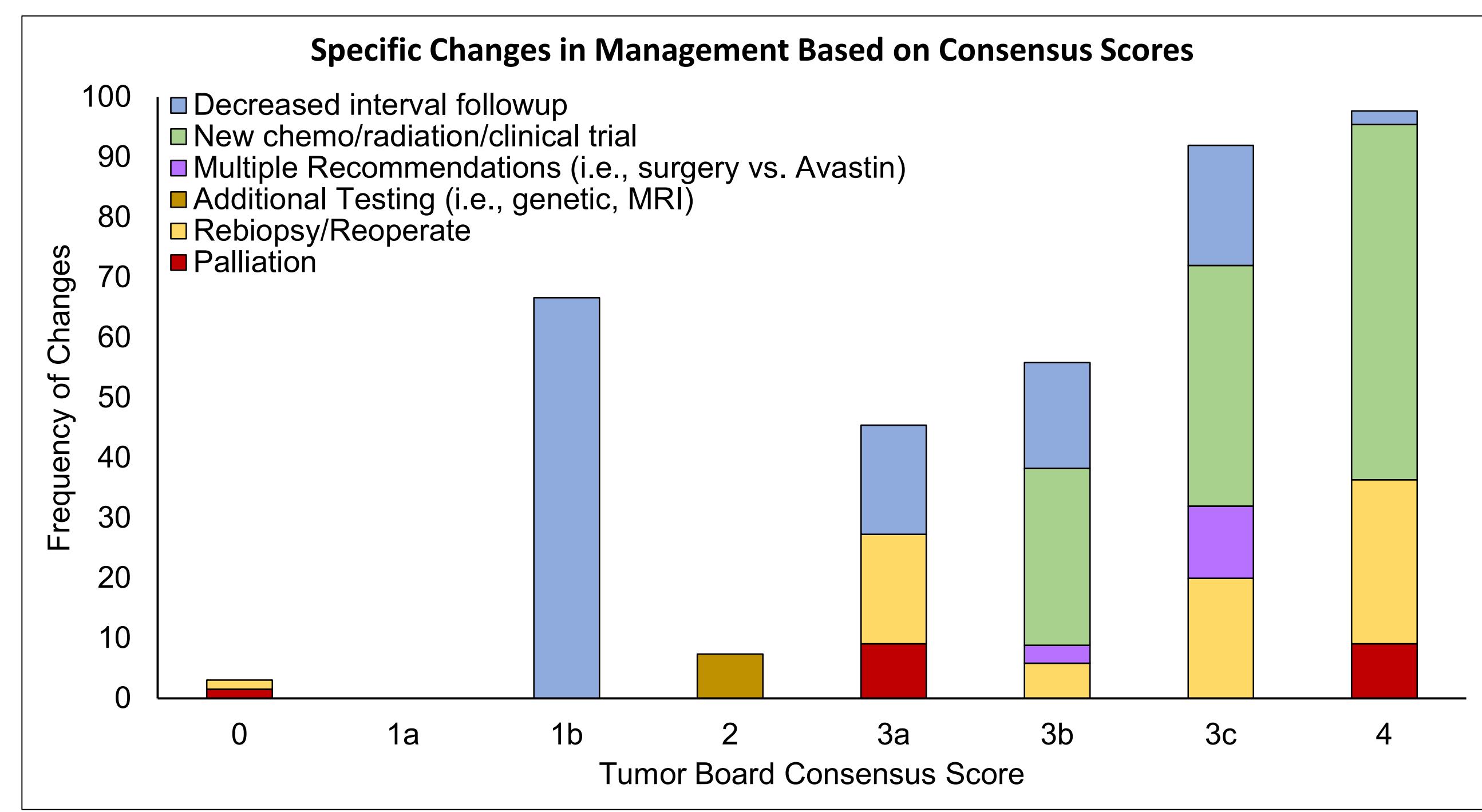


Figure 6. The percent changes in management recommended by tumor board based on the consensus score. The relative distributions of the specific changes in management are shown as well.

The frequency of management changes increased with increasing score, showing a correlation between severity of imaging findings and clinical changes. An exception to this was for 1b (improvement on imaging due to the effects of Avastin), for which most patients had a short-term follow-up. For patients that received a score of 4, 100% had a significant management change. The most common changes in management in patients with a score of 4 were new chemotherapy/radiation/clinical trial (57.8%), followed by rebiopsy/reoperation (26.7%) and transition to palliative care (9%).

CONCLUSION

Using a structured reporting system to categorize MRIs in brain tumor patients allows for precise characterization of variation between report conclusions on primary and secondary review. Overall agreement is good, but variation rates increase with worsening findings which may be harder to correctly interpret. BT-RADS scores reflecting worsened imaging (3a-4) are associated with higher rates of changes in management, including new chemotherapy, radiation therapy, and/or enrolling in a clinical trial. Future work includes prospective studies to assess BT-RADS prospective interrater reliability and ability to predict progression free and overall survival.

Acknowledgements

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