SUPPLEMENTARY FILES

Diagnostic accuracy of ultrasound in assessing medial collateral ligament and medial meniscus injuries? A systematic review and meta-analysis

Supplementary File 1 - Databases' search strategies

PubMed search

Title

"Diagnostic accuracy of ultrasound in assessing medial collateral ligament and medial meniscus injuries? A systematic review and meta-analysis."

PIRD framework

- **Population** – Adults who have suffered medial meniscus or medial collateral ligament injuries.
- **Index test** – ultrasound.
- **Reference test** – MRI and arthroscopy.
- **Diagnosis of Interest** – medial collateral ligament and medial meniscus injuries.

Search strategy pubmed

A) **Me-SH Terms**

#1 medial collateral ligament	"Medial Collateral Ligament, Knee"[MeSH]
#2 medial meniscus	"Menisci, Tibial"[MeSH]
#3 knee injuries	"Knee Injuries"[MeSH]
#4 ultrasound	"Ultrasonography"[Mesh] OR "Diagnostic Imaging"[MeSH]

B) **Tiab-terms [ti = title, ab = abstract]**

#1 medial collateral ligament	"medial collateral ligament*" [tiab]
#2 medial meniscus	"medial menisc*" [tiab]
#3 injuries	injur* or tear* or sprain* or strain* [tiab]
#4 ultrasound	ultrasound or sonograph* or sonogram or ultrasonography* or pocus or point-of-care ultrasound or point of care ultrasound or bedside ultrasound [tiab]

C) **Truncation**
- Use of " "
- Use of *

D) **Combing MeSH and tiab into search blocks**

#1 medial collateral ligament

"Medial Collateral Ligament, Knee"[MeSH] OR "medial collateral ligament*" [tiab]

#2 medial meniscus

"Menisci, Tibial"[MeSH] OR "medial menisc*" [tiab]

#3 injury

"Knee Injuries"[MeSH] OR injur* or tear* or sprain* or strain* [tiab]

#4 ultrasound

"Ultrasonography"[MeSH] OR "Diagnostic Imaging"[MeSH] OR ultrasound or

sonograph* or sonogram or ultrasonography* or pocus or point-of-care ultrasound or point of care ultrasound or bedside ultrasound [tiab]

#5 #1 OR #2 AND #3 AND #4

E) **Filters/limits applied**
- Adults
- Humans
- 10 years (1st October 2014 – 31st October 2024)
- English Language
- Full text

Embase search

Title

"Diagnostic accuracy of ultrasound in assessing medial collateral ligament and medial meniscus injuries? A systematic review and meta-analysis."

PIRD framework

- **Population** – Adults who have suffered medial meniscus or medial collateral ligament injuries.
- **Index test** – ultrasound.
- **Reference test** – MRI and arthroscopy.
- **Diagnosis of Interest** – medial collateral ligament and medial meniscus injuries.

Search strategy embase

F) **Me-SH Terms**

#1 medial collateral ligament	"Medial Collateral Ligament"[MeSH]
#2 medial meniscus	"Medial Meniscus"[MeSH]
#3 knee injuries	"Knee Injury"[MeSH]
#4 ultrasound	"Ultrasound/dia" [MeSH]

G) **Tiab-terms**

#1 medial collateral ligament	"medial collateral ligament*" [tiab]
#2 medial meniscus	"medial menisc*" [tiab]
#3 injuries	injur* or tear* or sprain* or strain* [tiab]
#4 ultrasound	ultrasound or sonograph* or sonogram or ultrasonography* or pocus or point-of-care ultrasound or point of care ultrasound or bedside ultrasound [tiab]

H) **Truncation**
- Use of " "
- Use of *

I) **Combing MeSH and tiab into search blocks**

#1 medial collateral ligament

"Medial Collateral Ligament, Knee" [MeSH] OR "medial collateral ligament*" [tiab]

#2 medial meniscus

"Medial Meniscus"[MeSH] OR "medial menisc*" [tiab]

#3 injury

"Knee Injuries"[MeSH] OR injur* or tear* or sprain* or strain* [tiab]

#4 ultrasound

"Ultrasound/dia"[MeSH] OR ultrasound or sonograph* or sonogram or ultrasonography* or pocus or point-of-care ultrasound or point of care ultrasound or bedside ultrasound [tiab]

#5 #1 OR #2 AND #3 AND #4

J) **Filters/limits applied**
- Adults
- Humans
- 10 years (1st October 2014 – 31st October 2024)
- English Language
- Full text

Cinahl ultimate search

Title

"Diagnostic accuracy of ultrasound in assessing medial collateral ligament and medial meniscus injuries? A systematic review and meta-analysis."

PIRD framework

- **Population** – Adults who have suffered medial meniscus or medial collateral ligament injuries.
- **Index test** – ultrasound.
- **Reference test** – MRI and arthroscopy.
- **Diagnosis of Interest** – medial collateral ligament and medial meniscus injuries.

Search strategy cinahl ultimate

K) **Cinahl ultimate MeSH terms**

#1 medial collateral ligament	"Medial Collateral Ligament, Knee" [MeSH]
#2 medial meniscus	"Menisci, Tibial" [MeSH]
#3 knee injuries	"Knee Injuries" [MeSH]
#4 ultrasound	"Ultrasonography" [MeSH]

L) **Tiab-terms (ti = title, ab = abstract)**

#1 medial collateral ligament	"medial collateral ligament*" [tiab]
#2 medial meniscus	"medial menisc*" [tiab]
#3 injuries	injur* or tear* or sprain* or strain* [tiab]
#4 ultrasound	ultrasound or sonograph* or sonogram or ultrasonography* or pocus or point-of-care ultrasound or point of care ultrasound or bedside ultrasound [tiab]

M) **Truncation**
- Use of " "
- Use of *

N) **Combing MeSH and tiab into search blocks**
#1 medial collateral ligament
"Medial Collateral Ligament, Knee" [MeSH] OR "medial collateral ligament*" [tiab]
#2 medial meniscus
"Menisci, Tibial"[MeSH] OR "medial menisc*" [tiab]
#3 injury
"Knee Injuries"[MeSH] OR injur* or tear* or sprain* or strain* [tiab]
#4 ultrasound
"Ultrasonography"[MeSH] OR ultrasound or sonograph* or sonogram or ultrasonography* or pocus or point-of-care ultrasound or point of care ultrasound or bedside ultrasound [tiab]
#5 #1 OR #2 AND #3 AND #4

O) **Filters/limits applied**
- Adults
- Humans
- 10 years (1st October 2014 – 31st October 2024)
- English Language
- Full text

Cochrane search

Title

"Diagnostic accuracy of ultrasound in assessing medial collateral ligament and medial meniscus injuries? A systematic review and meta-analysis."

PIRD framework

- **Population** – Adults who have suffered medial meniscus or medial collateral ligament injuries.
- **Index test** – ultrasound.
- **Reference test** – MRI and arthroscopy.
- **Diagnosis of Interest** – medial collateral ligament and medial meniscus injuries.

Search strategy pubMed

P) **Me-SH Terms**

#1 medial collateral ligament	"Medial Collateral Ligament, Knee"[MeSH]
#2 medial meniscus	"Menisci, Tibial"[MeSH]
#3 knee injuries	"Knee Injuries"[MeSH]
#4 ultrasound	"Ultrasonography"[MeSH]"

Q) **Tiab-terms (ti = title, ab = abstract)**

#1 medial collateral ligament	"medial ligament* collateral" [tiab]
#2 medial meniscus	"medial menisc*" [tiab]
#3 injuries	"injur* or tear* or sprain* or strain*" [tiab]
#4 ultrasound	"ultrasound or sonograph* or sonogram or ultrasonography* or pocus or point-of-care ultrasound or point of care ultrasound or bedside ultrasound" [tiab]

R) **Truncation**
- Use of " "
- Use of *

S) **Combing MeSH and tiab into search blocks**

#1 medial collateral ligament

"Medial Collateral Ligament, Knee"[MeSH] OR "medial collateral ligament*" [tiab]

#2 medial meniscus

"Menisci, Tibial"[MeSH] OR "medial menisc*" [tiab]

#3 injury

"Knee Injuries"[MeSH] OR "injur* or tear* or sprain* or strain*" [tiab]

#4 ultrasound

"Ultrasonography"[MeSH] OR "ultrasound or sonograph* or sonogram or ultrasonography* or pocus or point-of-care ultrasound or point of care ultrasound or bedside ultrasound" [tiab]

#5 #1 OR #2 AND #3 AND #4

T) **Filters/limits applied**
- Adults
- Humans
- 10 years (1st October 2014 – 31st October 2024)
- English Language
- Full text

Supplementary File 2 – Inclusion and exclusion criteria

Inclusion	Exclusion
• Empirical and grey literature research relating to diagnostic ultrasound of symptomatic medial meniscus and MCL injuries.	• Empirical and grey literature research relating to diagnostic ultrasound of ACL, PCL, LCL or lateral meniscus injuries only.
• Published between 1st October 2014 – 31st October 2024.	• Published pre-1st October 2014.
• Cross-sectional (cohort) studies, diagnostic accuracy comparative studies.	• Case control studies.
• Humans.	• Animal/Cadaver studies.
• Adults.	• Study Population of less than 20.
• English Language.	• Review Studies.
• Full text.	• Duplicate Studies.
• Must include TP, FP, TN, FN information.	• Missing TP, FP, TN, FN information.
• Reference standard of arthroscopy and/or MRI.	• No reference standard included or different from arthroscopy and/or MRI.

Supplementary File 3 - Excluded articles from final search process/review

Inclusion & Exclusion Numbers from Final Process for Inclusion within Review

SOURCE	INCLUDED	EXCLUDED	TOTAL
Embase	4	6	**10**
Pubmed	1	9	**10**
Google Scholar	5	4	**9**
Other	4	7	**11**
Total	**14**	**26**	**40**

Excluded Articles' Details & Reasons for Exclusion

No.	Authors	Title	Year	Journal	Reason for Exclusion
1.	Artul S, Khazin F, Hakim J, Habib G.	Ultrasonographic findings in a large series of patients with knee pain.	2014	Journal of Clinical Imaging Science	Non-DTA study/no reference standard included, such as MRI or arthroscopy.
2.	Kijowski R, Roemer F, Englund M, Tiderius CJ, Swärd P, Frobell RB.	Imaging following acute knee trauma	2014	Osteoarthritis and Cartilage	Review study.
3.	Nogueira-Barbosa MH, Gregio-Junior E, Lorenzato MM, Guermazi A, Roemer FW, Chagas-Neto FA, Crema MD.	Ultrasound assessment of medial meniscal extrusion: a validation study using MRI as reference standard.	2015	American Journal of Roentgenology	Only measuring meniscal extrusion, no evidence of injury or tear.
4.	Artul S, Jabaly-Habib H, Artoul F, Habib G	The association between Baker's cyst and medial meniscal tear in patients with symptomatic knee using ultrasonography.	2015	Clinical Imaging	Non-DTA study/no reference standard included, such as MRI or arthroscopy.
5.	Akatsu Y, Yamaguchi S, Mukoyama S, Morikawa T, Yamaguchi T, Tsuchiya K, Iwasaki J, Akagi R, Muramatsu Y, Katsuragi J, Fukawa T.	Accuracy of high-resolution ultrasound in the detection of meniscal tears and determination of the visible area of menisci.	2015	JBJS	Subjects = cadavers.
6.	Singh B, Pawar KN, Kachewar S, Ghule SS, Lakhkar DL	Evaluation of knee joint by ultrasound and MRI.	2016	Journal of Dental and Medical Sciences	Poor/limited methodology, with no inclusion or exclusion criteria included, no information on who completed or assessed the images.
7.	Ghosh N, Kruse D, Subeh M, Lahham S, Fox JC.	Comparing point-of-care-ultrasound (POCUS) to MRI for the diagnosis of medial compartment knee injuries.	2017	Journal of Medical Ultrasound	Only 9 subjects included within study, and as <20 subjects included, excluded as per inclusion/criteria.

No.	Authors	Title	Year	Journal	Reason for Exclusion
8.	Diermeier T, Achtnich A, Imhoff AB, Wörtler K, Petersen W.	Meniscal extrusion in ultrasound as a new diagnostic tool for evaluation of medial meniscus function.	2017	Orthopaedic Journal of Sports Medicine	Study based on non-symptomatic subjects.
9.	Liao CL, Yu CW, Cheng YH, Wang TG.	Is Ultrasound Reliable for the Diagnosis of Knee Medial Collateral Ligament Injury?	2017	Rehabilitation Practice and Science	Very limited statistical information provided, including no sensitivity, specificity or accuracy data.
10.	Abram SG, Beard DJ, Price AJ, BASK Meniscal Working Group.	National consensus on the definition, investigation, and classification of meniscal lesions of the knee.	2018	The Knee	Review study.
11.	Mostafa HA, Abou Elfotuh AM, Alsakka MM.	MRI versus ultrasound in diagnosis of meniscal tear in knee joint.	2019	The Egyptian Journal of Hospital Medicine.	Doesn't include any statistical information/break down on medial meniscal tears, including sensitivity, specificity, accuracy etc – puts all information together including lateral and medial meniscal tears. Authors contacted by email requesting whether information available – no response to request.
12.	Chiba D, Sasaki E, Ota S, Maeda S, Sugiyama D, Nakaji S, Ishibashi Y.	US detection of medial meniscus extrusion can predict the risk of developing radiographic knee osteoarthritis: a 5-year cohort study.	2020	European Radiology	No reference standard of MRI or arthroscopy utilised.
13.	Reisner JH, Franco JM, Hollman JH, Johnson AC, Sellon JL, Finnoff JT.	Ultrasound assessment of weight-bearing and non–weight-bearing meniscal extrusion: a reliability study.	2020	PM&R	Non-DTA study/no reference standard included, such as MRI or arthroscopy.
14.	El Sheikh H, Faheem M, Abdelmoeim A.	Role of ultrasonographic examination of the knee in evaluation of meniscal injury in correlation with magnetic resonance imaging.	2020	Benha Medical Journal	Limited methodology included – no information on who completed ultrasound or MRI, no information on order of imaging, no information on whether blinding occurred, no information on flow and timing of index or reference standard.
15.	Abuomira IE, Ahmed YA, Elshahat MT.	Comparison between ultrasonography and MRI in diagnosis of knee joint meniscal injuries.	2021	Al-Azhar Assiut Medical Journal	Extremely limited methodology+++.

No.	Authors	Title	Year	Journal	Reason for Exclusion
16.	Jokela MA, Mäkinen TJ, Koivikko MP, Lindahl JM, Halinen J, Lindahl J.	Treatment of medial-sided injuries in patients with early bicruciate ligament reconstruction for knee dislocation.	2021	Knee Surgery, Sports Traumatology, Arthroscopy	No diagnostic ultrasound included within study, was based on findings based on stress radiographs and MRI.
17.	Sundararajan SR, Ramakanth R, Sethuraman AS, Kannan M, Rajasekaran S.	Correlation of factors affecting correction of meniscal extrusion and outcome after medial meniscus root repair.	2022	Archives of Orthopaedic and Trauma Surgery	Screening of MRI used only, no diagnostic ultrasound included within study.
18.	Oo WM, Linklater JM, Bennell KL, Daniel MS, Pryke D, Wang X, Yu SP, Deveza L, Duong V, Hunter DJ.	Reliability and convergent construct validity of quantitative ultrasound for synovitis, meniscal extrusion, and osteophyte in knee osteoarthritis with MRI.	2022	Journal of Ultrasound in Medicine.	Only included information on medial extrusion and patients with knee pain, no history of injury/trauma. Study based on diagnostic accuracy of ultrasound v MRI in diagnosing osteoarthritis, such as medial extrusion.
19.	Chiba D, Sasaki T, Ishibashi Y	Greater medial meniscus extrusion seen on ultrasonography indicates the risk of MRI-detected complete medial meniscus posterior root tear in a Japanese population with knee pain.	2022	Scientific Reports	All subjects without any history of injury/trauma, study based on degenerative medial meniscal pathology/ osteoarthritis, rather than medial meniscal tears.
20.	Falkowski AL, Jacobson JA, Cresswell M, Bedi A, Kalia V, Zhang B.	Medial Meniscal Extrusion Evaluation with Weight-Bearing Ultrasound.	2022	The Journal of Ultrasound in Medicine.	No clear history of injury within inclusion, study focusing on medial extrusion including normal, degenerative meniscal and tears. No clear information included on DTA of ultrasound v MRI regarding sensitivity, specificity or accuracy data.
21.	Maheshwari M, Yadav PK, Jain S, Batham IK, Gupta A, Swaika S.	Imaging of Knee Joint Pathologies: A Comparative Study of Ultrasound and Magnetic Resonance Imaging.	2022	Journal of Medical Sciences	No methodology included within study.
22.	Gayathri Mohanan DU, Job S.	Sonological evaluation of medial knee injuries and its comparison with magnetic resonance imaging findings: A study.	2022	International Journal of Orthopaedics	Duplicate study – but published with different title and in different Journal.
23.	Wasilczyk C.	The Value of Ultrasound Diagnostic Imaging of Meniscal Knee Injuries Verified by Experimental and Arthroscopic Investigations.	2023	Diagnostics	Subjects = Cadavers.

No.	Authors	Title	Year	Journal	Reason for Exclusion
24.	VS SR, Jinu CK.	Diagnostic Accuracy of Ultrasound in the Evaluation of Collateral Ligaments and Meniscal Injuries of Knee in Comparison with Magnetic Resonance Imaging.	2023	RGUHS Journal of Medical Sciences	Limited methodology included – no information on who completed ultrasound or MRI, no information on order of imaging, no information on whether blinding occurred, no information on flow and timing of index or reference standard.
25.	Uusimaa AP, Kemppainen A, Nevalainen MT.	Medial meniscus extrusion is associated with meniscus tears in US and MRI: A case control study.	2024	Journal of Clinical Ultrasound	Case study
26.	Kanayama T, Nakase J, Ishida Y, Yanatori Y, Takemoto N, Demura S.	Identifying unstable ramp lesions using ultrasonography.	2024	Journal of Medical Ultrasonics	Non-DTA study, no clear information on including no sensitivity, specificity or accuracy data.

Supplementary File 4 – Study characteristics

Table S1. Study characteristics of studies analysing diagnostic accuracy of ultrasound for Medial Collateral Ligament (MCL) & Medial Meniscus (MM) Injury

No.	Reference (Year)	Study Design	Study Setting	Sampling	Subject No.	Mean Age (Years)	Age range (Years)	Male	Female	Acute/ Chronic?	Probe	Positioning	DTA of MCL/ MM?	Reference Test	Index Test(s)
1	Ahmadi et al. (2022)	Prospective cross-sectional	Emergency Department (ED)	Convenience	250	25	n/a	217	33	Acute (3 days from injury)	Linear Probe 5-12 MHz	Prone 20-30 degrees knee flexion & hip external rotation	MCL	MRI	USS
2	Ahmadi et al. (2022)	Prospective cross-sectional	Emergency Department (ED)	Convenience	55	35	n/a	38	17	Acute (<5/7 post injury)	Linear Probe 5-12 MHz	Supine - knee flexion 15-90 degrees	Medial Meniscus	MRI	USS
3	Ahmadi et al. (2024)	Prospective cross-sectional	Emergency Department (ED)	Convenience	157	25	15-51	94	63	Acute (<5/7 post injury)	Linear Probe 5-12 MHz	Supine - knee flexion 90 degrees	Medial Meniscus	Arthroscopy	USS MRI
4	Singh et al. (2021)	Prospective cross-sectional	Hospital - Radiology	Convenience	103	33	n/a	78	25	Unknown	Linear Probe 4-13 MHz	Supine - knee flexion & hip external rotation for AHMM Prone - knee extended for PHMM	MCL & Medial Meniscus	MRI	USS
5	Muresan et al. (2017)	Prospective longitudinal comparative study	Medical Centre (Radiology/ orthopaedics/ Rehab)	Convenience	45	29	18-36	30	15	Unknown	Linear Probe 5-13 MHz	Supine - extension & varying knee flexion	Medial Meniscus	Arthroscopy	USS MRI
6	Singh et al. (2018)	Prospective cross-sectional	Hospital - Radiology	Convenience	60	n/a	15-65	42	18	Unknown	Linear Probe 7-18 MHz	Supine - knee flexion 20-30 degrees	MCL & Medial Meniscus	MRI	USS
7	Elshimy et al. (2023)	Observational cross-sectional comparative study	Hospital - Radiology	Convenience	60	33	18-60	45	15	Unknown	Linear Probe 9-15 MHz	Supine MCL and supine/ prone for MM	MCL & Medial Meniscus	Arthroscopy	USS MRI
8	Mohanan et al. (2023)	Prospective cross-sectional	Hospital – (Radiology/ Orthopaedics)	Convenience	60	n/a	18-60	44	16	Acute & Chronic (majority 1 - 4/52 post injury)	Linear Probe 5-6Mhz	Supine - hip in external rotation	MCL & Medial Meniscus	MRI	USS

9	Khalaf et al. (2020)	Prospective cross-sectional	Hospital - Radiology	Convenience	50	35	19-56	30	20	Unknown	Linear Probe 11 MHz	Supine - knee flexion & hip external rotation for AHMM Prone - knee extended for PHMM	MCL & Medial Meniscus	Arthroscopy/ MRI	USS
10	Hussain et al. (2019)**	Prospective cross-sectional	Hospital - Radiology	Convenience	30	33	18-57	21	9	Unknown	Linear Probe 12 MHz	Supine & prone	MCL & Medial Meniscus	MRI	USS
11	Ali et al. (2021)*	Prospective cross-sectional	Hospital - Radiology	Convenience	40	43	15-69	18	22	Unknown	Linear Probe 7-11 MHZ)	Supine	MCL*	MRI	USS
12	Elkholy et al. (2022)	Prospective cross-sectional	Hospital - Radiology	Convenience	40	37	15-60	28	12	Acute & chronic (exact timescale post injury/ pain, not known)	Linear Probe 7-10 MHz	Supine - knee flexion 30-90 degrees flexion & hip external rotation for AHMM Prone - knee 20 degrees flexion for PHMM	Medial Meniscus	MRI	USS
13	Mir et al. (2021)	Prospective cross-sectional	Hospital - radiology	Convenience	60	36	21-30	48	12	Acute trauma as majority sporting or RTA but unclear of time to enrolment	Linear Probe 7-15MHz	Supine with knee in flexion	MCL & Medial Meniscus	MRI	USS
14	Awan et al. (2024)	Retrospective analysis	Community	Convenience	249	38	Unknown	136	113	Unknown	Linear Probe 12-17MHz	Unknown	Medial Meniscus	MRI	USS

* Study's data only on MCL included.
**Study's results of AHMM & PHMM combined for overall MM results.
DTA = diagnostic test accuracy, USS = ultrasound scan, MRI = Magnetic Resonance Imaging, n/a = not applicable, AHMM = anterior horn medial meniscus, PHMM = posterior horn medial meniscus.

Supplementary File 5 – Medial collateral ligament injuries – plots

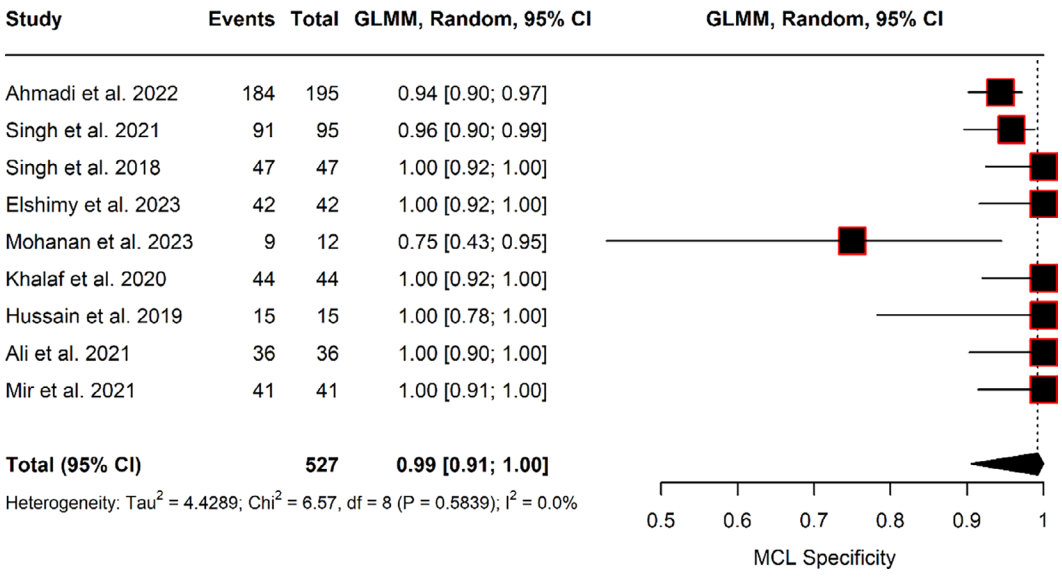

Figure S1. MCL Specificity Forest Plot

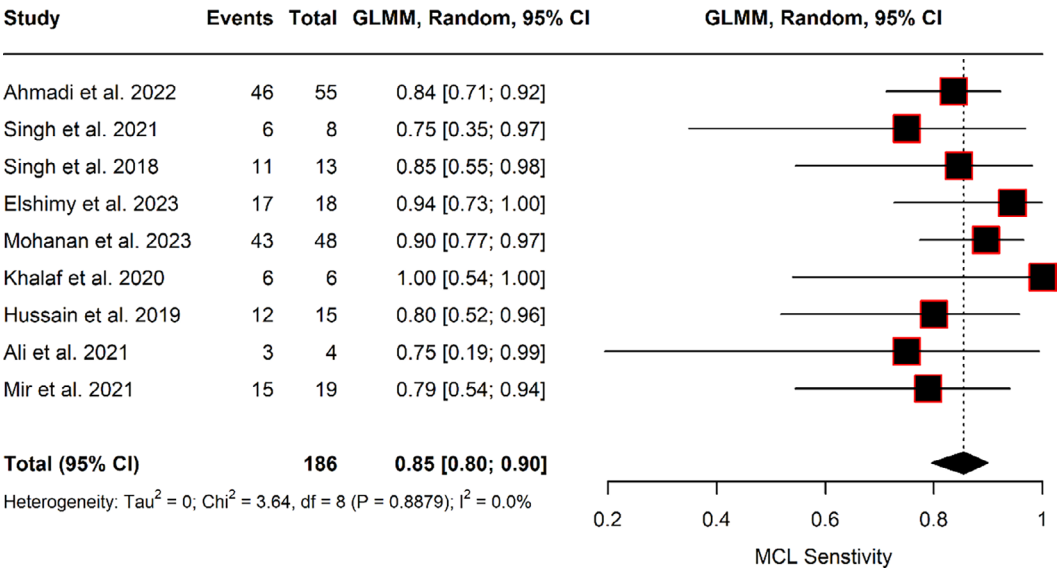

Figure S2. MCL Sensitivity Forest Plot

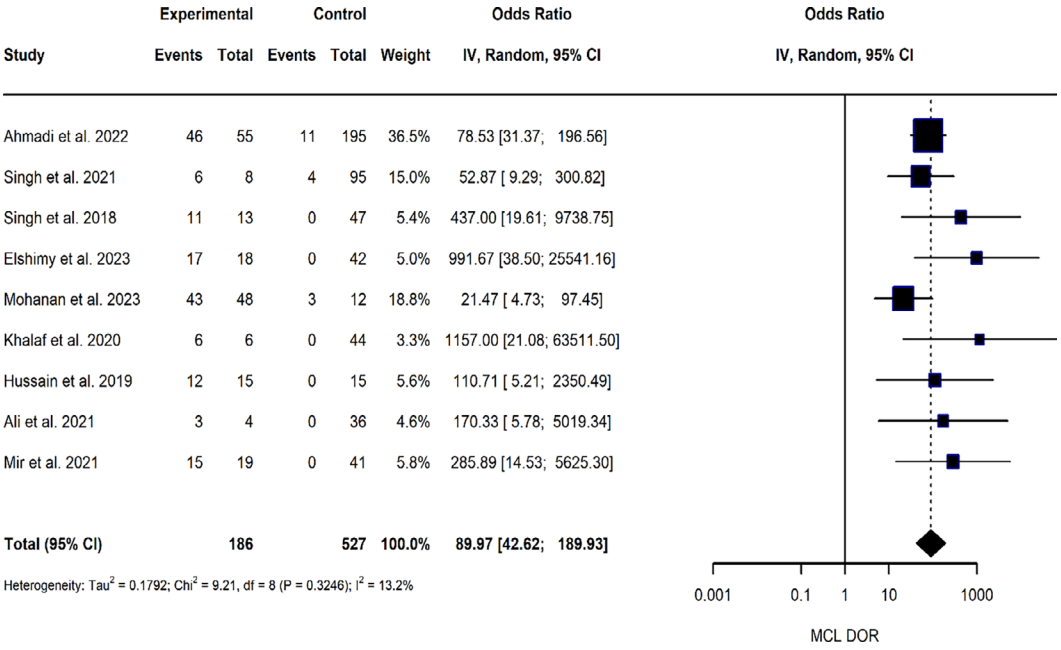

Figure S3. MCL DOR Forest Plot

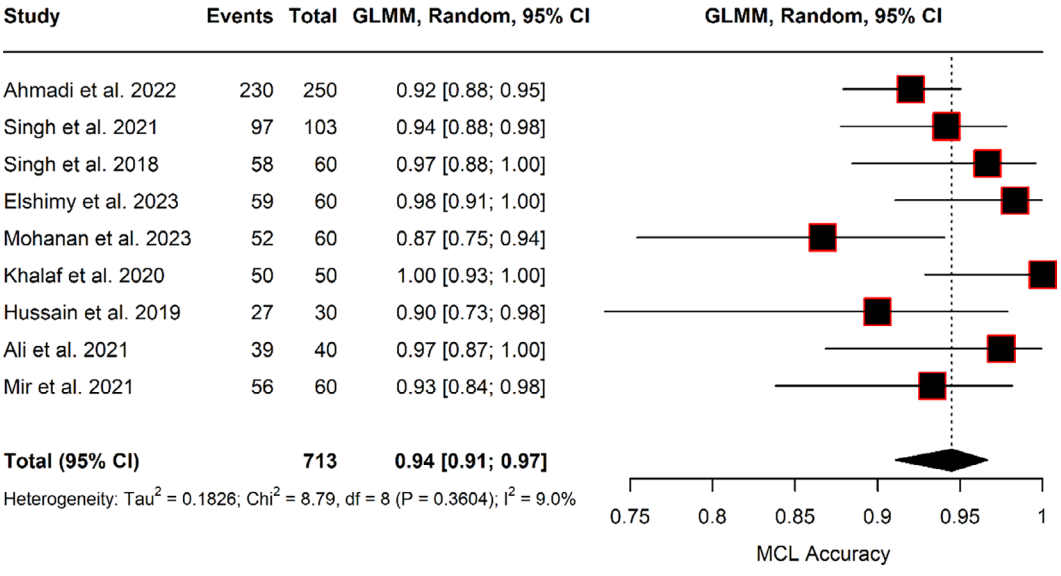

Figure S4. MCL Accuracy Forest Plot

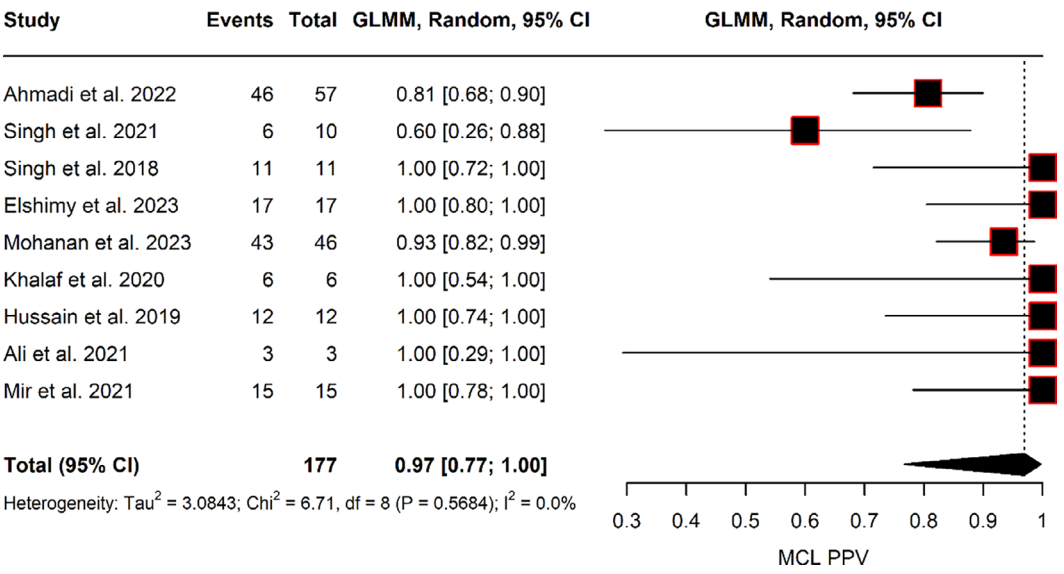

Figure S5. MCL PPV Forest Plot

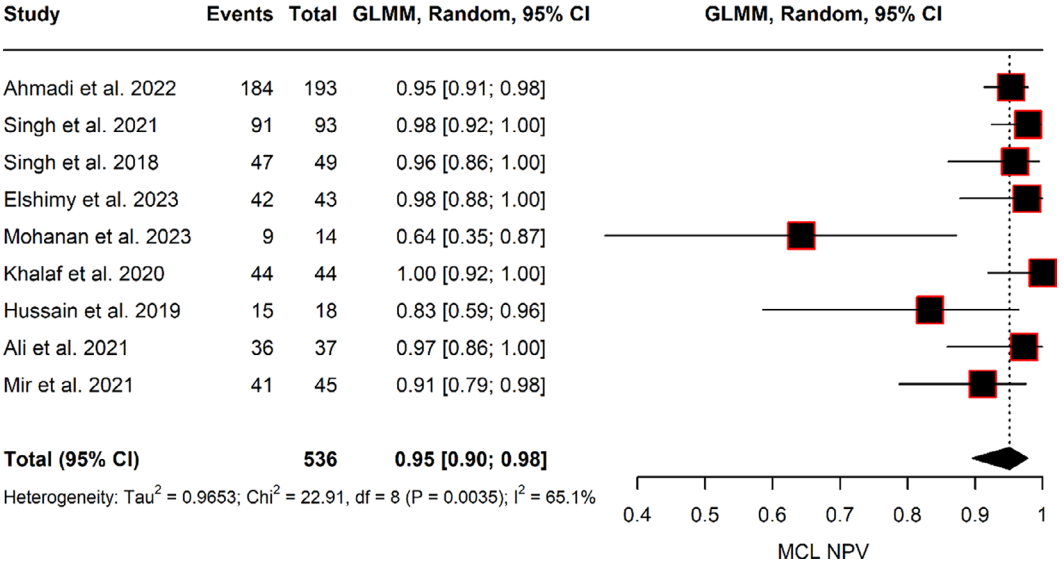

Figure S6. MCL NPV Forest Plot

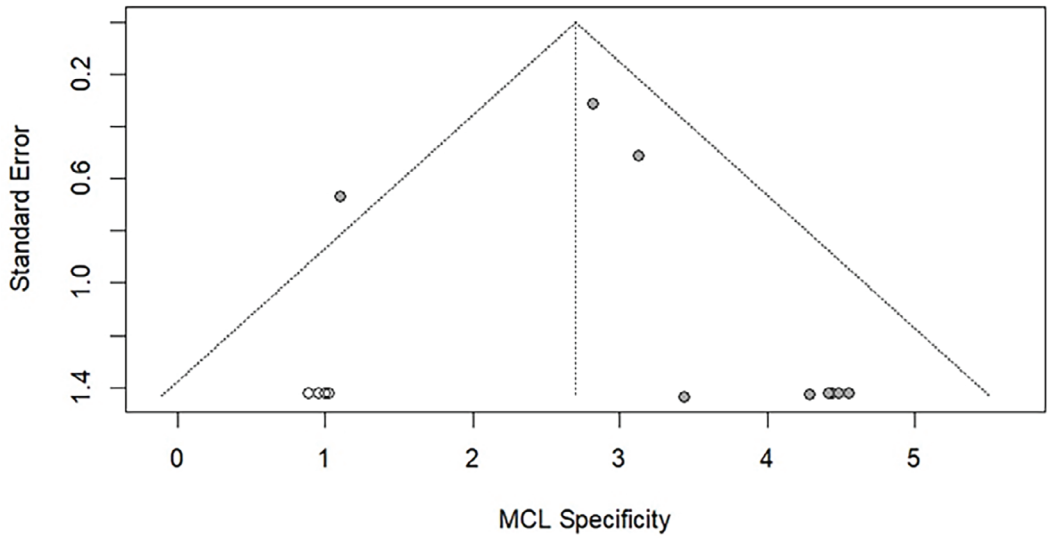

Figure S7. MCL Specificity Funnel Plot

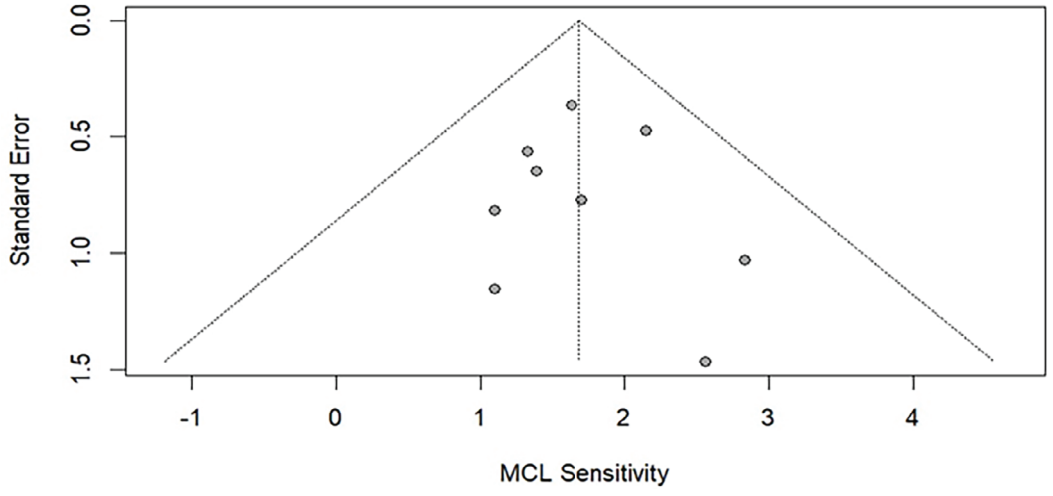

Figure S8. MCL Sensitivity Funnel Plot

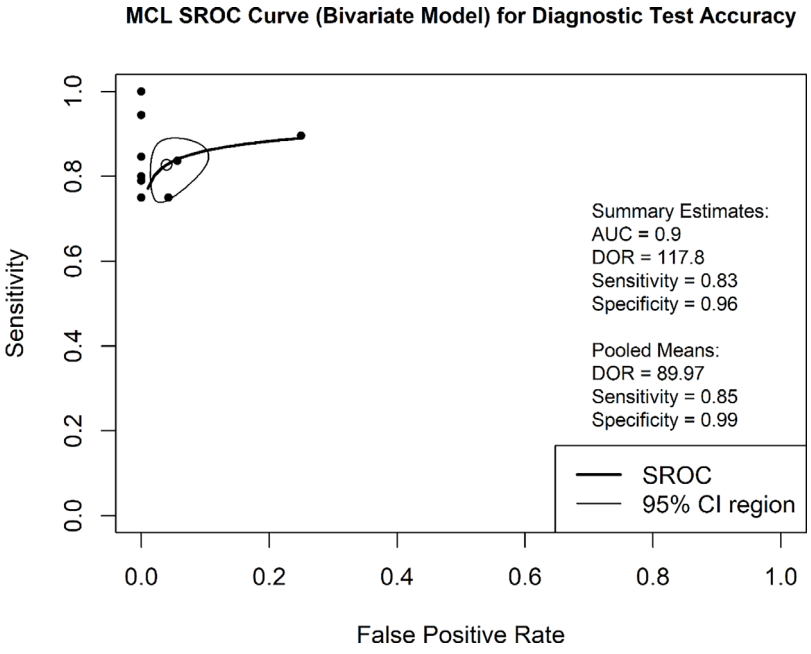

Figure S9. MCL SROC Curve Based on REML Bivariate Modelling

Supplementary File 6 – Medial meniscus injuries – plots

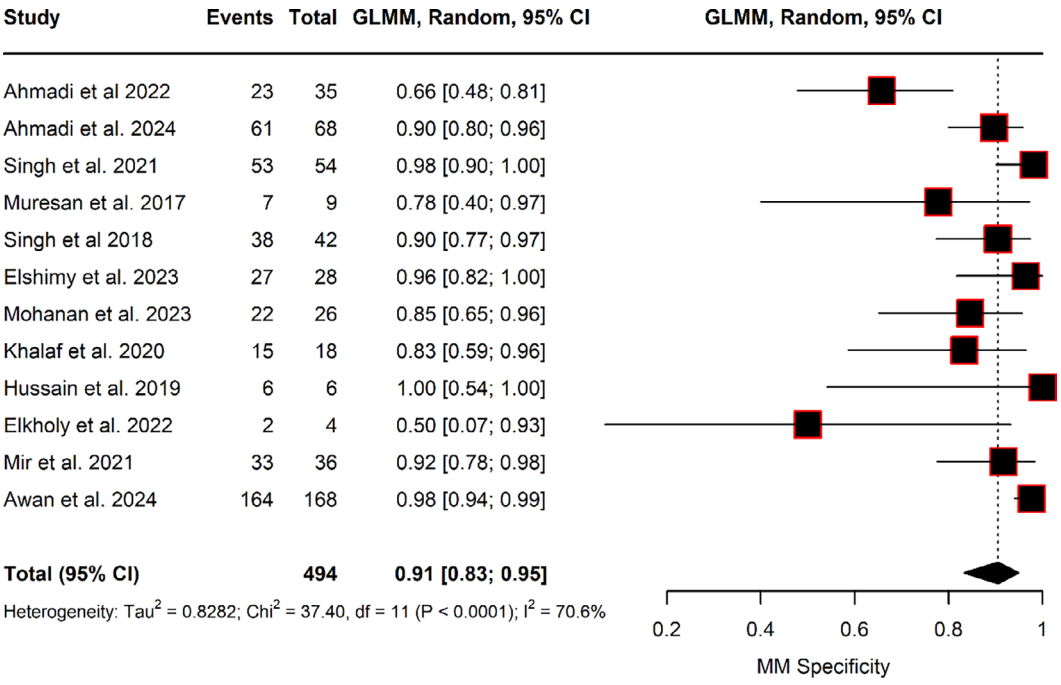

Figure S1. MM Specificity Forest Plot

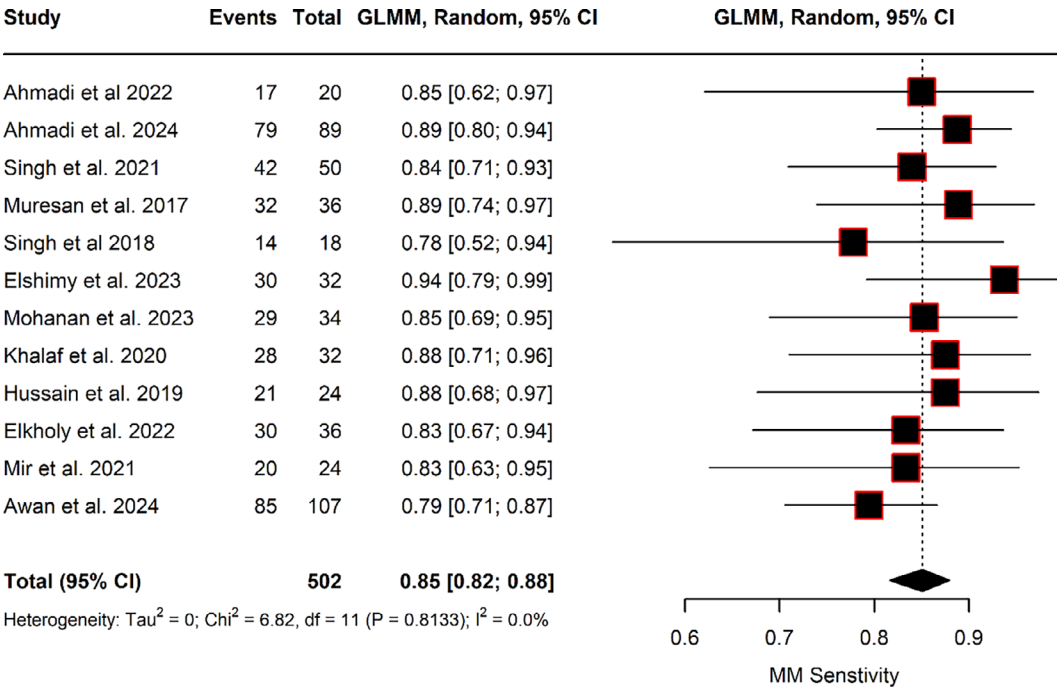

Figure S2. MM Sensitivity Forest Plot

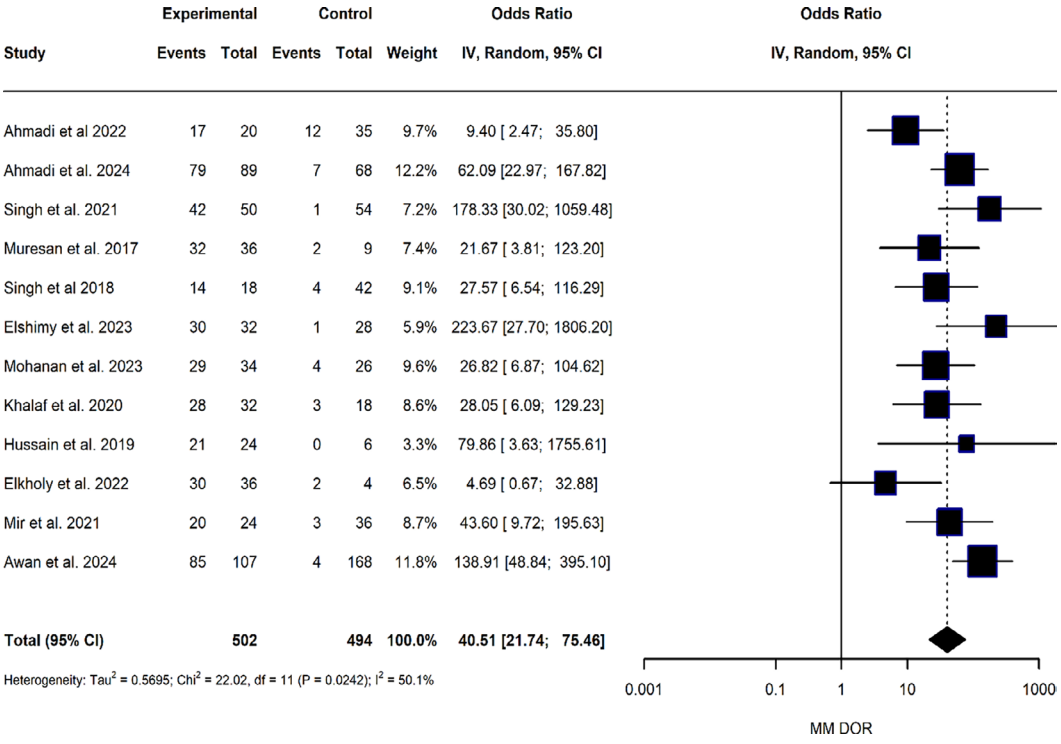

Figure S3. MM DOR Forest Plot

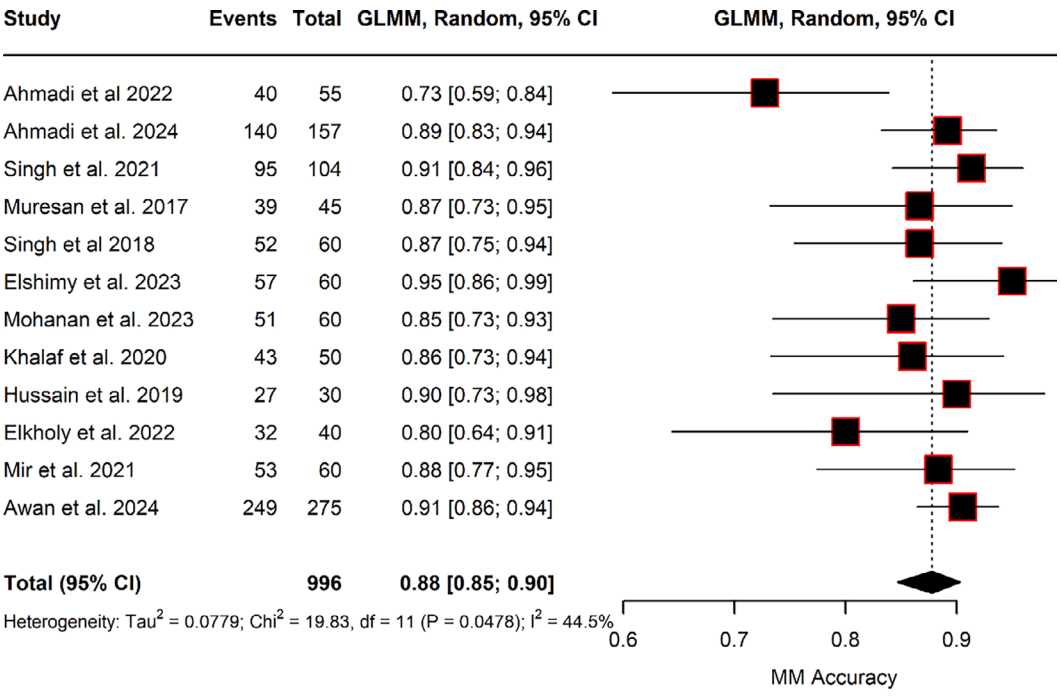

Figure S4. MM Accuracy Forest Plot

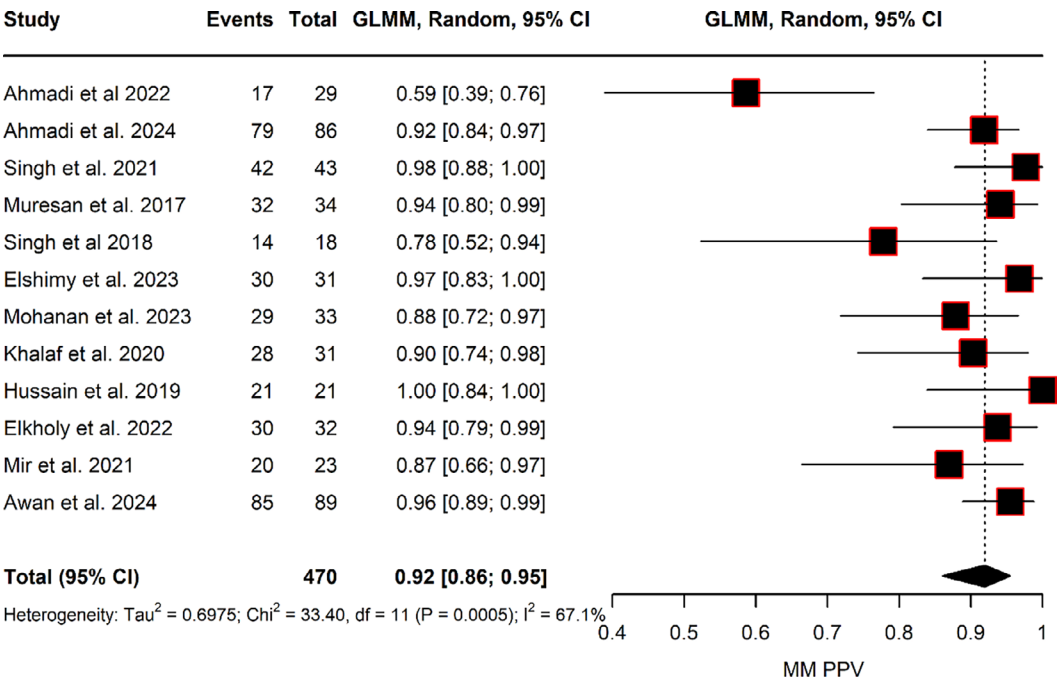

Figure S5. MM PPV Forest Plot

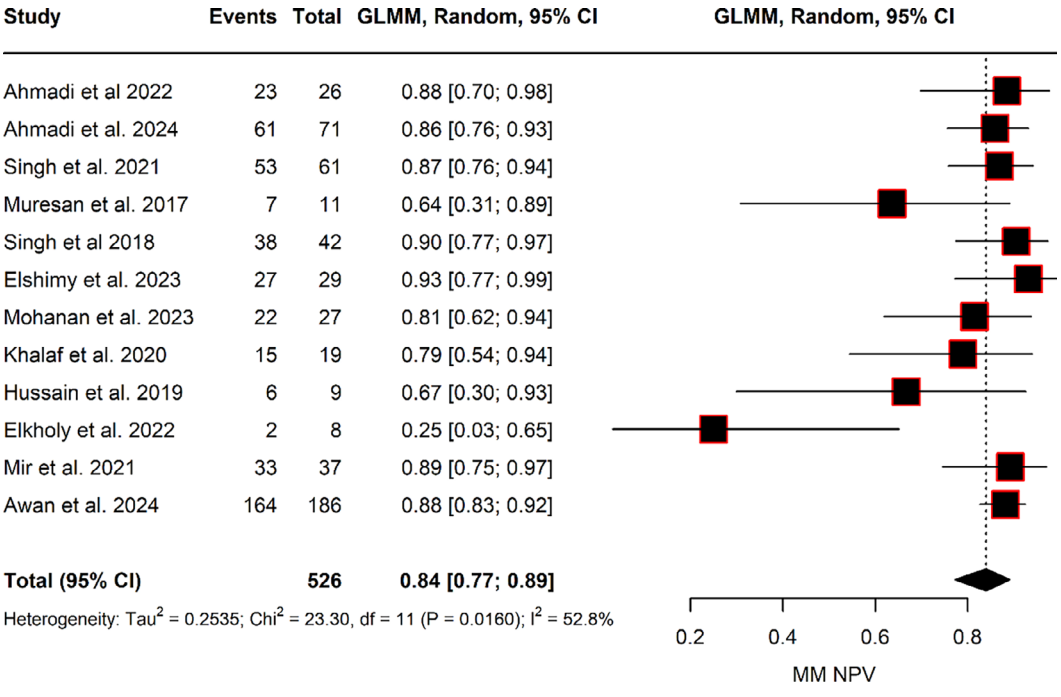

Figure S6. MM NPV Forest Plot

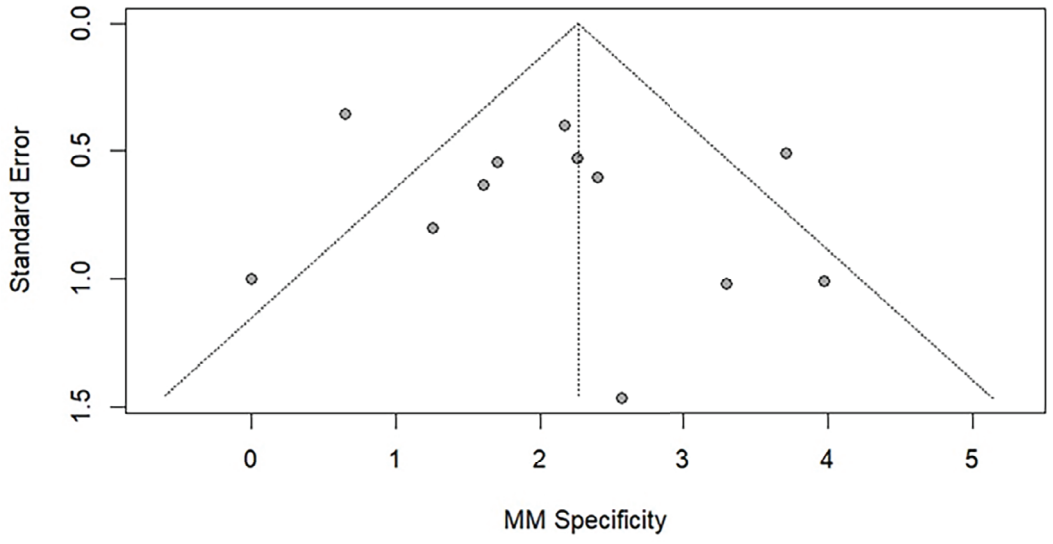

Figure S7. MM Specificity Funnel Plot

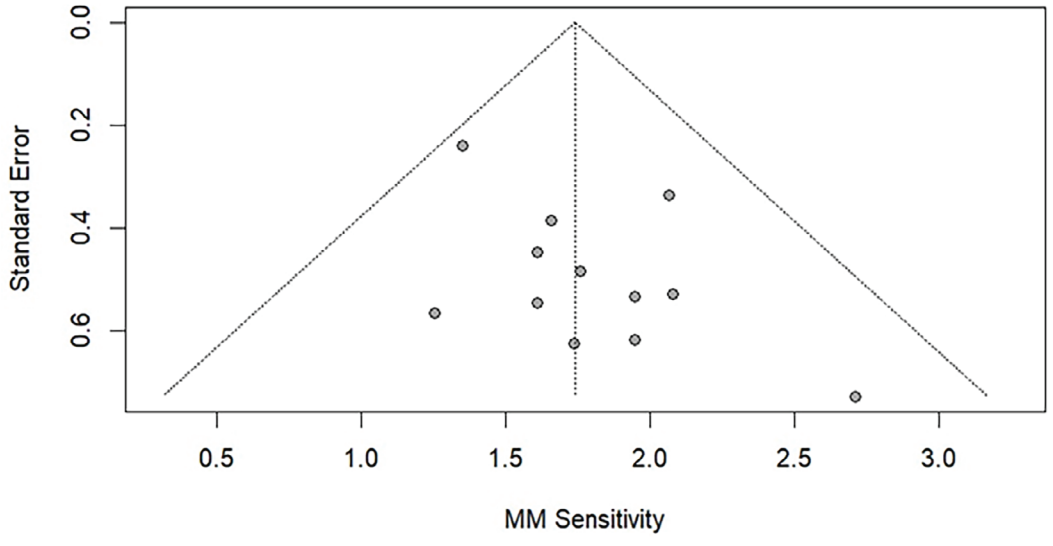

Figure S8. MM Sensitivity Funnel Plot

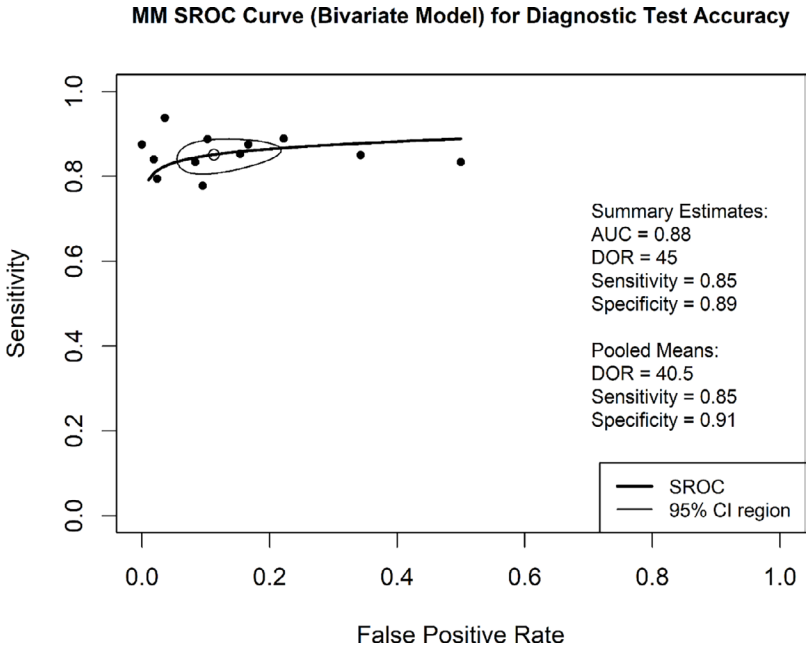

Figure S9. MM SROC Curve Based on REML Bivariate Modelling