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IMPACT OF NECK DISSECTION TYPE ON SHOULDER RANGE OF MOTION IN ORAL SQUAMOUS CELL CARCINOMA PATIENTS: ANATOMICAL BASIS, COMPARATIVE FUNCTIONAL OUTCOMES AND STRATEGIES FOR PREVENTION

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ABSTRACT

Background: Shoulder morbidity following neck dissection (ND) for oral squamous cell carcinoma (OSCC) is principally attributable to injury to the spinal accessory nerve (SAN). The extent of dissection is the primary determinant of functional outcome, yet objective, longitudinal goniometric data comparing modified radical neck dissection (MRND), supraomohyoid neck dissection (SOHND), and extended supraomohyoid neck dissection (ESOHND) through the adjuvant radiotherapy period remain limited.

Aim: To prospectively evaluate and compare shoulder range of motion (ROM) across MRND, SOHND, and ESOHND at defined perioperative and post-radiotherapy intervals, and to establish normative ROM values in a healthy control population.

Materials and Methods: A prospective study was conducted at Gurunanak Institute of Dental Sciences and Research, Kolkata (2023–2024). Six biopsy-proven OSCC patients (9 shoulders: MRND=3, SOHND=2, ESOHND=4) constituted the study group. Seven bilateral ROM parameters — flexion, extension, abduction, horizontal abduction, horizontal adduction, internal rotation, and external rotation — were measured using a universal goniometer at preoperative, immediate postoperative (days 1, 2, 3, 10, 30), pre-radiotherapy, immediate post-radiotherapy, and 2- and 3-month post-radiotherapy intervals. One-way ANOVA and paired t-tests were employed for statistical analysis ($p<0.05$).

Results: MRND consistently yielded the highest mean ROM values, ESOHND the lowest, and SOHND occupied an intermediate position across all measured parameters. Statistically significant inter-group differences were confined to abduction at post-radiotherapy two months ($p=0.019$) and horizontal abduction at postoperative days 2 ($p=0.014$) and 3 ($p=0.009$). Internal rotation, external rotation, and horizontal adduction showed no significant inter-group differences at any time point.

Conclusion: ROM deficits following neck dissection demonstrate a clear gradient inversely proportional to the extent of SAN dissection. Functional impairment persists even after nerve-sparing procedures, implicating traction injury, C2–C4 motor-contribution disruption, and radiotherapy-related fibrosis as additional mechanisms. These findings underscore the importance of anatomically meticulous surgical technique, limitation of dissection to oncologically necessary levels, and structured postoperative physiotherapy rehabilitation.

KEYWORDS: Neck dissection; shoulder morbidity; spinal accessory nerve; range of motion; goniometry; oral squamous cell carcinoma; shoulder syndrome.

INTRODUCTION

Neck dissection (ND) remains a cornerstone of the surgical management of head and neck malignancy, yet the oncological imperative of adequate nodal clearance is inseparable from its functional cost. The principal determinant of that cost is injury to the spinal accessory nerve (SAN, cranial nerve XI), which supplies the trapezius and, when compromised,

produces the constellation of shoulder droop, pain, weakness and restricted range of motion (ROM) collectively termed 'shoulder syndrome'.[1,2] The progressive evolution from radical neck dissection (RND) through modified radical neck dissection (MRND) to selective neck dissection (SND) reflects a sustained effort to attenuate this morbidity without compromising cancer control. This review synthesises the available evidence on the anatomical mechanisms, comparative functional outcomes and prevention of shoulder morbidity across the spectrum of dissection types.
Despite this evolution, a prospective comparison of shoulder ROM across MRND, SOHND, and ESOHND through the adjuvant radiotherapy period remains incompletely characterised. This study aims to evaluate and compare postoperative shoulder ROM across these three dissection types at defined perioperative and post-radiotherapy intervals, contributing objective functional data to inform surgical decision-making in OSCC management.

MATERIALS AND METHODS

Study Setting

All patients operated for Oral Squamous Cell Carcinoma OSCC with Neck Dissection and /or Radiotherapy were included in the present study. Pre-operative informed consent was taken for patient selection.

Timeline

The present study was undertaken in the Department of Oral and Maxillofacial Surgery at Gurunanak Institute of Dental Sciences and Research, Panihati, Kolkata.
Patients attending OPD between 2023–2024, aged>18 years, were selected irrespective of sex. Diagnosis was based on history, clinical, and radiological examination. Ethical clearance was obtained was obtained from Institutional Ethics Committee.

INCLUSION CRITERIA

Biopsy-proven OSCC Medically fit to undergo Surgery

EXCLUSION CRITERIA

- Recurrence of Carcinoma
- Upfront Neo-Adjuvant Chemotherapy (NACT)/ Concurrent Chemo-Radiotherapy (CCRT)/ Radiotherapy (RT)
- Existing shoulder disability
- Rheumatoid Arthritis

MATERIALS - GONIOMETER

PATIENT SELECTION CRITERIA

STUDY GROUP (6 patients, 9 shoulders)

Neck Dissection followed by radiotherapy Radiotherapy; observed at stiulated times from Pre-operative till 3 months following Completion of Radiotherapy

Range of Motion All participants had bilateral objective measurement of 7 ROM parameters:
- Flexion,
- Extension,
- Abduction,
- Horizontal Abduction,
- Horizontal Adduction ,
- Internal (Medial) Rotation
- External (Lateral) Rotation.

Comparisons were done both within each group (intra-group) and between Group A and Group B (inter-group).

METHOD

Biopsy-proven OSCC underwent wide local incision, Neck Dissection and Reconstruction as and when necessary, based on NCCN Guidelines and AJCC, 8th Edition guidelines.
The control group was assessed without any surgical intervention.
The type of Neck Dissection and Radiotherapy was recorded, pre-operative shoulder assessment was done and continued post-operatively for 3 months at stipulated time intervals for all patients.
The patients were evaluated objectively by goniometry before surgery and post surgically for immediate post-op 1st, 2nd, 3rd days ,10th day and 30th days.
Radiotherapy patients were evaluated pre-Radiotherapy, Post-Radiotherapy-immediate, 2nd and 3rd months.
Patients were re-evaluated for any recurrence clinically on all visits.

SAMPLE DESIGN- Prospective Study
The primary objective was to evaluate the impact of neck dissection on shoulder dysfunction.

PARAMETERS

GONIOMETER: 14-inch stainless steel Universal Goniometer with a body and two arms(stationary arm, moving arm) was used. The body of a universal goniometer resembled a protractor and form a full circle. Scale calibration was 0-360 degrees with 1° and 5° increments. The fulcrum of the goniometer is placed over the approximate location of the axis of

motion of the joint being measured. Hand dominance were mentioned independently as right or left side. Activity level or occupational background were not recorded.
Measurement Protocol: Number of measurements per joint was once.   Intra-observer or inter-observer reliability was not done. The same examiner had performed all measurements.

STATISTICAL ANALYSIS-The data was entered using MS Excel 2021.The statistical analysis was done using the IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp software. The continuous variables was presented in terms of Mean and Standard Deviation. Inferential statistics for the comparison of the groups was done using one way ANOVA. Chi-square statistics were computed to study the distribution of the variables. The Paired t- test was done to compare between different time period. The p value was kept at 0.05.

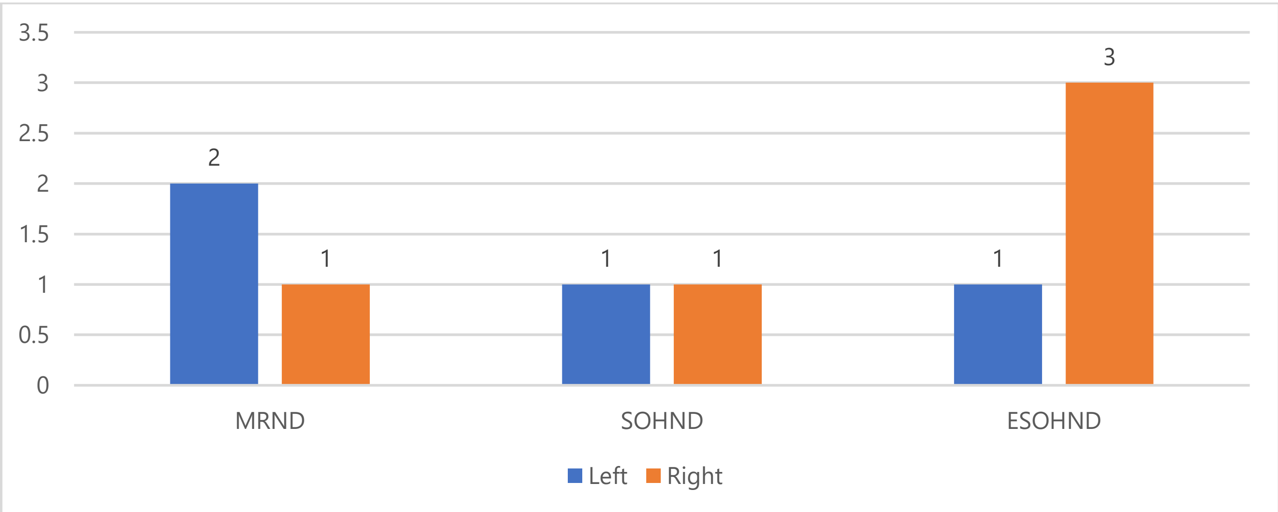
RESULTS

Comparison of Different Types of Neck Dissection

Types of Neck Dissection	MRND		SOHND		ESOHND		P Value
	Frequency (N)	Percentage (%)	N	%	N	%	
Left Side	2	66.6	1	50	1	25	0.09
Right Side	1	33.4	1	50	3	75	0.08

TABLE-Representation of MRND, SOHND and ESOHND

• **Modified Radical Neck Dissection (MRND):** The left side was operated in 66.6% of cases (n=2), while the right side was operated in 33.4% of cases (n=1).
• **Selective Supraomohyoid Neck Dissection (SOHND):** Both the left and right sides were equally operated, each accounting for 50% of cases (n=1).
• **Extended Supraomohyoid Neck Dissection (ESOHND):** The right side was predominantly operated in 75% of cases (n=3), while the left side was operated in 25% of cases (n=1).



BAR GRAPH-Graphical representation of MRND, SOHND and ESOHND

Comparison between different types of Neck Dissection (MRND, SOHND, ESOHND) with the Range of Motion across stipulated time intervals

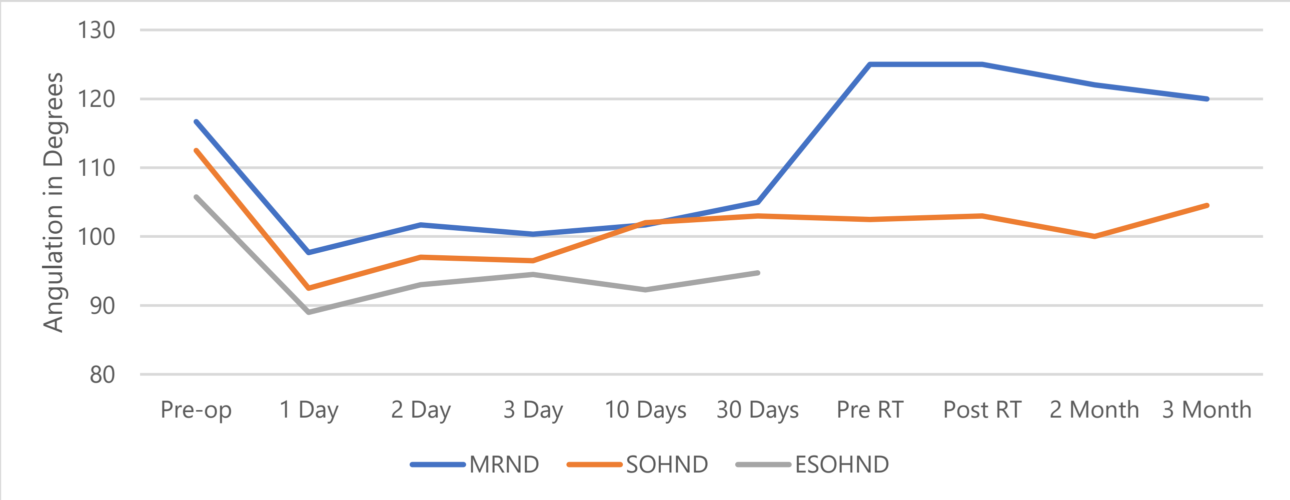
1. Flexion

MRND= 3 SOHND=2 ESOHND=4		Mean	S.D.	95% Confidence Interval for Mean		Min	Max	F Score	P Value
				Lower Bound	Upper Bound				
Pre-op	MRND	116.67	21.197	64.01	169.32	94	136	.341	.724
	SOHND	112.50	10.607	17.20	207.80	105	120		
	ESOHND	105.75	16.800	79.02	132.48	85	123		
1 Day	MRND	97.67	10.786	70.87	124.46	90	110	.279	.766
	SOHND	92.50	10.607	-2.80	187.80	85	100		
	ESOHND	89.00	18.637	59.34	118.66	70	105		
2 Days	MRND	101.67	20.207	51.47	151.86	90	125	.256	.782
	SOHND	97.00	9.899	8.06	185.94	90	104		
	ESOHND	93.00	14.071	70.61	115.39	78	105		
3 Days	MRND	100.33	17.898	55.87	144.79	90	121	.131	.880
	SOHND	96.50	12.021	-11.50	204.50	88	105		

	ESOHND	94.50	13.699	72.70	116.30	75	105		
10 Days	MRND	101.67	16.073	61.74	141.59	90	120	1.015	.417
	SOHND	102.00	2.828	76.59	127.41	100	104		
	ESOHND	92.25	4.992	84.31	100.19	85	96		
30 Days	MRND	105.00	18.028	60.22	149.78	90	125	.760	.508
	SOHND	103.00	1.414	90.29	115.71	102	104		
	ESOHND	94.75	7.089	83.47	106.03	85	100		
Pre RT	MRND	125.00	.	.	.	125	125	161.333	.050
	SOHND	103.00	1.414	90.29	115.71	102	104		
	ESOHND	.	.	.	.	.	.		
Post RT	MRND	125.00	.	.	.	125	125	27.000	.121
	SOHND	102.50	3.536	70.73	134.27	100	105		
	ESOHND	.	.	.	.	.	.		
Post-Rt 2 Month	MRND	122.00	.	.	.	122	122	6.453	.239
	SOHND	100.00	7.071	36.47	163.53	95	105		
	ESOHND	.	.	.	.	.	.		
Post-Rt 3 Month	MRND	120.00	.	.	.	120	120	.726	.551
	SOHND	104.50	14.849	-28.92	237.92	94	115		
	ESOHND	.	.	.	.	.	.		

Table-Comparative analysis of Flexion ROM for MRND, SOHND and ESOHND

Interpretation-
Significant differences in Pre-RT values. MRND tends to yield higher values across time, whereas ESOHND consistently exhibits the lowest readings.



LINE GRAPH-Comparative analysis in Flexion ROM for MRND, SOHND and ESOHND

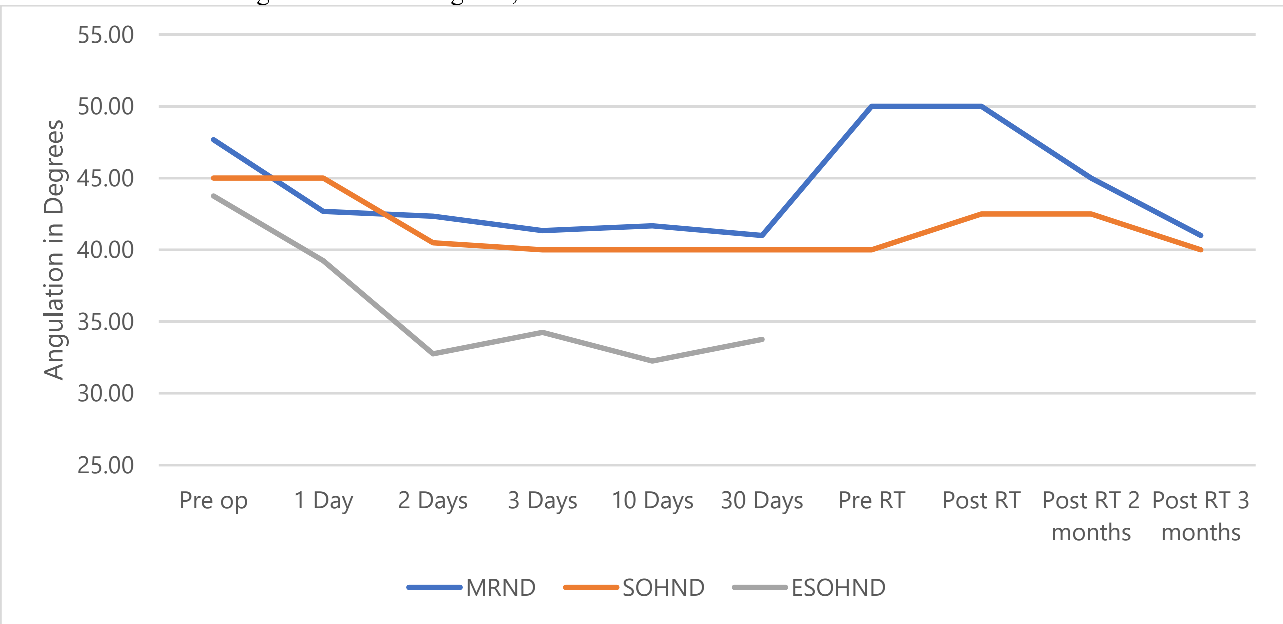
2. Extension

MRND= 3 SOHND=2 ESOHND=4		Mean	Std. Dev	95% Confidence Interval for Mean		Min	Max	F Score	P Value
				Lower Bound	Upper Bound				
Pre-op	MRND	47.67	4.041	37.63	57.71	43	50	.281	.764
	SOHND	45.00	7.071	-18.53	108.53	40	50		
	ESOHND	43.75	8.180	30.73	56.77	35	54		
1 Day	MRND	42.67	7.506	24.02	61.31	35	50	.584	.586
	SOHND	45.00	7.071	-18.53	108.53	40	50		
	ESOHND	39.25	5.377	30.69	47.81	32	45		
2 Days	MRND	42.33	7.506	23.69	60.98	35	50	2.755	.142
	SOHND	40.50	.707	34.15	46.85	40	41		
	ESOHND	32.75	5.188	24.49	41.01	25	36		
3 Days	MRND	41.33	4.163	30.99	51.68	38	46	2.625	.152
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	34.25	5.058	26.20	42.30	28	40		
10 Days	MRND	41.67	7.638	22.69	60.64	35	50	2.121	.201
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	32.25	6.551	21.83	42.67	24	40		

30 Days	MRND	41.00	8.544	19.78	62.22	33	50	.818	.485
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	33.75	8.958	19.50	48.00	24	45		
Pre RT	MRND	50.00	.	.	.	50	50		
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	.	.	.	.	.	.		
Post RT	MRND	50.00	.	.	.	50	50	3.000	.333
	SOHND	42.50	3.536	10.73	74.27	40	45		
	ESOHND	.	.	.	.	.	.		
POST-RT 2 MONTH	MRND	45.00	.	.	.	45	45	.333	.667
	SOHND	42.50	3.536	10.73	74.27	40	45		
	ESOHND	.	.	.	.	.	.		
POST-RT 3 MONTH	MRND	41.00	.	.	.	41	41	.003	.963
	SOHND	40.00	14.142	-87.06	167.06	30	50		
	ESOHND	.	.	.	.	.	.		

TABLE-Comparative analysis of Extension for MRND, SOHND, and ESOHND

Interpretation- Pre-radiotherapy and post-radiotherapy values indicate that SOHND shows a slight increase post-RT. MRND maintains the highest values throughout, while ESOHND demonstrates the lowest.



LINE GRAPH-Comparative analysis of Extension for MRND, SOHND, and ESOHND

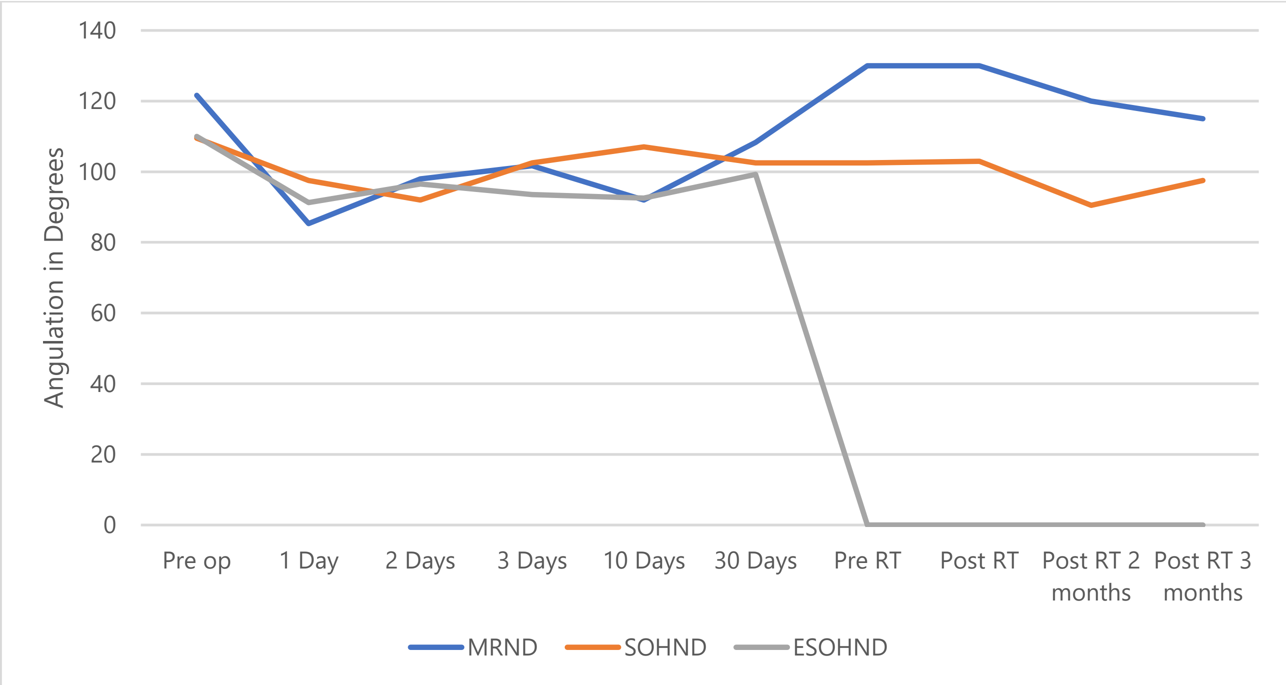
3. Abduction

MRND= 3 SOHND=2 ESOHND=4		Mean	Std. Dev	95% Confidence Interval for Mean		Min	Max	F Score	P Value
				Lower Bound	Upper Bound				
Pre-op	MRND	121.67	23.629	62.97	180.36	95	140	.490	.635
	SOHND	109.50	.707	103.15	115.85	109	110		
	ESOHND	110.00	14.142	87.50	132.50	90	120		
1 Day	MRND	85.33	5.033	72.83	97.84	80	90	2.128	.200
	SOHND	97.50	3.536	65.73	129.27	95	100		
	ESOHND	91.25	7.974	78.56	103.94	84	100		
2 Days	MRND	98.00	18.083	53.08	142.92	79	115	.073	.930
	SOHND	92.00	2.828	66.59	117.41	90	94		
	ESOHND	96.50	19.807	64.98	128.02	76	120		
3 Days	MRND	101.67	7.638	82.69	120.64	95	110	1.322	.334
	SOHND	102.50	3.536	70.73	134.27	100	105		
	ESOHND	93.50	8.888	79.36	107.64	84	105		
10 Days	MRND	92.00	7.211	74.09	109.91	86	100	5.135	.050
	SOHND	107.00	4.243	68.88	145.12	104	110		
	ESOHND	92.50	5.000	84.54	100.46	90	100		
30 Days	MRND	108.33	22.546	52.33	164.34	85	130	.282	.764
	SOHND	102.50	3.536	70.73	134.27	100	105		

	ESOHND	99.25	12.685	79.06	119.44	83	114		
Pre RT	MRND	130.00	.	.	.	130	130	40.333	.099
	SOHND	102.50	3.536	70.73	134.27	100	105		
	ESOHND	.	.	.	.	.	.		
Post RT	MRND	130.00	.	.	.	130	130	27.000	.121
	SOHND	103.00	4.243	64.88	141.12	100	106		
	ESOHND	.	.	.	.	.	.		
POST-RT 2 MONTH	MRND	120.00	.	.	.	120	120	1160.333	.019*
	SOHND	90.50	.707	84.15	96.85	90	91		
	ESOHND	.	.	.	.	.	.		
POST-RT 3 MONTH	MRND	115.00	.	.	.	115	115	16.333	.154
	SOHND	97.50	3.536	65.73	129.27	95	100		
	ESOHND	.	.	.	.	.	.		

Table-Comparative analysis of Abduction for MRND, SOHND, and ESOHND

Interpretation- A significant difference at the post-RT 2-month. MRND consistently maintained higher values, while ESOHND and SOHND exhibited more gradual trends. Pre- and post-radiotherapy values for MRND remained constant, while SOHND showed only minor changes.



LINE GRAPH-Comparative analysis of Abduction for MRND, SOHND and ESOHND.

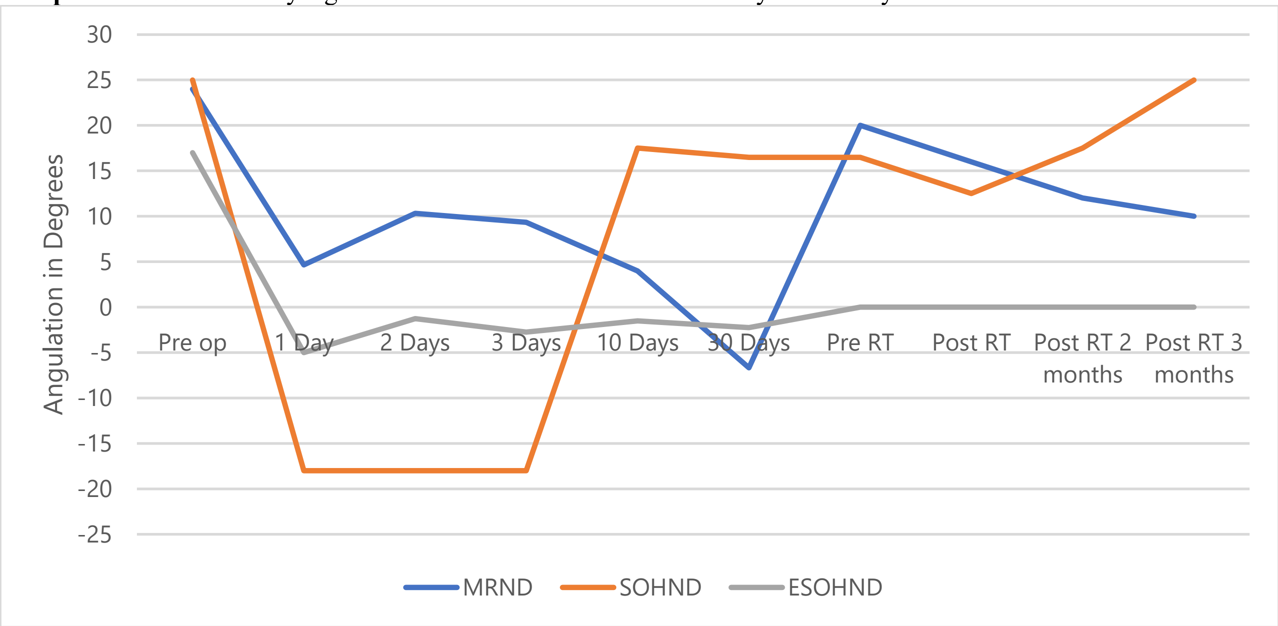
4. Horizontal Abduction

MRND= 3 SOHND=2 ESOHND=4		Mean	Std. Dev	95% Confidence Interval for Mean		Min	Max	F Score	P Value
				Lower Bound	Upper Bound				
Pre-op	MRND	24.00	12.000	-5.81	53.81	12	36	.812	.487
	SOHND	25.00	7.071	-38.53	88.53	20	30		
	ESOHND	17.00	6.218	7.11	26.89	10	24		
1 Day	MRND	4.67	21.572	-48.92	58.25	-20	20	1.493	.298
	SOHND	-18.00	2.828	-43.41	7.41	-20	-16		
	ESOHND	-5.00	10.033	-20.97	10.97	-11	10		
2 Days	MRND	10.33	1.528	6.54	14.13	9	12	9.526	.014
	SOHND	-18.00	2.828	-43.41	7.41	-20	-16		
	ESOHND	-1.25	9.845	-16.91	14.41	-10	10		
3 Days	MRND	9.33	1.155	6.46	12.20	8	10	11.462	.009
	SOHND	-18.00	2.828	-43.41	7.41	-20	-16		
	ESOHND	-2.75	8.655	-16.52	11.02	-9	10		
10 Days	MRND	4.00	19.053	-43.33	51.33	-18	15	1.347	.329
	SOHND	17.50	3.536	-14.27	49.27	15	20		
	ESOHND	-1.50	10.599	-18.36	15.36	-11	10		
30 Days	MRND	-6.67	37.859	-100.71	87.38	-50	20	.478	.642

	SOHND	16.50	2.121	-2.56	35.56	15	18		
	ESOHND	-2.25	22.366	-37.84	33.34	-32	19		
Pre RT	MRND	20.00	.	.	.	20	20	1.815	.407
	SOHND	16.50	2.121	-2.56	35.56	15	18		
	ESOHND	.	.	.	.	.	.		
Post RT	MRND	16.00	.	.	.	16	16	.653	.567
	SOHND	12.50	3.536	-19.27	44.27	10	15		
	ESOHND	.	.	.	.	.	.		
POST-RT 2 MONTH	MRND	12.00	.	.	.	12	12	1.613	.425
	SOHND	17.50	3.536	-14.27	49.27	15	20		
	ESOHND	.	.	.	.	.	.		
POST-RT 3 MONTH	MRND	10.00	.	.	.	10	10	3.000	.333
	SOHND	25.00	7.071	-38.53	88.53	20	30		
	ESOHND	.	.	.	.	.	.		

TABLE-Comparative analysis of Horizontal Abduction for MRND, SOHND, and ESOHND

Interpretation- Statistically significant differences in MRND at 2nd-day and 3rd day was seen.



Line Graph-Comparative analysis of Horizontal Abduction for MRND,SOHND, and ESOHND

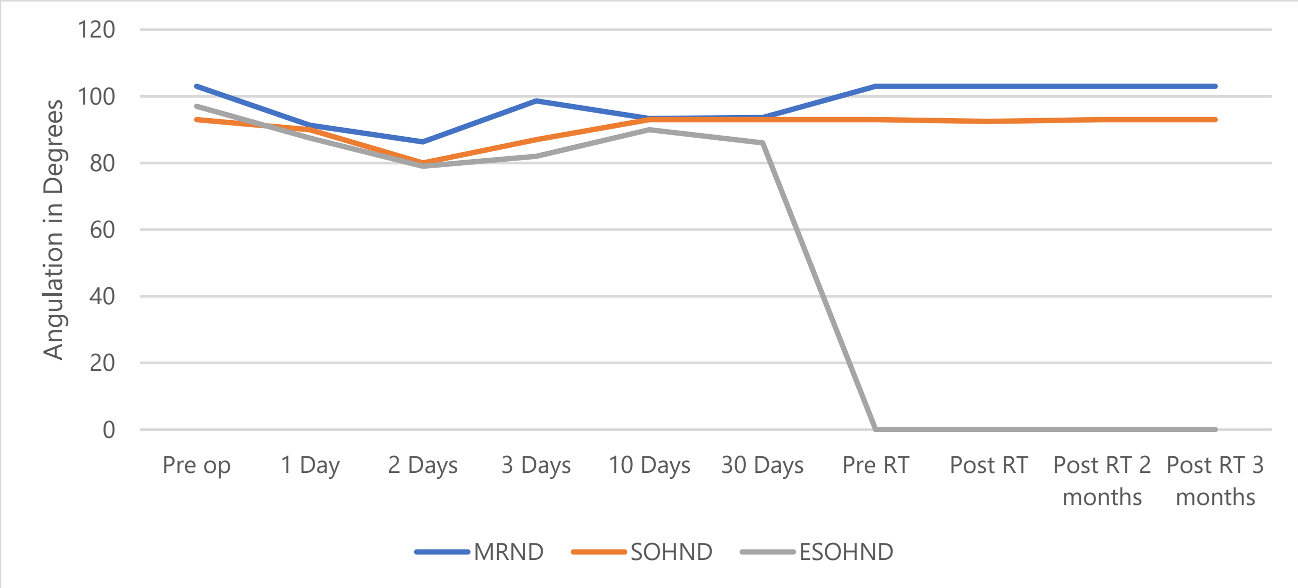
5. Horizontal Adduction

MRND= 3 SOHND=2 ESOHND=4		Mean	Std. Dev	95% Confidence Interval for Mean		Min	Max	F Score	P Value
				Lower Bound	Upper Bound				
Pre-op	MRND	103.00	3.000	95.55	110.45	100	106	1.186	.368
	SOHND	93.00	4.243	54.88	131.12	90	96		
	ESOHND	97.00	9.832	81.36	112.64	85	106		
1 Day	MRND	91.33	9.609	67.46	115.20	81	100	.113	.895
	SOHND	90.00	.000	90.00	90.00	90	90		
	ESOHND	87.50	13.128	66.61	108.39	76	106		
2 Days	MRND	86.33	10.263	60.84	111.83	75	95	.485	.638
	SOHND	80.00	.000	80.00	80.00	80	80		
	ESOHND	79.00	11.605	60.53	97.47	70	96		
3 Days	MRND	98.67	8.083	78.59	118.75	90	106	2.285	.183
	SOHND	87.00	4.243	48.88	125.12	84	90		
	ESOHND	82.00	12.728	61.75	102.25	68	98		
10 Days	MRND	93.33	16.073	53.41	133.26	75	105	.073	.931
	SOHND	93.00	4.243	54.88	131.12	90	96		
	ESOHND	90.00	11.662	71.44	108.56	78	100		
30 Days	MRND	93.67	20.793	42.01	145.32	70	109	.257	.781
	SOHND	93.00	4.243	54.88	131.12	90	96		
	ESOHND	86.00	13.441	64.61	107.39	74	105		
Pre RT	MRND	103.00	.	.	.	103	103	3.704	.305

	SOHND	93.00	4.243	54.88	131.12	90	96		
	ESOHND	.	.	.	.	.	.		
Post RT	MRND	103.00	.	.	.	103	103	5.880	.249
	SOHND	92.50	3.536	60.73	124.27	90	95		
	ESOHND	.	.	.	.	.	.		
POST-RT 2 MONTH	MRND	103.00	.	.	.	103	103	3.704	.305
	SOHND	93.00	4.243	54.88	131.12	90	96		
	ESOHND	.	.	.	.	.	.		
POST-RT 3 MONTH	MRND	103.00	.	.	.	103	103	3.704	.305
	SOHND	93.00	4.243	54.88	131.12	90	96		
	ESOHND	.	.	.	.	.	.		

Table-Comparative analysis of Horizontal Adduction for MRND, SOHND, and ESOHND

Interpretation-No statistically significant differences seen in Horizontal Adduction



Line Graph-Comparative analysis of Horizontal Adduction for MRND,SOHND, and ESOHND

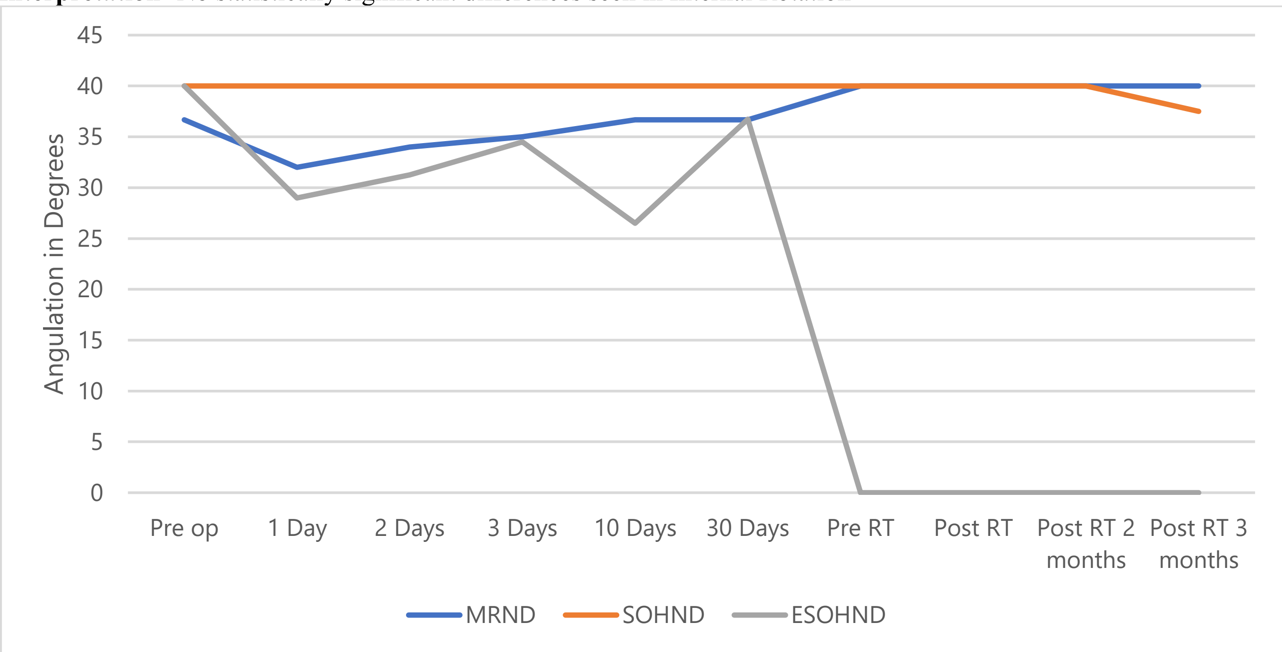
6. **Internal(Medial) Rotation**

MRND= 3 SOHND=2 ESOHND=4		Mean	Std. Dev	95% Confidence Interval for Mean		Min	Max	F Score	P Value
				Lower Bound	Upper Bound				
Pre-op	MRND	36.67	5.774	22.32	51.01	30	40	.571	.593
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	40.00	4.082	33.50	46.50	35	45		
1 Day	MRND	32.00	3.464	23.39	40.61	30	36	3.333	.106
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	29.00	6.377	18.85	39.15	20	35		
2 Days	MRND	34.00	6.557	17.71	50.29	27	40	1.005	.420
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	31.25	8.539	17.66	44.84	20	40		
3 Days	MRND	35.00	5.000	22.58	47.42	30	40	.990	.425
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	34.50	5.260	26.13	42.87	30	40		
10 Days	MRND	36.67	5.774	22.32	51.01	30	40	2.848	.135
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	26.50	9.256	11.77	41.23	20	40		
30 Days	MRND	36.67	5.774	22.32	51.01	30	40	.298	.753
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	36.75	5.852	27.44	46.06	30	43		
Pre RT	MRND	40.00	.	.	.	40	40		
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	.	.	.	.	.	.		
Post RT	MRND	40.00	.	.	.	40	40		
	SOHND	40.00	.000	40.00	40.00	40	40		

	ESOHND	.	.	.	.	.	.		
POST-RT 2 MONTH	MRND	40.00	.	.	.	40	40		
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	.	.	.	.	.	.		
POST-RT 3 MONTH	MRND	40.00	.	.	.	40	40	.333	.667
	SOHND	37.50	3.536	5.73	69.27	35	40		
	ESOHND	.	.	.	.	.	.		

TABLE-Comparative analysis of Internal Rotation for MRND, SOHND, and ESOHND

Interpretation- No statistically significant differences seen in Internal Rotation



Line Graph-Comparative analysis of Internal Rotation for MRND, SOHND, and ESOHND

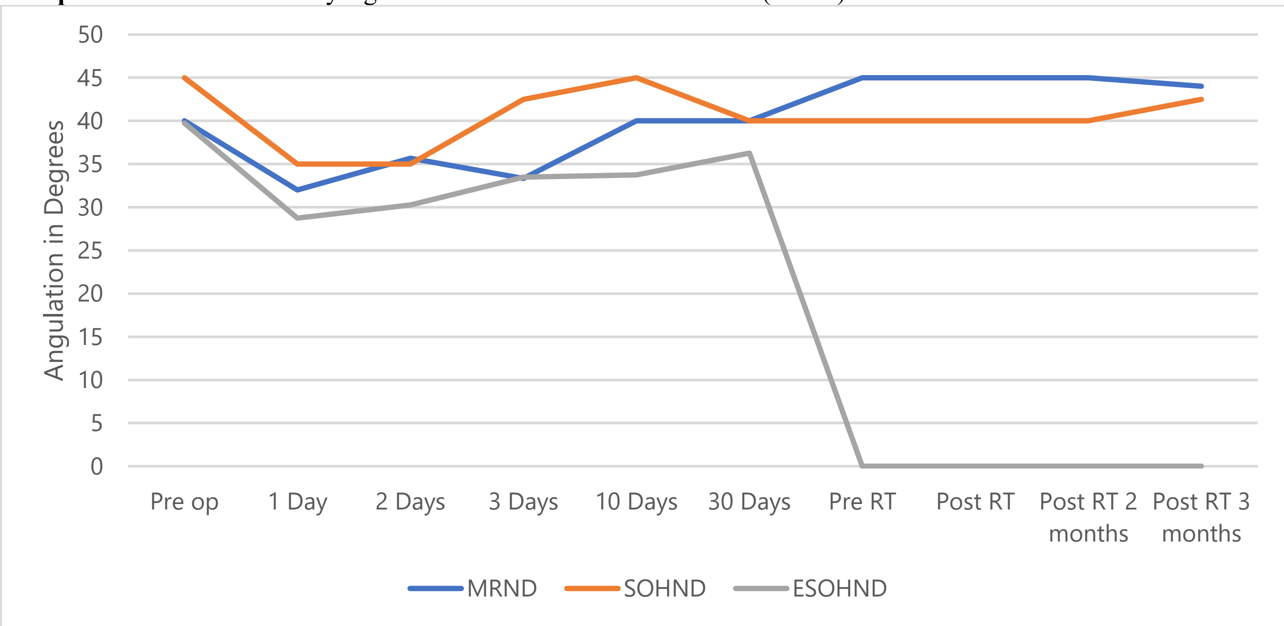
7. External(Lateral) Rotation

MRND= 3 SOHND=2 ESOHND=4		Mean	Std. Dev	95% Confidence Interval for Mean		Min	Max	F Score	P Value
				Lower Bound	Upper Bound				
Pre-op	MRND	40.00	8.660	18.49	61.51	30	45	.341	.724
	SOHND	45.00	7.071	-18.53	108.53	40	50		
	ESOHND	39.75	7.365	28.03	51.47	32	47		
1 Day	MRND	32.00	9.849	7.53	56.47	21	40	.355	.715
	SOHND	35.00	7.071	-28.53	98.53	30	40		
	ESOHND	28.75	8.539	15.16	42.34	20	40		
2 Days	MRND	35.67	12.097	5.62	65.72	22	45	.328	.732
	SOHND	35.00	7.071	-28.53	98.53	30	40		
	ESOHND	30.25	8.180	17.23	43.27	20	40		
3 Days	MRND	33.33	7.638	14.36	52.31	25	40	1.958	.221
	SOHND	42.50	3.536	10.73	74.27	40	45		
	ESOHND	33.50	4.726	25.98	41.02	30	40		
10 Days	MRND	40.00	8.660	18.49	61.51	30	45	1.299	.340
	SOHND	45.00	7.071	-18.53	108.53	40	50		
	ESOHND	33.75	8.539	20.16	47.34	25	45		
30 Days	MRND	40.00	8.660	18.49	61.51	30	45	.349	.719
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	36.25	6.292	26.24	46.26	30	45		
Pre RT	MRND	45.00	.	.	.	45	45		
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	.	.	.	.	.	.		
Post RT	MRND	45.00	.	.	.	45	45		
	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	.	.	.	.	.	.		
POST-RT 2 MONTH	MRND	45.00	.	.	.	45	45		

	SOHND	40.00	.000	40.00	40.00	40	40		
	ESOHND	.	.	.	.	.	.		
POST-RT 3 MONTH	MRND	44.00	.	.	.	44	44	.120	.788
	SOHND	42.50	3.536	10.73	74.27	40	45		
	ESOHND	.	.	.	.	.	.		

TABLE-Comparative analysis of External Rotation for MRND, SOHND, and ESOHND

Interpretation- No statistically significant differences seen in External(lateral) Rotation.



Line Graph-Comparative analysis of External Rotation for MRND, SOHND, and ESOHND

TYPES OF NECK DISSECTION

Comparison of Different Types of Neck Dissection-MRND, SOHND and ESOHND

1. **FLEXION-** Statistical comparisons across time intervals indicate no significant differences, except for the Pre-RT phase, suggesting a potential distinction in outcomes at that stage. Overall, the data suggests that MRND tends to yield higher values across time, whereas ESOHND consistently exhibits the lowest readings.

2. EXTENSION- Pre-radiotherapy (Pre-RT) and post-radiotherapy (Post-RT) values indicate that SOHND shows a slight increase post-RT. Statistical comparisons indicate no significant differences across groups, suggesting comparable recovery trends among the three procedures. Overall, MRND maintains the highest values throughout, while ESOHND demonstrates the lowest values, highlighting potential differences in recovery patterns.

3. ABDUCTION- A significant difference was noted at the post-RT 2-month, indicating a potential variance in recovery between groups. Overall, MRND consistently maintained higher values, while ESOHND and SOHND exhibited more gradual trends. Pre- and post-radiotherapy values for MRND remained constant, while SOHND showed only minor changes.

4.HORIZONTAL ABDUCTION- Statistical significant differences in MRND at the 2-day and 3-day intervals was seen. In contrast, the p-values for other time points and groups, such as pre-op and post-RT, do not show statistical significance. The data indicates considerable variation in values across different groups and time points, with statistical significance emerging at specific intervals for certain variables.

5. HORIZONTAL ADDUCTION- Statistical analysis shows no significant differences across groups at most time points, suggesting similar recovery trends among types of neck dissections. Pre-radiotherapy (Pre-RT), MRND returns to its baseline value, while SOHND and ESOHND exhibit slight variations.

6. INTERNAL (MEDIAL) ROTATION- Statistical analysis reveals no significant differences between the types at most time points, indicating comparable recovery trends among the types of neck dissections.

7. EXTERNAL(LATERAL) ROTATION- Statistical analysis reveals no significant differences between groups at any time points, suggesting comparable recovery patterns across different surgical approaches.

DISCUSSION

Anatomical and Neurophysiological Basis of Shoulder Morbidity

The vulnerability of the SAN is anatomically determined. Leipzig et al. observed that, near its entrance into the sternocleidomastoid muscle (SCM), the nerve frequently divides, its trapezius branch continuing medially and becoming susceptible to transection or strong traction during clearance of nodes beneath the lower SCM and within the posterior cervical triangle.[1] The trapezius, however, does not depend upon the SAN alone. Combined clinical and electrophysiological studies by Soo et al. in patients whose SAN and/or cervical contributions had been divided demonstrated graded wasting across the three portions of the muscle; excision of the upper SAN reproduced the deficit of complete nerve loss, establishing the primacy of the upper trunk, and led the authors to postulate an additional, hitherto undescribed motor supply to the trapezius beyond the SAN and cervical plexus — a contribution that may explain why some patients tolerate classical RND with unexpectedly few signs.[3] This concept is reinforced by Pu et al., who attributed the partial trapezius denervation seen even after SAN-sparing MRND to interruption of motor input from the ventral rami of C2–C4, and argued that preservation of these cervical branches conserves motor function without compromising clearance, since posterior triangle nodes are seldom involved in head and neck squamous carcinoma.[2]

A second, distinct deformity is atrophy of the SCM itself. In an anatomical and electromyographic study, Ohtawa et al. attributed post-ND SCM atrophy to intraoperative insult to its innervation, blood supply or substance — including traction injury to the thin intramuscular nerve fibres, muscular fibrosis arising from intramuscular haematoma, and muscular detrition from surgical handling.[4] Their cadaveric dissections characterised two patterns of SAN ingress into the SCM: a penetrating type, in which the nerve traversed the muscle at a mean depth of 8.8 mm (range 4–15 mm), and a non-penetrating type, in which the truncal SAN ramified toward the SCM and trapezius a mean of 12.7 mm (range 4–32 mm) proximal to the ingress site. Critically, in 90.8% of specimens the nerve ingress lay at or cranial to the carotid bifurcation — an observation with direct surgical implications considered below.[4]

Finally, post-ND pain is not a single entity. Two mechanisms operate: neuropathic pain within the distribution of the superficial cervical plexus, and myofascial pain associated with trigger points in the head and neck musculature and closely linked to SAN dysfunction. Roh et al. demonstrated that sacrifice of the sensory cervical rootlets, over and above SAN sacrifice, is a major and independent contributor: in their cohort myofascial pain localised most often to the levator scapulae (43%), trapezius (32%) and rhomboideus (15%), while allodynia, hyperpathia and shoulder pain were all significantly more frequent in the nerve-removed than the nerve-preserved group (shoulder pain 69% versus 9%).[5]

Comparative Morbidity Across Dissection Types

Radical neck dissection carries the heaviest functional burden. Leipzig et al. graded shoulder dysfunction in 60% of classic RND patients, against 50% with nerve-only preservation and 30% with combined nerve, muscle and vein preservation, and noted that nerve-sparing procedures produced less associated pain even when the disability was comparable.[1] Consistent with this, Dijkstra et al. found that 70% of RND patients reported pain before hospital discharge, trapezius paralysis producing loss of scapular rotation and impaired abduction beyond 90°;[6] Krause et al. recorded severe ROM limitation combined with severe pain in 31% of RND patients at a mean of 29 months;[7] and Fialka et al. documented severe or strong shoulder pain in 77% of RND patients within six months of surgery.[8] Cheng et al., combining subjective and objective assessment, reported shoulder pain in all RND patients and shoulder droop in 80%.[9]

Preservation of the SAN in modified radical dissection substantially reduces, but does not abolish, this morbidity; complaints persist in 31–60% of patients. Remmler et al. characterised the post-MRND course as a temporary, reversible phase of trapezius dysfunction — a mild but statistically significant reduction in upper and middle trapezius strength with electrodiagnostic evidence of denervation — that recovered to a ROM comparable with nerve-sacrificing procedures at later follow-up, in contrast to the profound and permanent morbidity of RND; notably, abduction beyond 90° remained possible even after nerve sacrifice, through the compensatory scapular rotation of serratus anterior.[10] Shah et al. and Saunders et al. independently confirmed significantly fewer shoulder-related symptoms after MRND than RND beyond six months,[11,12] and El Ghani et al. quantified the gap, with 50% of RND patients reporting severe activity disability compared with under 26% after MRND.[13] Short et al. similarly found that SAN preservation conferred less pain, less disability and greater strength.[14]

Selective neck dissection is associated with the least morbidity. Cheng et al. found that the SND group sustained the least SAN damage, shoulder strength returning to preoperative levels by six months;[9] Umeda et al. reported preserved shoulder function in 90 of 96 SAN-sparing dissections at three months, against severe limitation after all nerve-sacrificing procedures;[15] and Carr et al. found no or only mild upper-limb dysfunction in 77% of SND patients.[16] Selective dissection is nonetheless not free of morbidity: Van Wilgen et al. reported long-term pain in 28% of patients, particularly on overhead reaching or carrying,[17] while the earlier functional-dissection data of Zibordi et al., comparing SCM-, SAN- and internal-jugular-preserving dissection with RND, established the comparative framework on which this literature rests.[18]

Several studies place the three procedures upon a single gradient of morbidity. Kuntz et al. confirmed that RND and MRND impair quality of life more than SND in the early period, although the MRND–SND difference had disappeared by six months; the same work drew on Sobol's earlier observation of a progressive improvement in shoulder function and electromyographic findings from RND through MRND to supraomohyoid dissection.[19] Rogers et al. found the highest shoulder disability after RND and the lowest after SND, the latter indistinguishable from patients who had never undergone dissection,[20] and both Nibu et al. and Goldstein et al. concurred that RND produces the greatest impairment and SND the least, selective-dissection symptoms tending to improve over time while radical-dissection deficits do not.[21,22] Even minimally morbid SND, however, measurably reduces function relative to controls, as shown by Inoue et al., by Oz and Memis, and by Watkins et al.;[23,24,25] Guldiken et al. likewise recorded pain and stiffness scores at final follow-up that remained worse than baseline despite minimal measurable disability.[26]

The Role of Level V and Level IIb Dissection

The extent of dissection within a nerve-sparing operation independently affects outcome. Terrell et al. demonstrated that, among CN XI-sparing dissections, inclusion of level V significantly worsened shoulder and neck pain and physical function relative to dissections that omitted it — the longer posterior-triangle course of the skeletonised nerve increasing traction risk — and that the very act of skeletonising the nerve to preserve it is traumatic enough to provoke dysfunction.[27]

Cappiello et al. confirmed that level V dissection augments shoulder morbidity, and that subclinical nerve impairment is detectable even after level II–IV dissection when the submuscular recess is routinely cleared.[28]
When shoulder dysfunction arises in the absence of level V dissection, level II is the likely site of injury. Hinsley et al. showed that during level II clearance the SAN, identified at the anterior SCM border and skeletonised antero-superiorly deep to the posterior belly of digastric, is most at risk at that superior point, where its transition from a lateral to a medial position relative to the internal jugular vein (IJV) may in turn place the vein at risk; their intraoperative survey found a striking predominance of the lateral orientation of the nerve.[29] Building on the same rationale, Shah et al. argued that, because isolated level IIb involvement is uncommon, omission of level IIb clearance may spare the neuropraxia of traction and elevation without compromising oncological safety.[30] Celik et al., studying level IIb-preserving SND, found no significant clinical difference in shoulder movement or strength despite measurable electrophysiological change.[31]

Electrophysiological Change Versus Clinical Morbidity
A recurring theme across this literature is the dissociation between electrodiagnostic and clinical findings. Koybasioglu et al. recorded statistically significant reductions in distal SAN latencies and compound muscle action potentials at three weeks and three months, with resolution of motor-unit-potential loss by late follow-up.[32] Celik et al. found electromyographic abnormalities peaking at day 21 with no corresponding clinical deficit,[31] and the denervation documented by Remmler et al. likewise recovered clinically.[10] Together these data indicate that intraoperative nerve monitoring and serial electromyography detect subclinical injury earlier and more sensitively than clinical examination, but that such changes frequently do not translate into lasting functional loss.

Quality of Life, Occupational and Functional Impact
Beyond measurable impairment, shoulder syndrome carries substantial participation and occupational costs. Schuller et al. found that only 51.2% of 203 previously employed patients returned to their usual occupation, with comparable unemployment after MRND and RND.[33] Shone et al. reported that 77% of unilateral RND patients struggled with everyday tasks such as dressing, grooming and overhead reaching, that 19.5% abandoned recreational activities, and that 46% of previously employed patients ceased work specifically because of shoulder problems.[34]
The most granular functional data derive from the work of Gane et al. In a systematic synthesis they reported that shoulder pain, droop and loss of active abduction were most frequent after RND and least after SND, that preservation of the cervical root branches sharply reduced pain incidence (14% versus 69% when the branches were resected), and that pooled range-of-motion data across earlier cohorts documented progressively greater losses of abduction and flexion with more extensive dissection.[35] In a subsequent controlled study the same group found that SAN-preserving dissection left patients with an 11–31% reduction in cervical mobility, a 9–18% reduction in shoulder mobility, and deficits of 25–47% and 34–39% in neck and shoulder strength respectively relative to healthy controls, with no difference between SND and MRND — leading them to argue that the neck, and the dissection as a whole rather than SAN status alone, should be regarded as the source of impairment, and to endorse active physical therapy.[36] Their demonstration of persistent deficits against healthy rather than contralateral controls echoed the Dutch data of Speksnijder et al. and underscored that the unaffected side is an unsuitable comparator.[37] Eickmeyer et al. added quantitative benchmarks: nerve-sparing surgery limited shoulder flexion and abduction to approximately 140–160°, and nerve-sacrificing surgery to below 140°, persisting up to one year postoperatively.[38]

Strategies for Prevention and Rehabilitation
Several converging strategies emerge from the evidence. The first is preservation of neural structures beyond the SAN trunk: Roh et al. showed that sparing the sensory cervical rootlets significantly reduces neuropathic and myofascial pain,[5] and Pu et al. that conserving the C2–C4 contributions preserves trapezius motor input.[2] The second is anatomically informed technique to prevent SCM atrophy: on the basis of their cadaveric findings, Ohtawa et al. proposed limiting nodal clearance to the carotid bifurcation (below which the SCM-innervating branches rarely arise), identifying and conserving the SAN–cervical nerve relationship, handling the SCM gently to avoid intramuscular nerve injury and haematoma, and preserving the superior thyroid and subclavian arterial branches to the muscle.[4] The third is judicious limitation of the extent of dissection — omission of level V where oncologically feasible,[27,28] and of level IIb where nodal risk is low.[29,30] The fourth is minimisation of the operation itself: Murer et al. demonstrated significantly lower disability after sentinel node biopsy without SAN dissection than after elective ND, defining a benchmark for minimal-intervention approaches.[39] Finally, across every dissection type, structured postoperative physiotherapy is repeatedly emphasised — by Goldstein, by Gane and by Shah — as essential to counter adhesive capsulitis and to maximise functional recovery.[22,30,36]

CONCLUSION
This study compared shoulder ROM across seven planes of movement in patients undergoing MRND (n=3), SOHND (n=2), and ESOHND (n=4) for HNSCC, at multiple time points from the immediate postoperative period through three months post-radiotherapy. MRND consistently yielded the highest mean ROM values across all measured parameters, while ESOHND demonstrated the lowest, with SOHND occupying an intermediate position. This pattern is consistent with the well-established inverse relationship between the extent of SAN dissection and functional shoulder outcome, corroborated by four decades of literature from Leipzig et al.[1] to Gane et al.[35]
Statistically significant inter-group differences were confined to abduction at post-RT two months (p=0.019), and horizontal abduction at Day 2 (p=0.014) and Day 3 (p=0.009) postoperatively. The absence of significance across most

parameters must be interpreted in the context of the limited cohort size, which substantially constrains statistical power. The directional trends, however, are clinically meaningful and sustained throughout follow-up. SOHND showed progressive improvement in abduction during the post-radiotherapy period, consistent with resolution of neuropraxia and compensatory muscular adaptation, as previously described by Remmler et al.[10]

Importantly, even ESOHND — a nerve-sparing procedure — exhibited the lowest ROM values, underscoring that functional morbidity does not arise from SAN sacrifice alone. Traction injury, devascularisation, and disruption of C2–C4 motor contributions to the trapezius, as detailed by Pu et al.[2] and Ohtawa et al.[4] are operative in all dissection types. Gane et al.[36] similarly demonstrated that the ND as a whole — not merely SAN status — is a source of motor impairment. These observations collectively argue for intraoperative nerve monitoring, meticulous tissue handling, and limiting dissection to oncologically necessary levels.

The oncological imperative must remain primary; the choice of dissection type should be governed by nodal staging and tumour characteristics rather than functional considerations alone. Nevertheless, structured postoperative physiotherapy rehabilitation — strongly endorsed by Shah et al.[30] and Gane et al.[36] — must be considered an integral component of care across all dissection types. Future studies with larger prospective cohorts, standardised goniometric protocols, patient-reported outcome measures, and extended follow-up are warranted to establish definitive functional benchmarks and guide evidence-based surgical planning in HNSCC.

The literature is consistent: the extent of neck dissection directly determines the magnitude and permanence of shoulder morbidity, with RND producing the greatest and most lasting dysfunction, MRND an intermediate and largely reversible deficit, and SND with SAN and cervical-branch preservation the least. The underlying mechanisms — SAN transection or traction, interruption of the C2–C4 motor contribution, SCM devascularisation and sacrifice of the sensory cervical plexus — are individually identifiable and, to a considerable degree, individually preventable. Meticulous identification of the SAN at the digastric–IJV interface, avoidance of level V and, where oncologically safe, level IIb, preservation of the cervical rootlets, and structured rehabilitation together constitute the current evidence-based approach to minimising shoulder syndrome. Electrophysiological monitoring affords early and sensitive detection of nerve injury that clinical examination may miss, although such subclinical change frequently recovers. The recurring observation that morbidity persists even after nerve-preserving dissection, and that it correlates with the dissection as a whole rather than with SAN status alone, argues for continued refinement of technique, for standardised patient-reported outcome measurement, and for routine rehabilitation across all dissection types.

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