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Anatomic risk factors for arthroscopic Bankart repair failure: A case-control study comparing failure and non-failure groups in an Asian population

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ABSTRACT

Introduction: Post-arthroscopic Bankart repair failure/re-dislocation rates are influenced by several risk factors, including anatomic defects. There is limited evidence on the role of anatomic defects, especially for Hill-Sachs size in on-track lesions. This study aimed to assess glenoid bone loss, Hill-Sachs lesion and labral tear size and evaluate their contribution to post-operative instability after a primary repair.
Material and methods: Across 169 patients with on-track Bankart lesions who underwent primary arthroscopic Bankart repair from 2010 to 2015, this study matched 14 failure with 14 non-failure cases based on age/gender. Patient demographics, pre-operative radiological parameters (including size of glenoid bone loss and Hill-Sachs lesion) and labral tear size were compared between the failure and non-failure groups.
Result: All patients were male with a mean age of 21.01 ± 4.97. Significantly greater glenoid bone loss ($p = 0.024$) and labral tear size ($p = 0.039$) were found in the failure group. However, there was no significant difference in mean volume of Hill-Sachs lesion between the two groups ($p = 0.739$).
Conclusion: Extensive glenoid bone loss and labral tears are risk factors for post-arthroscopic Bankart failure. However, the size of Hill-Sachs lesion is not a risk factor for failure, in a specific group of on-track Hill-Sachs lesions.
Level of evidence: Retrospective Study, Level IV.

1. Introduction

Arthroscopic Bankart repair has become the main choice of management for anterior-inferior shoulder instability, offering similar or even superior outcomes compared to open repair over the past decade.[1–4] Despite the benefits of arthroscopic Bankart repair, failure or re-dislocation rates for arthroscopic Bankart repair remain suboptimal at approximately 7–18% in the short-term.[5–8]

Previous studies have established the following risk factors for arthroscopic Bankart failure: male sex, younger age (<20 years), collision injury, shoulder hyperlaxity, number of pre-operative dislocations, off-track Hill-Sachs lesions and glenoid bone loss.[9–13] However, the effect of anatomical defects on post-arthroscopic Bankart failure remains a topic of interest. Recent evidence has established that glenoid bone loss, Hill-Sach lesions as well as off-track state of Hill-Sachs lesions are all bony factors predisposing to post-arthroscopic Bankart repair failure. The evidence on glenoid bone loss is established, with most studies establishing a critical value of 20–25% bone loss (relative to the glenoid width), above which additional bone grafting is required.[14–16] Moreover, since Yamamoto et al. first established the concept of a “glenoid track” between the glenoid and humeral head,[17] several studies have shown that off-track Hill-Sach lesions predispose to post-arthroscopic Bankart failure.[13,18] However, the relationship between the extent of Hill-Sachs defect and arthroscopic Bankart failure remains unclear. While cadaveric studies have postulated that a greater defect size of Hill-Sachs lesions predisposes to glenohumeral joint stability,[19,20] the clinical evidence on this remains scarce.

Other than bony factors, another possible anatomical risk factor in post-arthroscopic Bankart failure is the size of labral tears. Although extensive labral tears can generally be repaired arthroscopically with good long-term functional outcomes,[21] there have been studies correlating features of labral defects, such as glenoid labral articular disruption (GLAD), on recurrent instability.[22] However, there is a paucity of evidence on the effect of labral tear size on retear rates.

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Therefore, the aim of this study was to assess whether there is an association between the size of anatomical defects, namely glenoid bone loss, Hill-Sach lesion and labral tears, and post-arthroscopic Bankart failure. Our hypothesis is that more extensive glenoid bone loss, Hill-Sach lesion and labral tears are risk factors for Bankart failure or re-dislocation.

2. Materials and methods

A total of 169 patients who underwent primary arthroscopic Bankart repair between May 2010 to May 2015 were reviewed. This study was approved by the Institutional Review Board. This study's inclusion criteria were: (1) primary arthroscopic Bankart repair using suture anchors, (2) presence of post-arthroscopic Bankart repair shoulder re-dislocations; and (3) non-engaging or on-track primary Bankart lesions.

Patients with the following were excluded: (1) glenoid defect above the critical value of 20%; (2) additional rotator cuff tear; (3) multidirectional or posterior instability; (4) engaging or off-track primary Bankart lesions; and (5) use of Remplissage procedure in primary Bankart repair. We excluded cases with glenoid loss of more than 20% in our study since previous studies have already established this to be a critical value where further bone grafting is required.[14–16,23,24] 14 of these 169 patients had post-repair recurrent dislocations with a mean age at time of injury of 21.01 ± 4.97 years. As the patient list was relatively small, a case control approach was adopted such that 14 other patients younger than the upper limit of the standard deviation (SD) of the recurrence patients (<25 years), without post-repair dislocations, were selected to compare with the 14 post-repair recurrent dislocations patients.

2.1. Pre-operative evaluation

Preoperatively, range-of-motion and shoulder stability, via anterior apprehension and load shift tests, were assessed. Demographic data including age, gender, shoulder dominancy, type and level of sports and duration to surgery were also recorded. Functional outcome scores such as the University of California Los Angeles (UCLA) shoulder score, Constant Shoulder Score (CSS) and Oxford Shoulder Instability score (OSIS) were evaluated pre-operatively. All patients underwent preoperative X-ray radiographs as well as magnetic resonance imaging of the injured shoulder.

2.2. Evaluation of bony defects

Pre-operative bony defects evaluated in this study consisted of 2 components: the glenoid aspect and the humeral aspect. All measurements were performed by 2 independent observers in a blinded manner. MRI images were retrieved and annotated via our picture archiving and communication system (PACS).

Glenoid bone loss was evaluated via the method reported by Huijsmans et al.[25,26] A best-fit circle was marked at the inferior-third of the glenoid. The diameter of the circle represented the expected glenoid width while the missing aspect of the circle represented the glenoid bone loss (Fig. 1a). This was conducted on the most lateral sagittal slice of the glenoid, with reference to the corresponding axial image (Fig. 1b).

Hill-Sachs defect size was evaluated using the method reported by Saito et al.[27] Similar to the evaluation of glenoid defect, sagittal and axial views were viewed concurrently. The sagittal and coronal views were used to measure the superior-inferior distance of the Hill-Sachs lesion, between the medial aspects of the rotator cuff footprint and Hill-Sachs lesion (Fig. 2a). The axial view was used to measure the depth, medial-lateral distance, and radial arc of the Hill-Sachs lesion (Fig. 2b). The size of Hill-Sachs defect was categorized into small (<0.87 mm), medium (0.87–1.47 mm) and large (>1.47 mm) as described by Cetik et al. and Arciero et al. (Table 3).[28,29] Inter-observer reliability was then assessed using the measurement of intra-class correlation coefficient between the 2 observers.

2.3. Evaluation of labral lesions

Arthroscopic evaluation of the location and size of the labral tears were also performed and were recorded based on the clock face system of the glenoid, according to the method described by Zughaib et al.[30] A point was given for every hour that the tear involved on the clock. For instance, a patient with a right labral tear of 1–6 o'clock would have a score of 6/12 (Fig. 3).

2.4. Surgical technique

Bankart repair surgery was done by two senior sports surgeons in our institution. 2–3 bioabsorbable suture anchors were used (DePuy Mitek Inc, NJ, USA) and positioned at 5:30, 4 and 3 o'clock for the right shoulder and at 6:30, 8 and 9 o'clock for the left shoulder. After the drill holes were made along the detached labrum, the first anchor was secured via horizontal mattress suturing while the second and third anchors were secured via simple vertical sutures, according to the hybrid suture technique described by Lai et al.[31,32]

2.5. Post-operative care

All patients wore a sling, with arm kept in internal rotation for 4 weeks with light active range of motion movements. After the first 4 weeks, they progressed to active range of motion without exceeding abduction past 90° and external rotation past 30°. From week 7 onwards, patients started performing strengthening exercises. Restricted sport activities were added into the regiment from week 13 onwards and

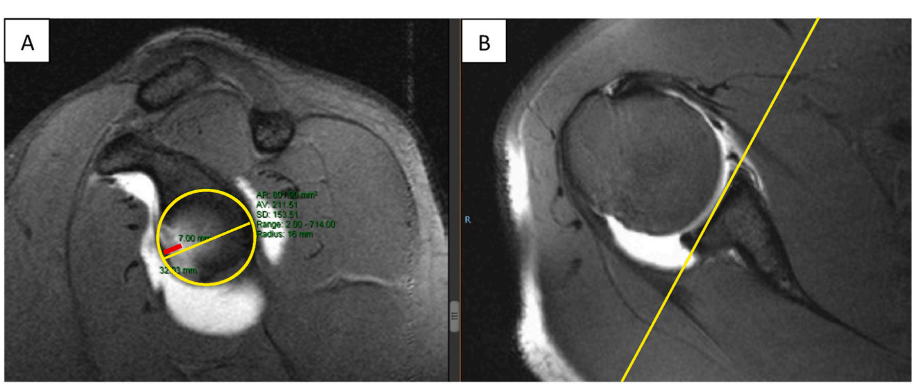

Fig. 1. Evaluation of glenoid defect: (a) Expected glenoid width was equal to the diameter of the best fit circle at the inferior third of the glenoid. The length of the missing aspect of the circle represented the glenoid bone loss (red line). (b) Corresponding axial image.

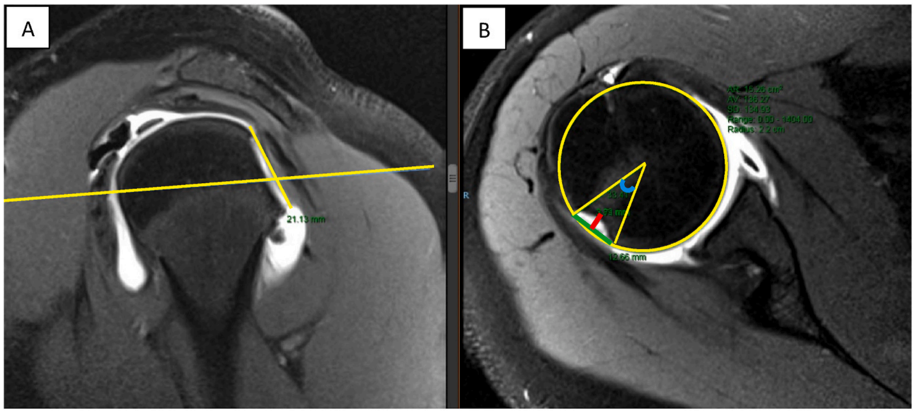

Fig. 2. Evaluation of Hill-Sachs defect: (a) Corresponding sagittal image, where the superior-inferior distance of the Hill-Sachs lesion was measured. (b) Axial image where the depth, medial-lateral distance and radial arc of the lesion was measured, using a circle of best fit. The distance between medial-lateral margins was measured as the distance (red line) between the deepest point of the lesion to the edge of the circle along a line that passes through the center of the circle.

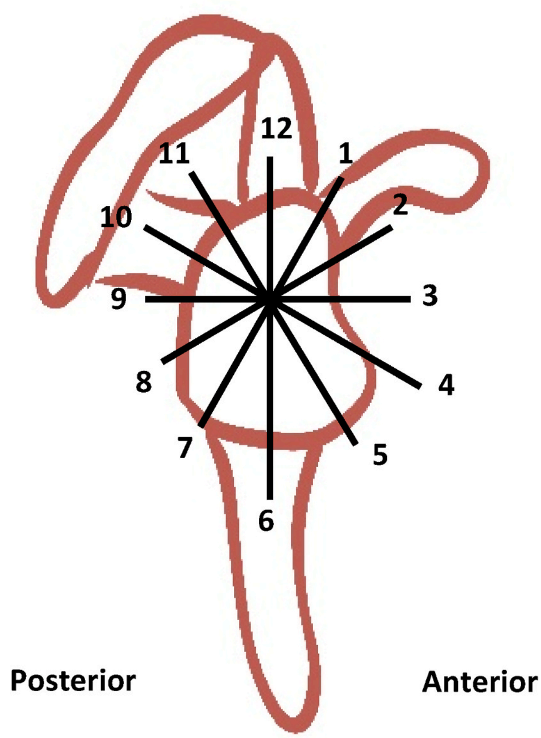

Fig. 3. Evaluation of labral lesions using the clock-face system.

unrestricted sports (contact included) were allowed after 24 weeks post-operation.

2.6. Post-operatively evaluation

Patients were evaluated via physical examination while the same clinical outcomes scores (UCLA, CSS, OSIS) were followed-up at 6 months and 24 months. Return to sports time and the level at which they could play at were also assessed. In this study, pre-injury sports level was defined as a recreational level or level at which participants are satisfied. For the 14 recurrent dislocation patients, the time to dislocation as well as the mechanism were also determined. For patients who missed follow-up, the remaining details were completed via telephone interview.

2.7. Statistical analysis

Categorical and continuous data were analysed using chi-square test, Student *t*-test, and Fisher variance analysis, with $p < 0.05$ representing statistical significance. All analysis was conducted using SPSS V5.0.

3. Result

3.1. Patient demographics

Our study population consisted of 28 patients after implementing inclusion and exclusion criteria as well as case control of age at time of injury. All patients were male. In both the failure and non-failure groups, 12(85%) patients in each group had surgery on the dominant side. The mean duration to primary Bankart repair in failure and non-failure groups was 15.7 ± 12.4 weeks and 18.95 ± 11.99 weeks respectively. The mean pre-operative number of dislocations in failure and non-failure groups was 3.21 ± 2.11 and 2.71 ± 2.16 respectively. The mean post-operative number of re-dislocations was 1.90 ± 1.51 in the failure group (Table 1).

Of the 169 patients who underwent arthroscopic Bankart repair, 14 experienced re-dislocation which puts the failure rate at 8.1%. For the patients in the failure group, the mean number of post-operative dislocations was 1.90 ± 1.51. The mean post-operative duration in months to recurrence was 12.77 ± 7.3. For mechanism of injury, 9 (64.28%) patients experienced recurrence while participating in sports, 4(35.71%) from trauma, and 1(7.1%) while sleeping.

3.2. Functional results

Although all post-operative mean shoulder scores demonstrated improvement as compared to pre-operative scores, the UCLA shoulder rating scale was the only scoring system that showed statistically significant improvement after surgery at 6-months' follow-up in both groups.

Post-operative sports level was determined during follow-ups in order to assess the patients' physical function. We found that in the failure group, 8 patients (52.5%) were able to return to the same level of sporting ability after operation, while 6 patients (47.5%) were unable to attain pre-operative level of sporting ability (Table 2).

3.3. Risk factors for bankart recurrence

9 failure patients (64.3%) and 4 non-failure patients (28.6%) had the presence of glenoid bone loss. The mean percentage bone loss in the failure and non-failure groups was 9.4% and 3.2% respectively, while

Table 1
Patient demographic data.

	Failure/Recurrence	Percentage	Non-failure/Non- recurrence	Percentage (%)	Remarks
Age at dislocation	21.01 ± 4.97		21.01 ± 4.97		Matched
Gender					
Male	14	100	14	100	Matched
Female	0	0	0	0	
Injury to dominant arm					
Yes	12	83.4	12	83.4	
No	2	16.6	2	16.6	
Injured side					
Right	9	64.28	10	71.42	
Left	5	35.72	4	28.58	
Type of sport					
Recreational	13	92.85	11	78.57	
Competitive	1	7.15	3	21.43	
No of dislocation before surg	3.21 ± 2.11		2.71 ± 2.16		
No of dislocation after surg	1.90 ± 1.51.				
Mean duration to 1st repair (weeks)	15.7 ± 12.4		18.95 ± 11.99		
No of suture anchor used					
2	4		6		
3	7		6		
4	2		1		
5	1		1		
SLAP lesion					
Yes	4	28.58	2	16.6	
No	10	71.42	12	83.4	
Size of Bankart tear	5.92 ± 1.14		5 ± 0.96		
Beighton score	1.35 ± 0.51		1.71 ± 1.00		

Table 2
Functional outcome in Recurrence/Failure and Non recurrence/Non failure cases at 6-months' follow-up.

	Recurrence/Failure		Non recurrence/Non failure		
	Pre op	Post op	Pre op	Post op	P-Value
Functional scores					
Oxford*	36.21 ± 5.08	33.78 ± 6.10	37.35 ± 6.48	35.78 ± 9.38	>0.05
UCLA	24.57 ± 2.95	28.57 ± 6.10	25.92 ± 1.64	30.35 ± 3.56	<0.05
Constant	72.92 ± 12.28	70.35 ± 15.02	74.57 ± 10.66	78.92 ± 9.44	>0.05
Sports level return %		52.5		76.1	n.a

*Decline in Oxford Instability Score, signifies improvement.

Table 3
Size of anatomic defects in Recurrence/Failure and Non recurrence/Non failure cases.

	Recurrence/Failure group	Non recurrence/Non failure Group	P-Value
Bone loss			
Glenoid bone loss	9	4	n.a
Volume %	9.4	3.2	0.044
Volume loss Size (mm)	2.66 ± 2.24	0.84 ± 1.39	0.024
Hill-Sachs lesion	11	10	
Volume (mm)	5.92 ± 1.14	5 ± 0.96	0.734
None/Small (<0.87)	4	5	n.a
Medium (0.87–1.47)	2	2	n.a
Large (>1.47)	8	7	n.a
Size of labral tear	5.92 ± 1.14	5 ± 0.96	0.039

the mean volume loss sizes were 2.66 ± 2.24 mm and 0.84 ± 1.39 mm respectively. Both percentage bone loss and mean volume loss size were significantly greater in the failure group (**p=0.044 and p=0.024**, respectively).

Hill-Sachs lesion was present in 11 failure patients (78.6%) and 10 non-failure patients (71.4%). The mean Hill-Sachs defect size in failure and non-failure groups was 5.92 ± 1.14 mm and 5 ± 0.96 mm respectively and this difference was not statistically significant (**p=0.734**). As established in our inclusion/exclusion criteria, none of these Hill Sachs lesions in this study were off-track or engaging.

Inter-observer measurements of the glenoid bone loss and Hill-Sachs lesions were performed to determine the validity of the values with high inter-observer correlation demonstrated (89%) (Table 3).

Labral tear size in the failure and non-failure group was 5.92 ± 1.14 mm and 5 ± 0.96 mm, respectively. The difference in labral tear size was statistically significant (**p=0.039**) (Table 3).

Risk factors such as number of pre-operative dislocation, laxity and presence of superior labrum anteroposterior lesion (SLAP) were not found to be associated with post-Bankart failure in this study, despite being reported in previous evidence.[9–13] Age and gender were not compared between the failure and non-failure groups since we matched them based on these factors.

4. Discussion

The literature on Hill-Sachs lesion as a risk factor for post-arthroscopic Bankart recurrence has largely focused on the effect of on-track versus off-track lesions, rather than size. Evidence has recommended the additional use of bone grafting and even humeral-sided procedures including Remplissage procedure in cases of off-track lesion to avoid the risk of post-Bankart failure.[14,18,33] However, there is currently no study evaluating the association between Hill-Sachs lesion size and post-Bankart failure, in a specific population of on-track, non-engaging lesions. Our study has demonstrated that the size of Hill-Sachs lesion does not affect the risk of post-arthroscopic Bankart failure in this population, which does not support our initial hypothesis. Nonetheless, other anatomic risk factors such as glenoid bone loss and labral tear respectively were found to be risk factors for Bankart failure, which supports our initial hypothesis.

The existing literature has widely established that the presence of Hill-Sachs lesions is associated with post-Bankart failure.[14,33–35] Moreover, biomechanical studies such as that by Kaar et al. and Sekiya et al.

have suggested that greater humeral head defect size is associated with increased glenohumeral instability, especially in the abducted and externally rotated position.[19,20] However, in contrast, our study did not find an association between the volume of Hill-Sachs lesion and occurrence of re-dislocation/failure. We hypothesize that this could be due to a few reasons. Firstly, our study attempted to measure the defect size of a Hill-Sach lesion within a specific population of on-track Hill-Sach lesions. However, several studies have described the importance of considering the engagement of Hill-Sachs lesions as well as the glenoid track in bipolar bone defects, especially as off-track lesions are a risk factor for post-Bankart failure.[13,14,17,18,29,36] Arciero at el found that concomitant glenoid and humeral head defects affects glenohumeral stability in a dynamic fashion, as their effects are augmented together.[29] Secondly, Schneider et al. found that variability for quantifying Hill-Sachs lesion via published methods was high,[37] highlighting the lack of a universally accepted and robust method for measuring humeral head defect sizes which may have hindered the accuracy of our findings. Nonetheless, this study found that the size of Hill-Sachs lesion was not associated with increased risk of post-Bankart failure and should not affect management in primary lesions that are on-track. In contrast, primary Bankart lesions that are off-track should be considered for further management such as Remplissage,[36] although this was excluded from our study.

Larger glenoid bone loss as a risk factor for post-arthroscopic Bankart failure rates has been widely studied in the literature. Several studies have established the critical value of bone loss to be around 20% of the glenoid width, above which bone grafting is required.[14–16,38] However, recent evidence has found that even with subcritical bone loss (<20–25%), a greater extent of bone loss is associated with poorer functional outcomes and higher failure rates.[39,40] Biomechanically, this can be explained by Burkhart et al.'s hypothesis that significant antero-inferior glenoid deficiency results in a glenoid 'dish' with reduced depth as well as a reduced arc length for the glenoid to withstand humeral forces.[14]

This study also found that the size of the labral tear is a risk factor for failure after arthroscopic Bankart repair. While the association between the size of pre-operative labral tear and failure rates have not been previously reported in the literature, we postulate a few reasons to our findings. Firstly, there could be an association between labral tear and glenoid bone loss, indirectly leading to greater instability. This is concordant with a recent study by Dekker et al. which found more extensive labral tears in a group with glenoid bone loss >5%.[41] Secondly, a larger labral tear heals poorly and requires a greater number of suture anchors to adequately repair it. Inadequate suture anchors increase the risk of post-repair failure, and we propose that a greater labral tear size is more susceptible to this.[33,34]

In terms of functional outcomes, UCLA score demonstrated significant pre-operative to post-operative improvement for both groups at short-term follow-up. For both OSIS and CSS, no significant improvement was demonstrated. However, this should be interpreted with caution for a few reasons. Firstly, we hypothesize that this was likely due to the small sample size in this study. Moreover, in the recurrence group, a significant improvement in functional outcome was not expected, especially in patients with Bankart failure and revision surgery prior to the follow-up. Nonetheless, this study found that majority of patients (52.5% in the failure group and 76.1% in the non-failure group) were able to return to pre-injury sports level, which in this study's case, is established at a recreational level or level that participants are satisfied. This aligns with a previous study from the same tertiary institution which reported that a large proportion of patients, from a similar cohort, experienced improvement in post-operative pain, expectation fulfilment and satisfaction.[42] Moreover, majority of this study's functional outcomes exceeded the 6-month threshold score for treatment success.[42] Lastly, the recurrence rate from the initial cohort of 169 cases was considerably low (8%). Together with the findings above, this highlights the success of primary arthroscopic Bankart repair.

A significant strength of our study is that anatomical risk factors were evaluated and measured on MRI by two independent observers using reliable, validated methods and displaying high inter-observer correlation (89%). However, our study is limited is not without its limitations. Firstly, the sample size is small, which lowers the power of our findings. This is likely due to a low rate of recurrence in our cohort, where only 14 out of 169 cases (8%) were found to have recurrence after a Bankart repair, compared to a range of 7–18% in the literature.[1–4] Lastly, this study is retrospective in nature with level of evidence inferior to other prospective ones.

Conclusion

In conclusion, this study found that greater volume and size of glenoid bone loss and labral tear were associated with post-arthroscopic Bankart failure. Pre- and intra-operative quantification of glenoid bone loss volume and labral tear size respectively are crucial in guiding management to reduce the risk of post-operative failure. However, in the context of on-track, non-engaging Bankart lesions, the size of Hill-Sachs lesion does not change the risk of post-Bankart failure and thus, in these lesions, primary arthroscopic Bankart repair should remain the method of choice.

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Informed consent

N/A.

Institutional ethical committee approval

Singhealth Institutional Review Board (IRB number 2017/2443).

Authors contribution

Conceptualization: M.Y., D.L., M.W.K.
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Formal analysis: T.C., E.W., M.W.K.
Funding acquisition: T.C., E.W., M.W.K.
Investigation: M.Y., T.C., E.W., M.W.K.
Methodology: M.Y., T.C., E.W., M.W.K.
Project administration: M.Y., T.C., E.W., M.W.K.
Resources: M.Y., T.C., E.W., M.W.K.
Software: M.Y., T.C., E.W., M.W.K.
Supervision: D.L.
Validation: D.L.
Writing – original draft: M.Y., D.L., T.C., E.W., M.W.K.
Writing – review and editing: M.Y., D.L., T.C.

Declaration of competing interest

None.

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