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Could children having bilateral temporomandibular joint ankylosis restore normal masticatory function post treatment with buccal pad of fat as Interpositional Arthroplasty

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Abstract

Temporomandibular joint ankylosis (TMJA) makes masticatory functions like biting, chewing, and trituration of food difficult. What happens to the masticatory function after release of bilateral TMJA in children is still unknown. In this study, masticatory functions in post-operative children were analyzed by two different ways (a) calculating maximum voluntary bite force and (b) measuring chewing efficiency. Twenty treated children of bilateral TMJA who were managed with buccal pad fat as interpositional arthroplasty were included in the study. There were two groups, study group (Group I) had 20 patients below the age of 12 years and had completed at least one year follow up post-surgery while twenty sex, age, and weight-matched normal subjects were included in control group (Group II). 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. A P-value of < 0.05 was considered significant. MVBF was 220.7±106.3 N for Group I and 256.7 ±95.0 N for Group II. MVBF for Group I was 86 % (P = 0.11) of Group II. Chewing efficiency was 12.4% (p= .34), 13.4% (p= .28), 11.3% (p= .22), 10.4% (p= .18), and 8.8% (p= .8) less at 5, 10, 20, 30 and 50 strokes for Group I as compared to Group II. Altogether chewing efficiency of bilateral ankylosis children post release was 88.8% (p= .17) of normal subjects. In conclusion, buccal pad fat (BFP) as interpositional arthroplasty in bilateral TMJA restore

masticatory function. Hence, in children with bilateral TMJ ankylosis, BFP is a good option for interpositional arthroplasty as masticatory function is not significantly affected as proven by maximum voluntary bite force and chewing efficiency.

Keywords: masticatory function, chewing efficiency, interpositional arthroplasty, maximum voluntary bite force, buccal pad of fat, TMJ ankylosis

Introduction

Bilateral temporomandibular joint (TMJ) ankylosis in children is extremely rare condition. It is usually caused by trauma involving bilateral mandibular condyle and symphysis or systemic infection.[1] TMJ ankylosis not only affect the growth and development of jaws but also have psychological effect on children due to facial deformity which is progressive with time. 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 attain good mouth opening, lessen recurrence, however but no focus had been given to masticatory function. The capability of these different treatment methods 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, trituration, and consolidation of food bolus.[2] Factors that influence the MF incorporate muscular activity, range of mandibular movement, mouth opening and, bite force.[3,4] Bite force test determines patient's capability to triturate food and are related to the integrity of the stomatognathic system.[4] Moreover, ample literature supports MVBF to be an index of MF, showing the functional condition of the stomatognathic system.[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 methods have been used to measure CE which includes calorimetric method, evaluation of occlusal wear of posterior tooth, and digital method. [7-11] Several pieces of literature suggest digital method to be most authentic. [10,11] 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 children having bilateral TMJ ankylosis cases treated with interpositional arthroplasty with buccal pad fat.

Material and method

The study was accepted by the Institutional ethical committee. The study was done in Postgraduate Institute of Medical Education and Research, Chandigarh, India from 12 September 2018 to 31 December 2019. 20 operated patients of bilateral ankylosis having age below 12 years and were treated with interpositional arthroplasty with BFP. Those patients who 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 in nature. Study group, Group A included 20 operated bilateral ankylosis patients. 20 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, mouth opening and, condition of remaining tooth was enumerated (Table 1). Patients with lost first molar tooth, having temporomandibular joint disorder were excluded.

Surgical procedure

Surgeries were performed under general anesthesia following standard AL kyat Bramley approach. The ankylotic bony mass was first exposed. Then the bony mass was totally removed using chisels, burs, and osteotomes and 1.0 – 1.5 cm space was created. Mouth opening was checked, if there was resistance to free mouth opening, ipsilateral coronoidectomy was done through the same incision. Contralateral coronoidectomy through intraoral approach was performed if mouth opening of 35 mm could not be achieved. A pedicled buccal pad of fat was used in the created space to stop heterotopic bone formation.[12] Sub-periosteal dissection was extended anteriorly to expose the anteromedial border of coronoid process. A retractor was placed for retraction at the anterior border of coronoid process. Blunt dissection with curved artery forceps was done anteromedial to coronoid process, exposing the fat, which was gently advanced. The BFP was then used fill the gap. Suction drain was inserted and wound was closed in layers. Post-operatively, jaw physiotherapy was started the day immediately after the surgery using either Ora bite in children with deciduous or mixed dentition or Heister jaw opener.

Maximum Voluntary Bite force measurement procedure

MVBF was measured with a strain gauge transducer which was made in Punjab Engineering College, Mechanical Department, Chandigarh. The transducer incorporated compression load cell which had the capacity to accurately measure compression 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 gum (Hubba-Bubba) of two different colors and were stuck manually to form composite strip (Fig.1). Each subject was asked to chew separate test strip for each of the 5, 10, 20, 30, and 50 strokes (Fig.2). A minimum of one-minute gap was given among all chewing cycles, to reduce muscle fatigue. All chewed gums were then made 1mm thick wafers by compressing it between slabs and maintaining a space of 1mm with the help of Bio star 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. Unmixed Fraction (UF) ratio was calculated by using the equation

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

CE was calculated by subtracting unmixed percentage between Group I and Group II.

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 I and Group II had 11 males and 9 females each. The mean age for Group I was 9.0±2.9 years (range 6-12 years) and for Group II was 9.1±2.5 years (range 6-12 years). The mean weight for Group I was 22.4±2 kg (range 20-38 kg) and for Group II was 22.6±2.6 kg (range 22-37 kg). The age and weight distribution were homogenous and comparable in both groups. The mean duration of ankylosis was 3.5± 2.2 years. The mean maximum incisal opening for Group I pre operatively and post operatively was 1.6mm and 33.2 mm respectively. The cause of TMJ ankylosis was trauma in 83% and infection in 17% cases. The age and weight distribution were homogenous and comparable in both groups

Maximum Voluntary Bite Force between Group I and Group II

The MVBF in Group I was 220.7±117.3 N. In Group B MVBF was 256.8 ±95.0 N. MVBF in ankylosis patients was 85.9 % (P = 0.1) of normal subjects (Fig. 3).

Chewing efficiency between Group I and Group II

The mean unmixed color percentage in Group I and Group II at 5, 10, 20, 30, and 50 strokes. Proportion of unmixed color percentage remained high in Group I than Group II (Fig. 4). Chewing efficiency 12.4%, 13.4%, 11.3%, 10.4%, and 8.8% less at 5, 10, 20, 30 and 50 strokes for ankylosis patients as compared to normal subjects. The result was not statistically significant for any of the 5,10, 20, 30, and 50 strokes. Altogether chewing efficiency of Group, I was 88.8% (p= .0002) of Group II.

Discussion

Several treatment protocols are followed for the treatment of bilateral TMJ ankylosis in children. These ranges from interpositional arthroplasty to total TMJ replacement. There is an ongoing debate for the best treatment modality for the management of bilateral TMJ ankylosis. Costochondral graft has been considered as good treatment option due its anatomic and biologic similarity with mandibular condyle. Additionally, it has growth and regenerative potential.[13,14,15] Ko, Huang and Chen[15] reported mandibular prognathism in two cases of bilateral TMJ ankylosis in children managed with costochondral graft which later required orthognathic surgery. Many recent literatures have suggested TMJ replacement with alloplastic total joint. They have advocated that total TMJ replacement with alloplastic joint prevent reankylosis and these patients had good mouth opening, however there is not a single study that has focused on status of MF post ankylosis release of bilateral ankylosis patients. In this study, MVBF was

compared with matched subjects. Bite force of children were measured 256 N in our study. The values were in consistent with the finding of Kamegai. [16] The mean MVBF seen in bilateral ankylosis patients and normal subjects was 220.7 ± 105.1 N and 256.7 ± 129.5 N respectively which showed almost equivalent MVBF value in bilateral patients than normal subjects. The difference in bite force was not significant. Hellinger[17] had mentioned the fact that bony ankylosis often accompanied by disuse muscle atrophy or poor muscular development in children. However, as in children duration of ankylosis was short so irreversible atrophy of muscle had not taken place as suggested by Hellinger.

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.

Another test that measured masticatory function was chewing efficiency. Sharma et al [18, 19] in a questionnaire on chewing efficiency post-operative ankylosis release had 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 88.8 % than that of control group.

The study clearly proved that buccal pad of fat as interpositional arthroplasty restored normal masticatory function as both chewing efficiency and MVBF were negligibly affected. From the last three decades the fat, either buccal fat pad or abdominal fat are highly recommended over temporalis muscle as interpositional material. [21, 22, 23, 24] The fat apart from obliterating dead space also has intrinsic quality to prevent heterotrophic bone formation. [12, 25, 26] Between buccal fat pad and abdominal fat, the advantage of buccal fat pad is that it is harvested adjacent to the surgical site. Additionally, it is pedicled. However, for harvesting abdominal fat second surgical site is needed and also it is not pedicled. [26] The method for harvesting buccal fat pad was described by Rattan [12]. It has adequate bulk (around 10-12 cc) and lies closely to TMJ and can be easily harvested extra orally from same surgical site. It converts microenvironment from osteogenic to adipogenic hence preventing osteogenesis. In long-term BFP was found viable for years.[26]

Alloplastic TJR is currently performed frequently to reinstitute joint function in recurrent cases of bilateral TMJ ankylosis patients.[27] However, as these devices have small life span and are mechanical rather than biological in nature hence, it not a suitable option in the young and growing patient. The main issue with TMJ TJR devices is the longevity of and their lack of growth potential in itself. Moreover, these devices are quite expensive making them unavailable for majority of population.

In a nut shell, buccal fat pad as interpositional arthroplasty is effective in reinstituting masticatory function in bilateral TMJ ankylosis. More studies are required in this direction to test masticatory function of patients being treated with different protocols to find out best method for the management of TMJ ankylosis.

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Legend Tables and Figures

Table 1: Showing age of the 20 patients, cause of ankylosis, side involved, pre- and post-operative mouth opening

Sn.	Age	Cause of ankylosis	Pre-operative maximum mouth opening (mm)	Post operative maximum mouth opening (mm)
1	8	Trauma	0	30
2	9	Trauma	1	32
3	9	Infection	1	31
4	10	Trauma	0	31
5	7	Trauma	4	30
6	9	Unknown	0	31
7	8	Trauma	0	28
8	10	Unknown	1	29
9	11	Infection	3	32
10	8	Unknown	0	31
11	9	Trauma	0	29
12	6	Trauma	1	30
13	8	Trauma	0	30
14	7	Trauma	0	32

15	7	Unknown	2	34
16	7	Trauma	5	33
17	11	Trauma	4	34
18	10	Unknown	0	38
19	12	Trauma	0	36
20	11	Unknown	3	34

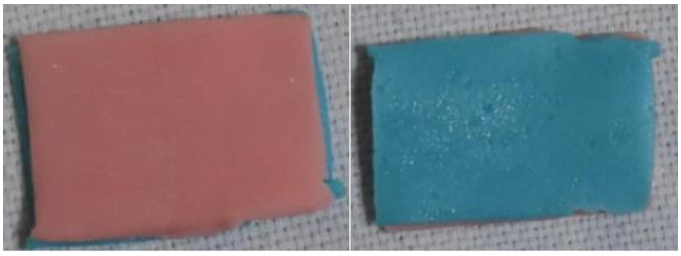

Fig.1: Strips of 3 cm length were cut and manually stuck for giving subjects to chew for 5, 10, 20, 30 and 50 strokes

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

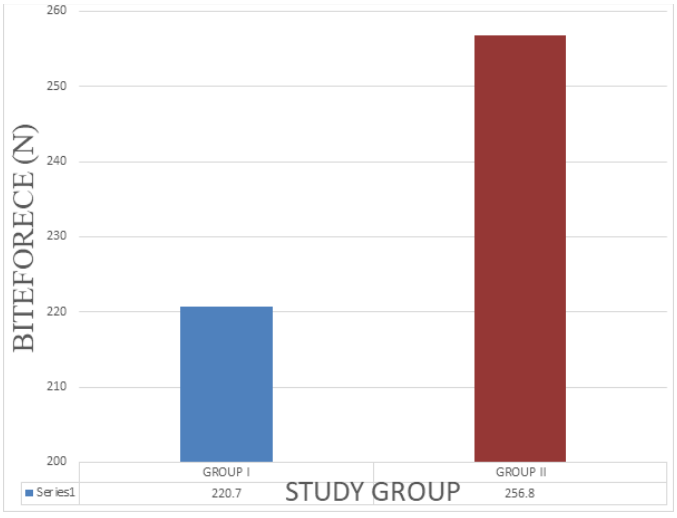

Fig.3: Maximum voluntary bite force between bilateral ankylosis patients and normal subjects

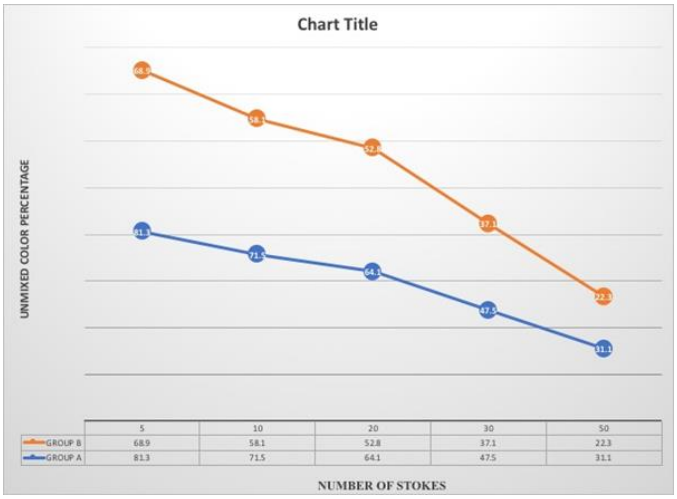

Fig.4: Chewing efficiency ankylosed adult at 5, 10, 20, 30 and 50 strokes and control group