Association Between Facet Fluid on Supine Axial T2-Weighted MRI and Sagittal Instability on Dynamic Standing Lateral Radiographs in Patients with Degenerative Lumbar Disease

Abstract:

StudyDesign:Prospectiveobservationalstudyconductedatalargetertiarycarecenterin Karachi,Pakistan.

Purpose:Toexaminetheassociationbetweenpositivefacetfluidon T2-weightedMRIoflumbosacralspineandthepresenceofinstabilityonlateralflexion/extensionradiographs,andtodeterminewhetheracorrelationexistsbetweenthequantityoffacetfluidonaxialMRIandthedegreeofspinalinstabilityonlateralstandingflexion/extensionradiographs.

Overviewofliterature:Thepresenceofincreasedfacetfluidonaxial T2-weightedmagneticresonanceimaging(MRI)hasbeenproposedasapotentialmarkerformotionsegmentinstabilityinthelumbarspine.BothfacetfluidonMRIandspinalinstabilityondynamicx-raysarecrucialindiagnosingandmanaginglowbackpain,guidingdecisionsonsurgicalinterventions.

Methods:Weanalyzedtheprospectivelycollecteddatafrompatientsmeetingtheinclusioncriteria.Facetfluidmeasurementsweremadeaccordingto Schinnerer'scriteriaonaxial T2-weightedimagesandanteriortranslationasamarkerofinstabilitywasevaluatedondynamicradiographsforalleligiblepatients.StatisticalanalysiswasperformedusingIBMSPSSversion23,employingcross-tabulations,chi-squaretests,andPearsoncorrelation.Thestudyutilizedanullhypothesistoevaluatetheassociationbetweenfacetfluidandspinalinstability.

Results:

Ourfindingsdemonstratedastatisticallysignificantassociationbetweenpositivefacetfluidon MRIandtheoccurrenceofinstabilityonlateralflexion/extensionradiographs.Moreover,wefoundastrongpositivecorrelationbetweenthevolumeoffacetfluidonaxialMRIandthelevelofspinalinstabilityonstandingflexion/extensionradiographs.

Conclusion:

Basedupontheseoutcomes,weproposethatstandinglateralflexion–extensionradiographsshouldberoutinelyadministeredtopatientsexhibitingincreasedfacet fluidsignalsonMRI,astheymayprovidevaluableinformationregardingpotentialspinalinstability.Furtherresearchwillhelp establishtheclinicalutilityofthisapproachinmanagingdegenerativelumbardiseases.

Keywords:(lumbarfacetfluid,axialT2-weightedMRI,motionsegmentinstability,degenerativelumbardisease,dynamicstandinglateralradiography)

Introduction:

Mechanicalbackpaincausedbysegmentalspinalinstabilityisacommonclinicalcondition.Spinalinstabilityreferstoabnormalmovementbetweentwoormorevertebraeinthespine,whichcanresultfromvariousconditionssuchastrauma,degenerativechanges,andafterspinalsurgery.Severalradiologicalparameters,includingstaticanddynamiclumbosacralspinex-rays,MRI,3-Dcomputedtomography,andprovocativediscography,aresuggestedfordetectingmotionsegmentinstability.[1-4]

Traditionally,instabilityofthelumbosacralspinewasdiagnosedwithflexion/extensionx-rays.However,MRIisusuallytheinitialinvestigationforpatientswithbackpain,evaluationoffacetfluidcanprovideacluetospinalinstability.Facetjoints,locatedbetweenthesuperiorandinferiorarticularfacetsofthetwovertebralbodies,helpstabilizethespineandallowformovement.SignalchangesonMRIinthefacetjointcanbeseeninaspectrumofinflammatoryordegenerativejointdiseases,includingosteoarthritis,facetjointsyndrome,andspinalstenosis.

Whenapatientwiththisconditionliessupineduringan MRIexamination,theunstablelumbarspinalsegmentisunloadedandcanreduceposteriorly,producingagapwithinthedegeneratedfacetjoint.Fluidthataccumulatesinthisgapcanbedetectedasahyperintensesignalon T2-weightedMRIsequences.[12]However,evenasymptomaticindividualsmayhavethesefindings,anditisunclearwhetherincreasedfacetfluidisareliablemarkerofmotionsegmentinstability(2, 5-8)

FacetfluidonMRIandspinalinstabilityondynamiclumbosacralx-raysaretwoimportantinterrelatedfindingsintheevaluationoflowbackpain,providingvaluableinformationforthediagnosisandmanagement,suchastheneedforsimpledecompressionversusarthrodesis.(9, 10)Therefore,weconductedthisstudytoanalyzetheassociationbetweenincreasedlumbarfacetfluiddetectedonsupineMRIandsagittalinstabilitydetectedondynamicradiographsinpatientswithdegenerativelumbardisease.

Thenullhypothesesforthisstudywerethat,thereisnoassociationbetweenincreasedfacetfluidonaxialimagesofsupineMRIandsagittalinstabilitydetectedonstandinglateralflexion/extensionradiographsinpatientswithdegenerativelumbardisease,andthatthereisnocorrelationbetweentheamountoffacetfluidonMRIandthegradeofspondylolisthesisonflexion/extensionradiographs.

Materials andMethods:

EthicsStatement:Alladultparticipantsprovidedwritteninformedconsentbeforeundergoinglumbarspine MRIanddynamicflexion/extensionradiographs.ThestudyadheredtotheDeclarationofHelsinkiprinciples,andpatientconfidentialitywasstrictlymaintained.Proper approvalwas taken from the hospital'sethicalreviewcommittee.

StudyDesign:Prospectiveobservationalstudyconducted at oneofthelargesttertiarycarecentreinKarachi,PakistanfromJanuary2020toJune2021,withprospectivedatacollection.

Thestudyincludedadultpatientswhounderwentlumbarspine MRIwithsignsandsymptomsofbackpain,withorwithoutlumbarradiculopathy,andhaddegenerativespinaldiseaseonMRIofthelumbosacralspine.Patientswithspinalfractures,spinalinfection,spinaltumor,deformity,orskeletaldysplasiaandthosewhohavepreviouslyunderwentspinalsurgerywereexcluded.Allpatientsmeetingtheinclusioncriteriaunderwentdynamicflexion/extensionradiographs.

Thefacetfluidwasmeasuredonaxial T2-weightedimagesusingSchinnerercriteria(11),withjointeffusiongreaterthan1mmconsideredasincreasedfluid.AllMRIscanswereperformedon3TToshibaAtlasExcelARTVantageMRImachine.Aqualifiedradiologistwithfellowshipdegreeandatleastfiveyearsofpost-fellowshipexperienceinneuroradiologyinterpretedtheimages.

Thepresenceorabsenceofsegmentalinstabilitywasassessedontheweight-bearing(standing)flexion/extensionviewsoflumbarradiographsofthesamepatients.Instabilitywasdefinedonweight-bearingflexion/extensionviewsasanteriortranslationofthesuperiorvertebraovertheinferior(measuredinmillimeters)onlateralflexion/extensionradiographs.

IBMSPSSversion23wasusedforstatisticalanalysis.Cross-tabulationsandchi-squaretestswereusedtoanalyzethestatisticallysignificantassociationbetweenpositiveandnegativefacetfluidonMRIandth

epresenceorabsenceofinstabilityonradiographs,withp-valueof<0.05consideredsignificant.PearsoncorrelationwasusedtoanalyzethecorrelationbetweentheamountoffacetfluidonMRIandthegradeofspinalinstabilityonradiographs.Agewaspresentedasmean±S.D,andfrequencieswereshownonhistogram.

WeusedthenullhypothesistoacceptorrejectourhypothesisthatthereexistsanassociationbetweenincreasedfacetfluiddetectedonaxialT2-weightedimagesanddynamicweight-bearingflexion/extensionviewsandthereiscorrelationbetweentheamountoffacetfluidonMRIandthegradeofspondylolisthesisonflexion/extensionradiographs.

Results:

Inourstudy,totalof216patientsparticipated,comprising91malesand125females.Themeanagewas58.99years(S.D10.28),rangingfrom33to84years.Thedistributionofagefrequenciesisillustratedin Figure 1.

Exaggeratedfacetfluid(>1mm)wasdetectedonMRIlumbosacralspineof93patientswhowerelabelledaspositive,while123patientswerelabellednegative.Amongthe93patientswithincreasedfacetfluidonMRIaxialT2-weightedimages,only14exhibitedinstabilityonsupinesagittalMRIofthelumbarspine.However,onflexion/extensionviewsofthesamepatients,58showedsignsofspinalinstability.

Conversely,amongthe123patientswithoutincreasedfacetfluidonMRIaxialT2-weightedimages,nonedisplayedinstabilityonsupinesagittalMRIofthelumbarspine.Onflexion/extensionviewsofthesepatients,12werepositiveforspinalinstability.

Cross-tabulationstatisticsindicatedsignificantassociationbetweenpositivefacetfluidonMRIandthepresenceofinstabilityonradiographs,leadingustorejectnullhypothesisno.1(Table1andTable2).Furthermore,uponanalyzingpearsoncorrelation,ourresultsdemonstratedstrongpositivecorrelationbetweentheamountoffacetfluidonaxialMRIandthegradeofspinalinstabilityonstandingflexion/extensionradiographs.Consequently,werejectednullhypothesisno.2(Table3).

Discussion:

Backpainisaprevalentclinicalconditionoftenattributedtosegmentalmotioninstability.Factorssuchasintervertebraldiscdegenerationandlumbarfacetjointdegenerationareknowncontributorstospinalinstability,whichcandevelopovertime.(12)Thelumbarspinalsegmentfunctionsasacohesiveunitwheretheintervertebraldiscandfacetjointsworktogethertoprovidestabilityandwithstandspinalstresses.

InabiomechanicalstudybyAdamsandHutton,(13)thelumbarfacetjointswereidentifiedascrucialinlimitingmotionbetweenvertebraeandsafeguardingintervertebraldiscsfromexcessiveforcesduringflexion,rotation,andshear.AxialT2-weightedimageshavebeenutilizedtodetectsegmentalmotioninstability,althoughitisrecognizedthatdynamicslipmaybereducedinthesupineposition,potentiallymaskingspondylolisthesisduringsupineMRI.

Kirkaldy-Willisoutlinesthree-phasemodelfordegeneration.Theinitialphaseinvolvesdysfunctionindiscoligamentousstructureswithminimalanatomicalalterations.Thesubsequentphaseischaracterizedbyrelativeinstability,markedbyreduceddischeight,laxityinfacetcapsulesandligaments,andarticularchanges,potentiallyresultinginexcessivetranslationalandrotationalmovement.Furtherdegenerationinthisstageleadstoincreasedrigidityandstabilizationthroughosteophyteformationandfibrosis.Theoretically,asdegenerationprogressesfrominstabilitytorestabilization,thereshouldbeadeclineinfacetjointeffusion.(14)

IncreasedfacetfluidonaxialT2-weightedimageshasbeenproposedasapotentialmarkerofinstability,suggestingitsutilityinrecommendingspinalarthrodesis.(9)ResearchershaveexploredtheuseofstaticMRIfordetectingspinalinstabilityStudiesbyMailleuxetal.,(15)Rihnetal.(5)Chaputetal.,(16)Schinnereretal.,(11)Choetal.,(17)andothers,(18, 19)havehighlightedtheassociationbetweenfacetfluidonMRIandspinalinstability,particularlyincasesofdegenerativespondylolisthesis.ThestudybyRihnetal.(5)identifiedcloselinearrelationshipbetweenthepresenceoffacetfluidandthedegreeofinstability,highlightingthepotentialutilityofMRIfindingsasindicatorsoflumbarinstability.Thefindingsalsorevealedthatthepresenceoffacetfluidon MRIservesasareliablepredictorofradiographiclumbarinstability,boastingrelativelyhighpositive(82%)andnegative(83%)predictivevalues.

WeutilizedcriteriabyShinnereretal.(11)todocumentpresenceofabnormalfluidsignalswithinthefacetjoins.TheShinnerercriteria(18)formeasuringfacetfluidinvolveddetailedassessmentofaxialMRIimages,focusingspecificallyonthepresenceofincreasedfluidwithinthefacetjoints.Eachfacetjoint(leftandrightsidesseparately)wasexaminedindependently.Jointwasconsiderednormaliftheamountoffluidpresentwasnomorethanwhatwasdeemedphysiologic,definedasafluidsignalmeasuri

nglessthan1millimeterbetweenthearticularprocesseswhenmeasuredasastraightlineperpendiculartothejointline.Iftheobservedfluidexceededthisthresholdof1millimeter,itwasclassifiedasabnormalor"exaggerated."(Figure2)Thepresenceorabsenceofsegmentalinstabilitywasassessedontheweight-bearing(standing)flexion/extensionviewsoflumbarradiographsofthesamepatients.Instabilitywasdefinedonweight-bearingflexion/extensionviewsasanteriortranslationofthesuperiorvertebraovertheinferioronlateralflexion/extensionradiographs.Anterolisthesiswasquantifiedinmillimetersateveryvertebrallevelspanningfrom L1-2 to L5-S1.Themeasurementofanterolisthesiswasconductedfromtheposteriorinferiorcornerofthesuperiorvertebratotheposteriorsuperiorcorneroftheinferiorvertebra.(Figure3)

Ourstudyrevealedasignificantassociationbetweenlumbarfacetfluiddetectedonaxial MRI and radiographicinstabilityobservedonstandingflexion/extensionlumbarradiographsinpatientswithdegenerativelumbardisease.Wealsofoundastrongpositivecorrelationbetweentheamountoffacetfluidonaxial T2-weighted MRI and thegradeofspinalinstabilityonlateralflexion/extensionradiographsinstandingposition. Strengthsofourstudyincludeitsprospectivedesignandstringentinclusioncriteria.Limitationsincludethelackofrandomizationandrelativelysmallsamplesize.Pendingfurtherdata,werecommendconductingstandinglateralflexion–extensionradiographsforallpatientsshowingincreasedfacetfluidsignalonMRI.Aprospectiverandomizedtrialcouldprovidemoreconclusiveevidence,althoughconductingMRIonasymptomaticindividualsposeschallenges.

Conclusion:

Inconclusion,ourstudyunderscoressignificantrelationshipbetweenlumbarfacetfluididentifiedonaxial MRI and radiographicinstabilityobservedonstandingflexion/extensionlumbarradiographsamongpatientswithdegenerativelumbardisease. Furthermore,weobservedapositivecorrelationbetweenthequantityoffacetfluidonaxial T2-weighted MRI and thedegreeofspinalinstabilityonlateralflexion/extensionradiographsinastandingposition.Strengthsofourinvestigationincludeitsprospectivenatureandrigorousinclusioncriteria,whichenhancethevalidityofourfindings.However,limitationssuchastheabsenceofrandomizationandarelativelysmallsamplesizeunderscoretheneedforfurtherresearch. Weadvocatefortheroutineuseofstandinglateralflexion–extensionradiographsinpatientsexhibitingelevatedfacetfluidsignalonMRI,astheymayprovidevaluableinformationregardingpotentialspinalinstability.Furtherresearchwillhelpestablishtheclinicalutilityofthisapproachinmanagingdegenerativelumbardiseases.

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Table1: Crosstabulationbetweeninstabilityasobservedonflexion/extensionradiographsinstandingpositionandamountof facetfluiddetectedonaxialMRIdemonstratingasignificantassociationbetweenpositivefacetfluidonMRIandthepresenceo finstabilityonradiographs

		Facet fluid on axial MRI positive >1mm =1, negative < 1mm =2		Total
		1.00	2.00	
Instability on flexion extension radiographgsPRESENT= 1, NOT PRSENT=2	1.00	58	12	70
	2.00	35	111	146
Total		93	123	216

Table

2:ChiSquaretestsonthedataobtainedbetweenflexion/extensionradiographsinstandingpositionandamountoffacetfluiddetectedonaxialMRI

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	66.914[a]	1	.000		
Continuity Correction[b]	64.534	1	.000		
Likelihood Ratio	70.296	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	66.605	1	.000		
N of Valid Cases	216				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 30.14.

b. Computed only for a 2x2 table

Table 3:

PearsoncorrelationsdemonstratingastrongpositivecorrelationbetweentheamountoffacetfluidonaxialMRIandthegradeo fspinalinstabilityonstandingflexion/extensionradiographs

		Value of facet fluid	Grade of spinal instability
Value of facet fluid	Pearson Correlation	1	.923[a]
	Sig. (2-tailed)		.000
	N	216	216
Grade of spinal instability	Pearson Correlation	.923[a]	1
	Sig. (2-tailed)	.000	
	N	216	216

a. Correlation is significant at the 0.01 level (2-tailed).

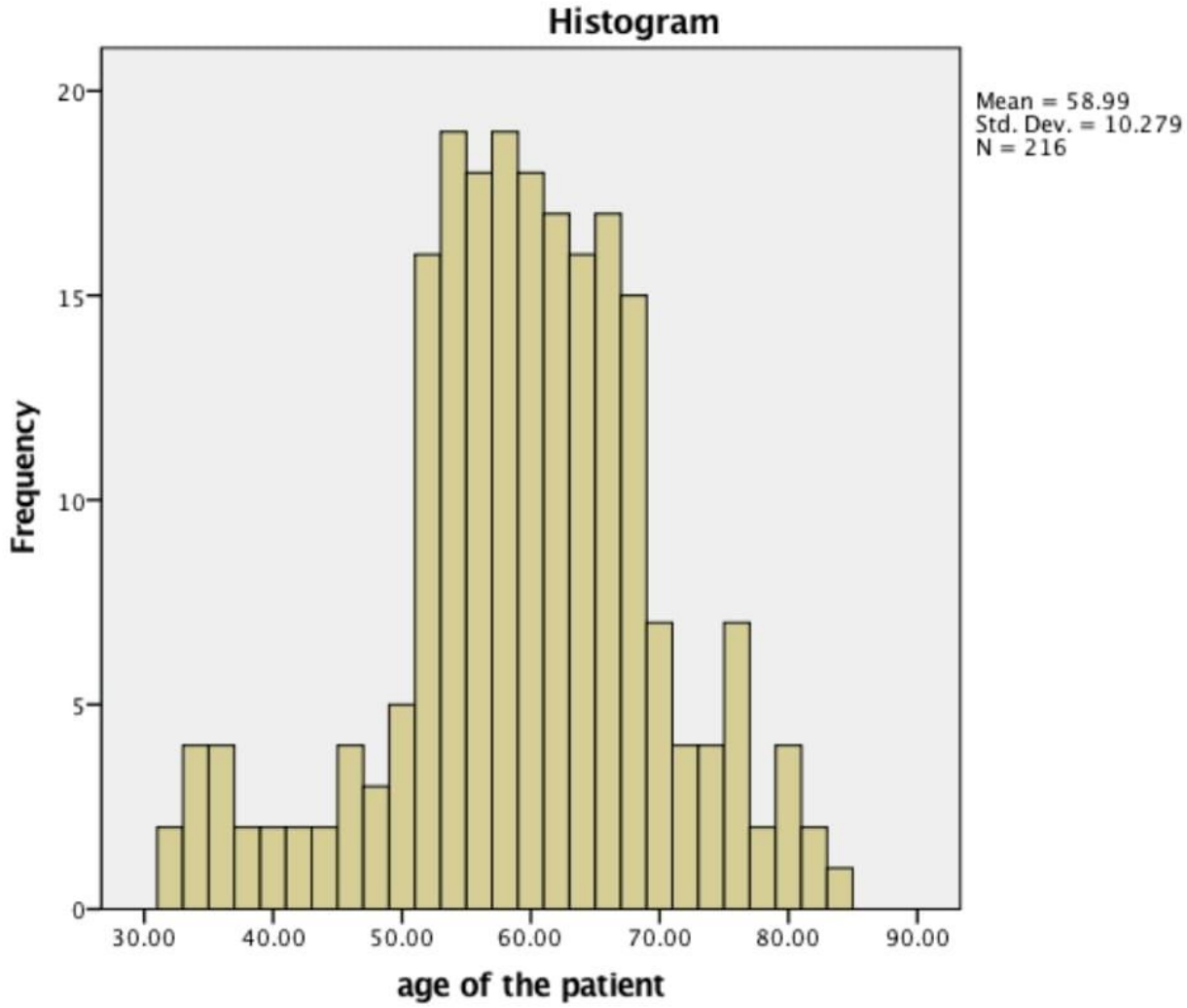

Figure1:Thedistributionofdatawithrespecttoagefrequenciescomprisingoftotal216patients

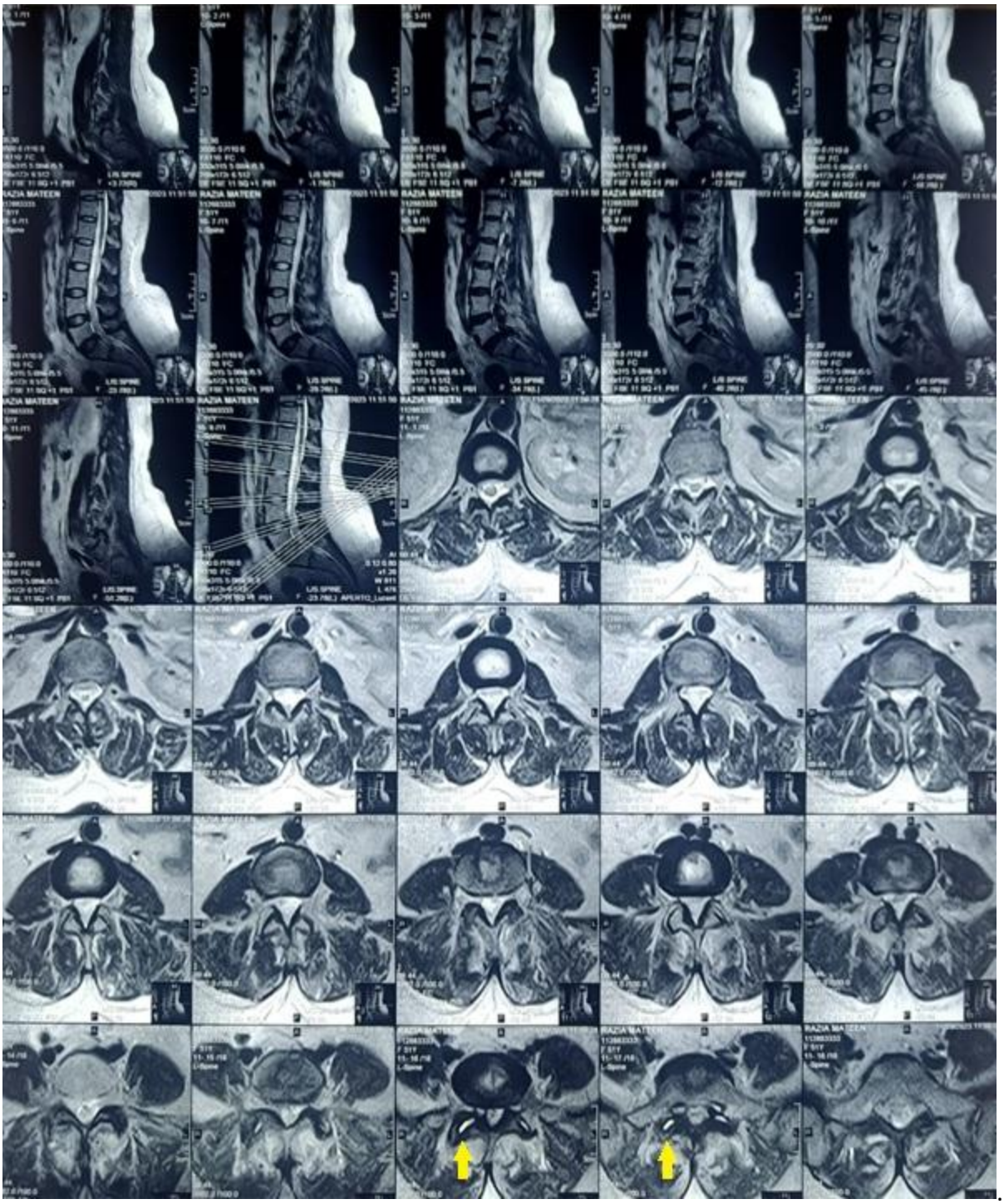

Figure2:MRILumbosacralSpine T2- weighted image ofthepatientshowingpresenceofsignificantfluidinfacetjointsatL5-S1level on axial cuts with abnormal facet fluid

marked with yellow arrows but no abnormality in alignment at L5-S1 level on supine sagittal view of MRI.

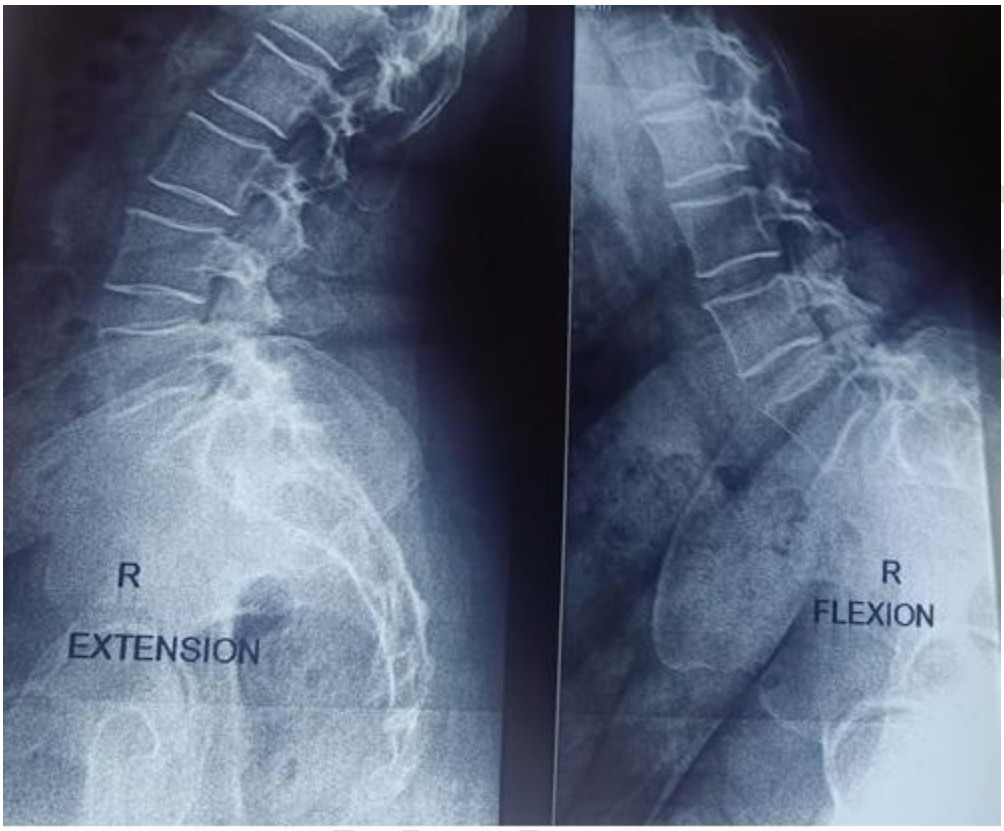

Figure 3: X-Ray Flexion Extension of the same patient showing significant anterolisthesis of L5 over S1 vertebra