ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 4, Issue – 6, November - 2021, Page No. : 64 - 72

Evaluation of masticatory function in operated cases of adult bilateral temporomandibular joint ankylosis treated with interpositional arthroplasty

[1]Ejaz Ahmad Mokhtar, Senior resident, Unit of Oral and Maxillofacial Surgery, Oral Health Sciences Centre, Postgraduate Institute of Medical Education and Research, Chandigarh,160012, India

[2]Sumit Kumar Roy, Senior Lecturer Prosthodontics and Crown and Bridge, Buddha Institute of Dental Sciences and Hospital

[3]Sumit Verma, Senior lecturer Oral and Maxillofacial Surgery, DR. B.R. Ambedkar institute of dental sciences and hospital

[4]Pallavi Priyadarshini, MDS, Oral and Maxillofacial Surgery, Buddha Institute of Dental Sciences and Hospital

[5]Pawan Kumar, MDS, Prosthodontics, Patna Dental College and Hospital, Patna

[6]Qalbi Fatima, MDS, Periodontics, Buddha Institute of Dental Sciences and Hospital

Corresponding Author: Ejaz Ahmad Mokhtar, Senior resident, Unit of Oral and Maxillofacial Surgery, Oral Health Sciences Centre, Postgraduate Institute of Medical Education and Research, Chandigarh, 160012, India

Citation of this Article: Ejaz Ahmad Mokhtar, Sumit Kumar Roy, Sumit Verma, Pallavi Priyadarshini, Pawan Kumar, Qalbi Fatima, "Evaluation of masticatory function in operated cases of adult bilateral temporomandibular joint ankylosis treated with interpositional arthroplasty", IJDSIR- November - 2021, Vol. – 4, Issue - 6, P. No. 64 – 72.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Temporomandibular joint ankylosis makes masticatory functions like biting, chewing, and trituration of food difficult. A knowledge gap exists on masticatory function post ankylosis release. In this paper, masticatory functions were analyzed by two different ways, by calculating maximum voluntary bite force and additionally by measuring chewing efficiency in twenty-five adult treated patients of bilateral temporomandibular joint ankylosis treated with interpositional arthroplasty. Our research paper included two groups; study group (Group A) who had completed at least one year follow up post-surgery while twenty-five sex, age, and weight-matched normal subjects were included in control group (Group B). The mean maximum voluntary bite force was calculated by placing strain gauge transducer between first molar tooth. Chewing efficiency calculated by chewing manually joined two contrast colored gum strips for several chewing cycles (5-50). Inferential t-test was used to check statistical significance. Maximum voluntary bite force was 237.9 ± 68.5 N for Group A and 530.6±70.5 N for Group B. Maximum voluntary bite force for ankylosis patients was 44.7 % of normal subjects. Chewing efficiency was 26.4%, 23.4%, 22.3%,

21.4% and 20.8% less at 5, 10, 20, 30 and 50 strokes for ankylosis patients. In conclusion, interpositional arthroplasty to treat bilateral temporomandibular joint ankylosis patients mainly affect maximum voluntary bite force but chewing efficiency is only slightly affected.

Keywords: masticatory function, chewing efficiency, interpositional arthroplasty, maximum voluntary bite force, muscle atrophy, TMJ ankylosis.

Introduction

Bilateral temporomandibular joint (TMJ) ankylosis is an extremely rare condition, usually caused by trauma involving bilateral mandibular condyle and symphysis [1]. It is a debilitating condition that affects the quality of life of individuals due to reduced mouth opening. The individuals are unable to masticate food due to reduced mouth opening. To increase mouth opening, a variety of treatment protocols are followed which ranges from gap arthroplasty, interpositional arthroplasty (IA) to TMJ replacement. The successful outcome of the treatment has been considered to lessen recurrence and to attain good mouth opening however, no focus had been given in measuring masticatory function. The capability of these different treatment protocols to reinstitute masticatory function (MF) is still unknown.

The MF function includes a complex synchronous action of hard and soft tissue elements of joint involving condylar process and the muscles of mastication. It includes three stages, which are manipulation then trituration, and finally consolidation of food bolus [2]. A number of factors that influence the MF incorporate muscular activity, range of mandibular movement, mouth opening and, bite force [3]. Bite force tests determine patient's capability to triturate food and are related to the integrity of the stomatognathic system. Moreover, ample literature supports MVBF to be an index of MF, showing the functional condition of the stomatognathic system [2,4,5]. Any disorder in the joint elements have negative effect on the MF. Bite force variations are seen between each tooth of oral cavity and maximum bite force is measured between occluding first molar [6]. Several factors that influence MVBF are the status of the dentition, the power of the jaw elevator muscles, pain threshold of the subject, degree of jaw opening, and muscle length. Furthermore, chewing efficiency (CE) is also used to measure MF. Several ways had been used to measure CE which includes calorimetric method, evaluation of occlusal wear of posterior tooth, and digital method. Several pieces of literature suggest digital method is most authentic [7,8]. To our knowledge to date no published studies had measured MF objectively in post-operative bilateral TMJ ankylosis patients. The study aimed to analyze MVBF and CE in adult bilateral TMJ ankylosis cases treated with interpositional arthroplasty.

Methodology

The research was accepted by the institutional ethical committee. The study was conducted in Postgraduate Institute of Medical Education and Research, Chandigarh, India from 12 September 2018 to 31 December 2019. 25 operated patients of bilateral ankylosis who were treated with interpositional arthroplasty and had completed at least one-year post surgery were included in the study. These patients were treated between the year 2008-2017. This study was prospective. Study group, Group A included 25 operated bilateral ankylosis patients. 25 normal subjects who were sex, age and weight-matched with that of ankylosis patients constituted control group (Group B). The patient age, side involved in ankylosis, pre- and post-operative mouth opening and, condition of remaining tooth was enumerated (Table 1). Patients with lost first molar tooth, having temporomandibular joint disorder, and patients under active fixed orthodontic treatment were excluded.

Bite force measurement procedure

MVBF was measured with a strain gauge transducer which was made with help from Punjab Engineering College, Mechanical Department, Chandigarh. The transducer incorporates compression load cell which has the capacity to measure load up to 5000N with ±.3 % precision. The height and width of the load cell were 13 mm and 6 mm respectively. Thermoplastic sheet was placed over steel metal fork for cushioning effect. The electric potential was measured by designed software using a Lab view platform that was connected to the bite force device. The software could take 80 readings per second and could record bite force ranging from 0-1300 Newton. The MVBF was calculated between upper and lower first molar teeth. Each subject was instructed to sit erect maintaining the Frankfort horizontal plane parallel to the floor. Both of the groups were asked to bite on the metal fork 3 times between occluding molars on each side, resting for 20 seconds between consecutive readings. The mean of all the three values was considered as mean MVBF. The metal fork was covered with a disposable polyethylene sheet to prevent cross-infection.

Methodology for calculating chewing efficiency (CE)

CE was computed by using two contrasting colored chewing gum strips. Strips of 3 cm were cut from taped chewing gum (Hubba-Bubba) of two different colors and flavors 'Sour Berry' (azure color) and 'Fancy Fruit' (pink color) which were stuck manually to form composite strip (Fig.1). The subject was asked to chew the separate test strip for each of the 5, 10, 20, 30, and 50 strokes (Fig.2). One minute gap was given among all chewing cycles, to reduce muscle fatigue. All chewed gum was then flattened to 1mm thick wafers by compressing it between glass slabs and maintaining a space of 1mm with the help of Biostar sheet. The chewed gum wafers were then collected into separate transparent plastic bags and marked. Both sides of the wafers were scanned by Runner IR 5075 (Canaon) with a resolution 600 dots per inch. The computerized analysis was carried out with the help of Adobe Photoshop 2.0®. The scanned image of fixed size (1175 · 925 pixels) was stored in Adobe Photoshop format (*.psd). As a reference scale scanned image of unmixed gum was copied in each image (area of 4779 pixels). The Magic wand' tool at a tolerance of 30 was used to select unmixed part of image on each side using the 'Histogram in Abode photoshop. Tolerance and mean of each figure were calculated. Unmixed Fraction (UF) ratio was calculated by using the equation:

$(\text{Pixel}_{\text{azure a}} + \text{Pixel}_{\text{azure b}}) - 2 \times \text{Pixels of scale} / 2\times\text{Pixel}_{\text{all}}$

Unmixed percentage was computed by multiplying the result by 100. CE was calculated by subtracting unmixed percentage between Group A and Group B.

Statistical Analysis

The results were analyzed using SPSS version 18 (IBM Corporation, SPSS Inc, Chicago, IL, USA). Interpretation of results was carried out by descriptive and inferential statistical analysis. The results on categorical measurement were presented as Frequency (Percentage). Inferential t-test was used to check the statistical significance. A P-value of < 0.05 was considered significant.

Result

Demographic data

Group A and Group B had 14 males and 12 females each. The mean age for Group A was 23.9±3.3 years (range 21-31 years) and for Group B was 24.1±5.5years (range 21-31 years). The mean weight for Group A was 66.4±20 kg (range 36-92 kg) and for Group B was 68.6±24.6 (range 22-86 kg). The age and weight distribution were homogenous and comparable in both groups. The mean duration of ankylosis was 10.4±9.3 years. The mean maximum incisal opening for Group A pre operatively

and post operatively was 1.4 mm and 32.9 mm respectively. The cause of TMJ ankylosis was trauma in 80% and infection in 20 %. The age and weight distribution were homogenous and comparable in both groups

Bite Force between Group A vs Group

The MVBF in Group A was 237.9 ± 68.5 N. In Group B MVBF was 530.6±70.5 N. Percentage-wise MVBF in ankylosis patients was 44.7% (P value= 0.003*) of normal subjects (Fig. 3).

Chewing efficiency between Group A vs Group

Table 2 showed the mean unmixed color fraction in Group A and Group B at 5, 10, 20, 30, and 50 strokes. There was a gradual reduction in unmixed color percentage with each increasing chewing stroke in both of the groups. Proportion of unmixed color percentage remained high in Group A than Group B (Fig. 4). Chewing efficiency was 26.4%, 23.4%, 22.3%, 21.4%, and 20.8% less at 5, 10, 20, 30 and 50 strokes for ankylosis patients as compared to normal subjects. The result was significant only for the last two strokes (30, 50). Overall CE was 22.8% for less for Group A.

Discussion

Several treatment protocols are followed for the treatment of bilateral TMJ ankylosis. These range from interpositional arthroplasty to total TMJ replacement. There is an ongoing debate for the best treatment modality for the management of bilateral TMJ ankylosis. Many recent literatures suggest TMJ replacement with alloplastic total joint. They advocate that total TMJ replacement with alloplastic joint prevent reankylosis and those patients also have good mouth opening, however not a single study focused on status of MF post ankylosis release of bilateral ankylosis patients. In this study, MVBF was compared with normal age and sex-matched subjects. MVBF was 530.6±70.5 N for normal subjects. The values were inconsistent with the finding of Varga et al [9], Kamegai et al, [10] and Braun et al. [11] The mean MVBF seen in bilateral ankylosis patients was 237.9 ± 68.5 N. Bilateral ankylosis patients can generate 44.7 % of force than normal subjects. In other words, it can be said bilateral ankylosis patients had 55.3 % less MVBF than normal subjects. This can be explained by known fact of Hellinger [12], had mentioned that bony ankylosis often may be accompanied by disuse muscle atrophy. In bilateral TMJ ankylosis due to the long duration of immobilization both sides of masticatory muscle might have undergone significant amount of muscle atrophy comparing to unilateral cases. Moreover, these findings were also inconsistent with the study of Tsukamoto [13] and Takasu [14] who had seen that prolonged disuse of muscle lead to atrophy of the muscle.

Amid surgery detachment of temporalis and masseter muscles took place while exposing the ankylotic mass. Even detachment of a single muscle brings about significant reduction in muscle strength hence at least one-year gap was given following ankylosis release, which was ample for adaptation of muscle of mastication.

In the recent era alloplastic joint replacement (TJR) is being advised with a promising result for regaining TMJ function in patients of TMJ ankylosis and other pathology [15, 16, 17]. Linsen et al [18] had evaluated MVBF after total TMJ replacement in 8 patients and total of 15 joints of both unilateral and bilateral TMJ ankylosis, having desperate pathology. They had found it to be 189.67 ± 130.33 N. They also used comparable strain-gage bite force transducer as used in this study. Our study group of patients generated higher bite force than the patients managed with TJR in their study (237.9 ± 68.5 N vs 189.67 ± 130.33 N). We could spot merely a single study by Linsen et al to compare. TJR devices have a limited

life span and they are mechanical in nature rather than biological.

MVBF computed in bilateral ankylosis patients was more than the minimum force needed for chewing of usual foodstuff which ranges from 50 –120 N. Hence, after IA although bite force was decreased, however it was adequate for normal chewing as confirmed by correlating CE with normal subjects.

Sharma et al [19] in a questionnaire on post-operative effect of ankylosis release in TMJ ankylosis patients. They noticed substantial increase in CE, however, in this paper, no identification of CE was performed. In our study CE was evaluated by computerized digital method as performed by Schimmel et al. [20]. A gradual reduction in unmixed color fraction was observed in both groups with increasing chewing strokes. Overall CE of bilateral ankylosis patients was 77.8 % than that of control group. The difference could be explained by disuse atrophy of bilateral masticatory muscles and also greater degree of muscle stripping in bilateral ankylosis cases.

This paper has undoubtedly shown that IA in bilateral ankylosis patients could restore MF to normal subjects as CE of more than 75% could be restored. However, MVBF was affected to greater extent due to muscle atrophy.

In a nutshell, interpositional arthroplasty to treat bilateral TMJ ankylosis patients mainly affects maximum voluntary bite force but chewing efficiency is moderately affected as it demands a lesser component of force.

Ethical approval: Ethical approval was obtained from the Institutional Ethics Committee PGIMER Chandigarh vide letter No. NK/4640/MDS/163.

Patient Consent: Written consent was obtained from the patients.

References

1. Benaglia MB, Gaetti-Jardim EC, Oliveira JG, Mendonça JC. Bilateral temporomandibular joint ankylosis as sequel of bilateral fracture of the mandibular condyle and symphysis. Oral and maxillofacial surgery. 2014 Mar;18(1):39-42.
2. Curtis DA, Plesh O, Miller AJ, Curtis TA, Sharma A, Schweitzer R, Hilsinger RL, Schour L, Singer M. A comparison of masticatory function in patients with or without reconstruction of the mandible. Head & Neck: Journal for the Sciences and Specialties of the Head and Neck. 1997;19(4):287-296. [doi: 10.1002/(sici)1097-0347(199707)19:4<287::aid-hed7>3.0.co;2-x]
3. Sybil D, Gopalkrishnan K. Assessment of masticatory function using bite force measurements in patients treated for mandibular fractures. Craniomaxillofacial trauma & reconstruction. 2013; 6(04):247-250. [doi: 10.1055/s-0033-1356755]
4. Gonzalez Y, Iwasaki LR, McCall Jr WD, Ohrbach R, Lozier E, Nickel JC. Reliability of electromyographic activity vs. bite-force from human masticatory muscles. European journal of oral sciences. 2011; 119(3):219-224. [doi: 10.1111/j.1600-0722.2011.00823.x]
5. Kiliaridis S, Kjellberg H, Wenneberg B, Engström C. The relationship between maximal bite force, bite force endurance, and facial morphology during growth: A cross-sectional study. Acta Odontologica Scandinavica.1993: 51(5):323-331. [doi: 10.3109/00016359309040583]
6. Van Der Bilt A, Tekamp A, Van Der Glas H, Abbink J. Bite force and electromyography during maximum unilateral and bilateral clenching. European journal of oral sciences. 2008; 116(3):217-222. [doi: 10.1111/j.1600-0722.2008.00531.x]

7. Sato S, Fueki K, Sato H, Sueda S, Shiozaki T, Kato M, Ohyama T. Validity and reliability of a newly developed method for evaluating masticatory function using discriminant analysis. Journal of oral rehabilitation. 2003: 30(2):146-151.
8. Olthoff LW, Van der Bilt A, Bosman F, Kleizen HH. Distribution of particle sizes in food comminuted by human mastication. Archives of Oral Biology. 1984: 29(11):899-903.
9. Varga S, Spalj S, Lapter Varga M, Anic Milosevic S, Mestrovic S, Slaj M. Maximum voluntary molar bite force in subjects with normal occlusion. The European Journal of Orthodontics. 2010 Nov 9;33(4):427-33. [DOI: 10.1093/ejo/cjq097]
10. Kamegai T, Tatsuki T, Nagano H, Mitsuhashi H, Kumeta J, Tatsuki Y, Kamegai T, Inaba D. A determination of bite force in northern Japanese children. The European Journal of Orthodontics. 2005 Feb 1;27(1):53-7. [doi: 10.1093/ejo/cjh090]
11. Braun S, Bantleon HP, Hnat WP, Freudenthaler JW, Marcotte MR, Johnson BE. A study of bite force, part 1: Relationship to various physical characteristics. The Angle Orthodontist. 1995 Oct;65(5):367-72. [
12. Hellinger MJ. Bony ankylosis of the temporomandibular joint. Oral Surgery, Oral Medicine, Oral Pathology. 1964;18(3):293-302. [doi: 10.1016/0030-4220(64)90076-3]
13. Tsukamoto S, Umeda T, Tamari Y, Kawakatsu K. Electromyographic activities of jaw muscles in ankylosis of the temporomandibular joint. Oral Surgery, Oral Medicine, Oral Pathology. 1968; 25:117-130.
14. Takasu H, Matsunaga T, Morita T, Hiraba K, Kuroki K, Saito K, Fujiwara T, Goto S. Changes in masseter muscle fibers by liquid diet rearing in rabbits and recovery by chewing of solid diet. Archives of oral biology. 2019;108:1045-1048. [doi: 10.1016/j.archoralbio.2019.104548]
15. Rhee SH, Baek SH, Park SH, Kim JC, Jeong CG, Choi JY. Total joint reconstruction using computer-assisted surgery with stock prostheses for a patient with bilateral TMJ ankylosis. Maxillofacial plastic and reconstructive surgery. 2019 Dec;41(1):1-6.
16. Chowdhury SK, Saxena V, Rajkumar K, Shadamarshan RA. Evaluation of total alloplastic temporomandibular joint replacement in TMJ ankylosis. Journal of maxillofacial and oral surgery. 2019 Jun;18(2):293-8
17. Gonzalez-Perez LM, Gonzalez-Perez-Somarriba B, Centeno G, Vallellano C, Montes-Carmona JF. Evaluation of total alloplastic temporo-mandibular joint replacement with two different types of prostheses: a three-year prospective study. Medicina oral, patologia oral y cirugia bucal. 2016 Nov;21(6):e766.
18. Linsen SS, Reich RH, Teschke M. Maximum voluntary bite force in patients with alloplastic total TMJ replacement–a prospective study. Journal of Cranio-Maxillofacial Surgery. 2013;41(5):423-428. [doi: 10.1016/j.jcms.2012.11.037]
19. Sharma VK, Rattan V, Rai S, Malhi P. Quality of life assessment in temporomandibular joint ankylosis patients after interpositional arthroplasty: a prospective study. Int J Oral Maxillofac Surg. 2019;48(11):1448–1455.
20. Schimmel M, Christou P, Herrmann F, Müller F. A two-colour chewing gum test for masticatory efficiency: development of different assessment methods. Journal of oral rehabilitation. 2007;34(9):671-678.

Legend Tables and Figures

Table 1: Showing age of the 25 patients, cause of ankylosis, pre- and post-operative mouth opening and condition of remaining tooth

Case number	Age	Cause of ankylosis	Pre-operative maximum mouth opening (mm)	Post-operative maximum mouth opening (mm)	Condition of residual tooth
1	21	Trauma	0	32	37 carious
2	22	Trauma	1	33	NA
3	31	Infection	0	34	34,44 carious
4	27	Trauma	2	32	65 carious
5	31	Trauma	4	30	44 carious
6	22	Trauma	0	31	NA
7	23	Trauma	0	28	NA
8	23	Trauma	1	29	45 carious
9	20	Infection	3	30	NA
10	22	Trauma	2	31	NA
11	26	Trauma	0	29	37 carious
12	24	Trauma	1	30	NA
13	25	Trauma	0	30	NA
14	26	Trauma	0	32	45 carious
15	29	Trauma	2	34	48,37 carious
16	22	Trauma	0	35	NA
17	20	Trauma	4	36	22,45 carious
18	20	Infection	0	38	47 carious
19	21	Trauma	0	36	15 carious
20	22	Infection	3	34	48 carious
21	23	Trauma	2	36	478carious
22	23	Trauma	7	32	38 carious
23	24	Trauma	0	36	37,48 carious
24	25	Infection	2	38	47 carious
25	27	Trauma	2	38	35,37,27 carious

Table 2: Unmixed color fraction at 5, 10, 20, 30 and 50 strokes

Mean unmixed color percentage ± S.D.	Group A	Group B	% difference in unmixed color percentage=chewing efficiency	P value
5 strokes	80.3	53.9	26.4	1.3
10 strokes	70.5	47.1	23.4	.9
20 strokes	62.7	40.4	22.3	.08
30 strokes	45.5	24.4	21.4	0.01*
50 strokes	30.1	9.3	20.8	0.008*

Chewing efficiency at each stroke = % difference in unmixed color percentage at each stroke.

P< .05 significant

Overall chewing efficiency= sum of chewing efficiency at 5, 10, 20, 30 and 50 strokes/ 5

Fig. 1: Strips of 3 cm length were cut and manually stuck for giving subjects to chew for 5, 10, 20, 30 and 50 strokes

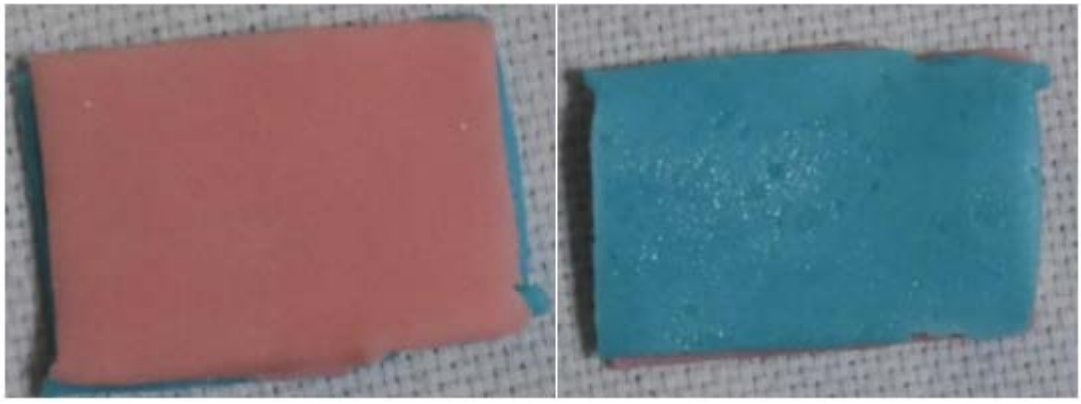

Fig. 2: Chewed chewing gum for 5, 10, 20, 30 and 50 strokes which will be further flattened to 1mm and then scanned for analyzing

Fig.3: Maximum voluntary bite force between bilateral ankylosis patients and normal subjects

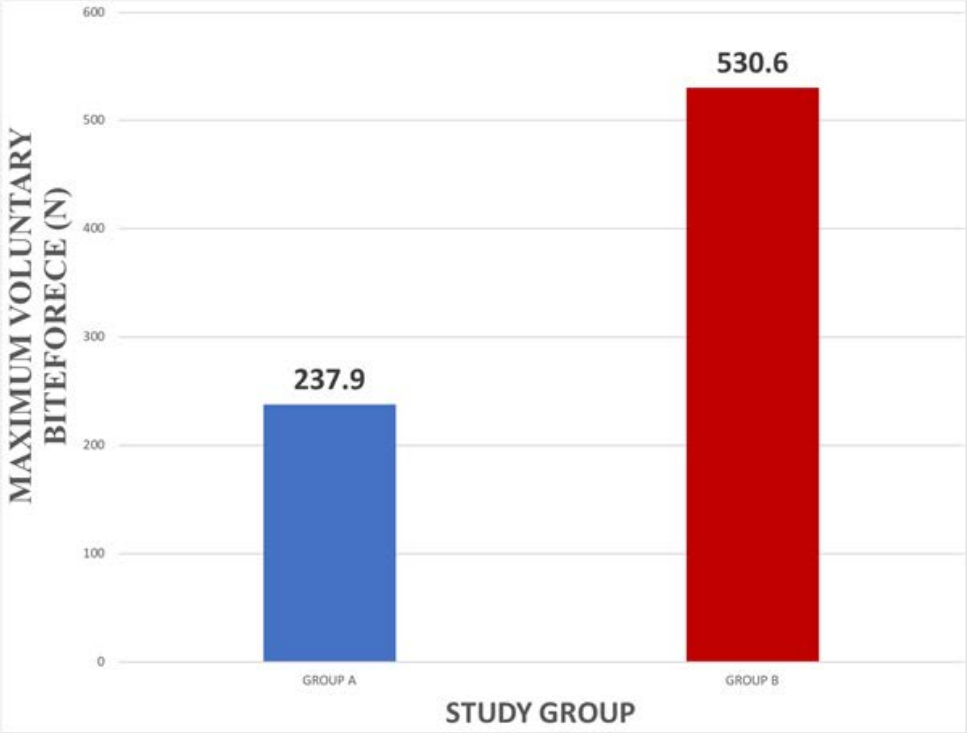

Fig.4: Unmixed color percentage between bilateral ankylosis patients and normal subjects