SYDNEY MAGNOGLIDE- INFLUENCE OF MAGNETIC FORCES FOR CLASS II CORRECTIONS – PRELIMINARY RESULTS OF A PILOT STUDY

Shazia Naser-ud-Din[1], M. Ali Darendeliler[2], Paul Taylor[3], Chien Wei Tan[4]

ABSTRACT

Objective: *To investigate the influence of magnetic forces on the skeletal and dentoalveolar effects for the correction of Class II malocclusion using the Sydney Magnoglide design with or without magnets.* ***Study Design:*** *An Inter university Prospective Randomized Controlled Clinical Trial* ***Place & Duration of Study:*** *Universities of Sydney and University of Queensland, Australia from March 2011 to August 2012.* ***Methodology:*** *Final sample size comprised of 12 subjects in Sydney magnoglide magnetic version at University of Sydney compared to 13 in the non-magnetic version at University of Queensland, Brisbane, Australia. A strict selection criteria was followed to ensure comparable groups hence the sample size. Lateral cephalograms were taken prior to treatment and immediately after functional correction. Pancherz analysis utilized. Comparisons performed with Student's t-tests significance set at (P <0.05).* ***Results:*** *The two groups were fairly homogenous reducing the selection bias. Overall treatment was successful for all patients treated either with the magnetic or non-magnetic Sydney Magnoglide.* ***Conclusion:*** *Based on the statistical results and the limitations of the current study the non-magnetic and the magnetic Sydney Magnoglide appliance seem to be equally effective in this pilot study.*

1- Associate Prof. Orthodontic Dept. PhD, MSc, BDS, DPHDent, FICCDE, DCPSP-HPE, MOrth. RCSEd, Hamdan Bin Mohammed College of Dental Medicine, Dubai, UAE

2- Professor Department of Orthodontics, BDS, PhD, Dip Orth, CertifOrtho, Priv. Doc, MRACDS (Ortho), FICD , School of Dentistry University of Sydney, AUSTRALIA

3- Clinical Consultant Department of Orthodontics, BDS, MSc, School of Dentistry University of Sydney, Australia

4- Postgraduate in Orthodontics BDS, MSc (Eng.) DClinDent, School of Dentistry, University of Queensland, Australia

Key Words: *Magnets Nd2Fe14 Br, Functional Appliance, Sydney Magnoglide, Pancherz analysis*

INTRODUCTION

Class II malocclusions constitute a major proportion of Orthodontic case load.[1] Studies have shown that the clinical presentations of Class II malocclusions are diverse and incorporate variations that would ultimately influence treatment strategies.[2] The most consistent characteristic in a Class II malocclusion is mandibular skeletal retrusion and increased overjet.

It is now well accepted that timing of treatment is critical for success in Class II functional orthopaedic correction. The rate of mandibular growth can be assessed on the basis of skeletal maturity. The cervical vertebral maturation method (CVM) has been validated as a biological indicator of mandibular and somatic skeletal maturity and has advocated the optimal time for functional orthopaedic treatment of Class II relationship between CVM stage 3 and 4. [3,4]

Functional appliances can grossly be classified as fixed (e.g. Herbst, Jasper Jumper) or removable (e.g. Twin-Block, activator). Removable functional appliances require full-time consistent wear by the patient and they are heavily dependent on the compliance of the patient for success. Fixed functional appliances, on the other hand, do not rely on patient cooperation but have failure issues due to design and construction.[5]

The use of magnets in functional appliances was investigated in the past, to improve efficiency of treatment and patient comfort by overcoming the shortcomings of traditional fixed functional appliances. Magnets have been used in orthodontics and dentofacial orthopaedics over three decades but with little success clinically mainly due to corrosion products and edge effect displayed by magnets. The advantages of magnets include frictionless mechanics, predictable force levels and direction when the magnets are in attraction or repulsion, no force decay over time, and reduced patient cooperation .[6]

A variety of magnetic functional appliances were developed in the past, such as the '"Functional Orthopaedic Magnetic Appliance" (FOMA II)[7] and ' Magnetic Activator Device II' (MAD)[8]. The Sydney Magnoglide

(Macono Orthodontic Lab, Sydney, Australia) is a recent new addition to the fixed functional appliance family.[9] It consists of maxillary and mandibular right and left bonded acrylic resin embedded blocks with neodymium iron boron ($Nd_2Fe_{14}B$) magnets. In the non-magnetic version of the Sydney Magnoglide, no magnets are present in the appliance. By bonding the appliance, the issue of compliance is eliminated and the absence of moving components in the mouth, thus reducing the risk of breakages and improving patient comfort and compliance.

The aim of this prospective inter-University study was to evaluate the effect of magnetic forces on the skeletal and dentoalveolar outcomes of Class II correction with the Sydney Magnoglide with and without magnets.

METHODOLOGY

The first clinical collaboration between two universities of Australia, University of Sydney where the Magnoglide design was conceived and University of Queensland (UQSR -2010000758), Brisbane to test the null hypothesis that magnetic forces have no influence on the skeletal and dentoalveolar changes.

Strict selection criteria for the study included:

1. Class II Division 1 malocclusion of a half or full cusp.
2. Overjet of at least 6 mm.
3. ANB angle of 4^o or greater.
4. Permanent dentition.
5. No previous orthodontic treatment.
6. CVM stage 3 or 4.

Final sample size comprised of 12 subjects in Sydney magnoglide magnetic version compared to 13 in the non-magnetic version matching the sample as closely as possible for homogeneity of groups and prevent selection bias. A total time of 17 months was recorded for data collection for patient following the Magnoglide intervention. The duration for functional appliance therapy was approximately 9 months (magnetic group: mean 8.89 months, SD 0.44 month; non-magnetic group: mean

8.80 months, SD 0.27 month). Lateral cephalograms were obtained prior to treatment (T1) and immediately after functional appliance therapy (T2).The magnetic and non-magnetic groups were closely matched according to age and CVM stage (Table I). The mean ages for the magnetic and non-magnetic groups at T1 were 13.8 years (SD 1.0 year) and 13.6 years (SD 1.2 years), respectively. The mean ages at T2 were 14.6 years (SD 1.0 year) and 14.3 years (SD 1.2 years) magnetic Sydney magnoglide and non-magnetic version respectively.

Table 1:. Descriptive statistics for age and CVM stage.

	Magnetic group (n=12)		**Non-magnetic group (n=13)**	
At T1	**Mean (Age)**	**SD (Age)**	**Mean (Age**	**SD (Age)**
Age (y)	13.8	1.0	13.6	1.2
	N of subjects	***%***	**N of subjects**	***%***
CS 1	0	0	0	0
CS 2	0	0	0	0
CS 3	2	16.7	4	30.8
CS 4	10	83.3	9	69.2
CS 5	0	0	0	0
CS 6	0	0	0	0
	Mean (CS)	**SD (CS)**	**Mean (CS)**	**SD (CS)**
CS	3.8	0.4	3.7	0.
At T2	**Mean**	**SD**	**Mean**	**SD**
Age (y)	14.6	1.0	14.30	1.2
	N of subjects	***%***	**N of subjects**	***%***
CS 1	0	0	0	0
CS 2	0	0	0	0
CS 3	1	8.3	0	0
CS 4	10	83.3	13	100
CS 5	1	18.3	0	0
CS 6	0	0	0	0
	Mean (CS)	**SD (CS)**	**Mean (CS)**	**SD (CS)**
CS	4.0	0.4	4.0	0.0

CS = CVM stage SD = standard deviation

The appliance consisted of 4 acrylic resin blocks bonded to the maxillary and mandibular right and left buccal segments. In the magnetic version of the Sydney Magnoglide, 2 neodymium-iron-boron magnets are embedded in each block (Figure 1a). The maxillary and mandibular blocks are modified with a ‘V’ shape configuration of anterior and posterior inclined planes to interlock the occlusion in a Class I relationship. Each magnetic block attracts the other magnetic block in the opposing jaw when the casts are locked in a Class I occlusion via the construction bite registration. Attractive forces between the anterior and posterior inclined planes not only help prevent the patient from sliding back to a retrusive position but also guides the mandible forward. In the non-magnetic version of the Sydney Magnoglide, the design is essentially similar to its magnetic counterpart except no magnets are embedded in the acrylic resin blocks (Fig 1b). On closure, the opposing jaws are interlocked, via the acrylic resin blocks, in a Class I occlusion but there are no magnetic forces. Both the magnetic and non-magnetic appliances were cemented for approximately 9 months for either groups , and no other fixed appliance treatment was provided during the functional appliance phase.

Figure 1a. Intraoral photographs. **A, B, C:** right, center and left views of the magnetic Sydney Magnoglide; **D, E, F:** right, center and left views of the non-magnetic Sydney Magnoglide.

Figure 1b: Occlusal Clinical views of Non magnetic Sydney Magnoglide (Palatal and lingual aspects).

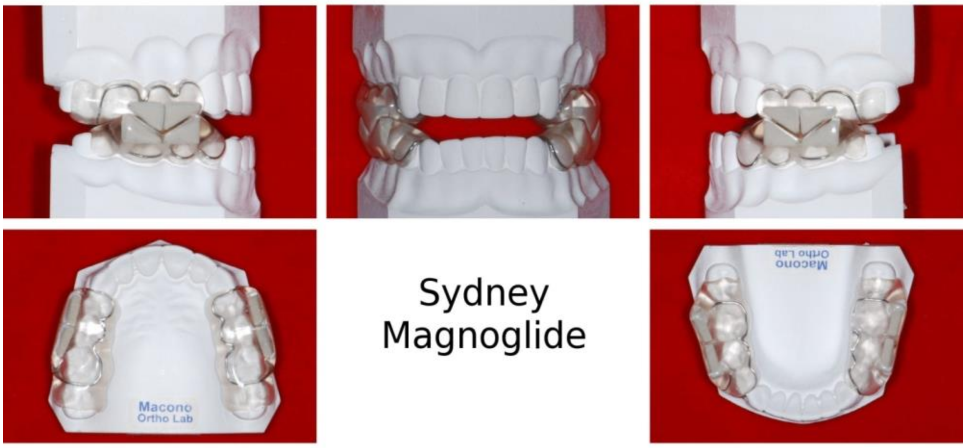


Figure 1c. Cast with Sydney Magnoglide clear view of Palatal and lingual aspects.

At the end of functional appliance therapy, all of the functional appliances were removed and radiographs were immediately taken. All lateral cephalograms were digitized and traced by the same operator (CWT) for the non-magnetic Brisbane group using Dolphin Imaging (Version 8.0, Dolphin Imaging, and Chatsworth, California). Pancherz Analysis along with classic linear and angular measurements were done for each case details found in the published paper. [9] The magnification factor of all lateral cephalograms was set at 8%.

Ten lateral cephalograms were randomly chosen from each treatment group 10-12 weeks post initial tracing and digitally retraced to determine the method error by Dahlberg’s formula

$$ME = \sqrt{(\sum d^2/2n)}$$

Where d is the difference between the two determinations and n is the number of double registrations. Errors for linear and angular measurements did not exceed 0.5 mm and 1.3^{o}. No significant differences between repeated measurements was observed.

An exploratory Shapiro-Wilks test showed normal distributions of the data in both the magnetic and non-magnetic groups. Thereafter, Student’s *t*-tests were performed to compare the initial cephalometric variables for the two groups at T1 and again for the cephalometric changes for both groups during treatment from T1 to T2. All statistical analyses were performed using MATLAB (Version 7.1/R14, The Mathworks Inc., Natick, USA).

RESULTS

All patients treated either with the magnetic or non-magnetic Sydney Magnoglide ended with successful correction of Class II relationship. The cephalometric angular and linear measurements between the magnetic and non-magnetic groups at T1 showed no statistically significant differences between them (Table II). The changes in the cephalometric variables for both groups from T1 to T2 are compared in Table III.

SNB angle increased by 1^{o} more in the non-magnetic group compared with the magnetic group. The resultant ANB angle was reduced in both groups with a slight difference of 0.7^{o}. The differences in the changes of the SNA, SNB and ANB angles between the two groups during treatment were not statistically significant (Table III, Figure 2a). SNA and y axis for both groups and SN-GoMe for the non magnetic group are within the range of the measurement error (< 1.3°) hence it is very difficult to attribute these changes to either measurement errors or therapeutic effects.

There was a very mild forward positioning of the maxillary base during functional appliance treatment; 0.5 mm for the magnetic group *versus* 0.9 mm for the non-magnetic group. However, the difference was not statistically significant given the measurement error, thus it is difficult to contribute the change to either measurement error or therapeutic effect (Table III, Figure 2b).

Mandibular length, as measured by the changes in Co-Gn and Ar-Gn, increased in both groups. There was a greater increase of 1.1mm and 1.8mm in Co-Gn and Ar-Gn, respectively, in the non-magnetic group compared with the magnetic group. However, the difference was not statistically significant as smaller than Standard Deviations (Table III).

The vertical changes in both groups, as represented by the y-axis, were similar and no statistical difference was found (Table III).

The overjet correction was greater in the magnetic group (4.9 mm) compared with the non-magnetic group (3.9 mm) however, the difference was not statistically significant. Mandibular incisor proclination was primarily responsible for the correction of the overjet in both groups. However, both the contribution of the retroclination of maxillary incisors and proclination of mandibular incisors in both groups were not statistically significant (Table III, Figure 3 and 4).

The maxillary molar had distalized by 1.2 mm within the maxillary base in the magnetic group. In contrast, the maxillary molar mesialized 0.3 mm within the maxillary base in the non-magnetic group and the difference between the two groups were statistically significant ($P < 0.05$). The change in mesial movement of the mandibular molar was also statistically significant in the magnetic (2.1 mm) and non-magnetic (3.5 mm) groups (Table III, Figure 3 and 4).

The comparison of treatment efficiency between the two magnetic and non-magnetic versions is depicted in bar graph (Figure 5) with regards to overjet correction, molar relationship and mandibular base advancements as these variables are directly related to Class II correction.

Table II:. Cephalometric analysis at T1. Magnification factor of cephalograms, 8%.

T1	Magnetic group (n = 12)		Non-magnetic group (n = 13)		Magnetic – non-magnetic	Significance †
	Mean	**SD**	***Mean***	**SD**	***Difference in mean***	
Cephalometric measurement						
SNA (°)	82.6	3.4	83.9	4.4	-1.3	NS
SNB (°)	76.7	3.1	78.1	3.9	-1.4	NS
ANB (°)	6.0	2.0	5.8	1.6	0.2	NS
SN-GoMe (°)	31.3	5.0	31.3	6.6	0.0	NS
Co-Gn (mm)	107.2	4.9	107.9	4.8	-0.7	NS
Ar-Gn (mm)	101.9	4.2	103.2	4.4	-1.3	NS
Y axis (°)	67.1	4.2	66.1	4.0	1.0	NS
U1 to SN (°)	110.7	4.7	113.6	5.6	-2.9	NS
L1 to GoMe (°)	99.1	6.7	93.8	6.6	5.3	NS
Pancherz analysis						
Maxillary base (mm) *ss/OLp(d)*	72.5	2.9	72.7	3.4	-0.2	NS
Mandibular Base (mm) *pg/OLp(d)*	70.4	4.6	71.8	2.8	-1.4	NS
Maxillary incisor (mm) *is/OLp(d)*	81.1	4.3	81.5	4.4	-0.4	NS
Mandibular incisor (mm) *ii/OLp(d)*	72.7	5.2	71.6	3.9	1.1	NS
Overjet (mm) is/OLp minus ii/Olp	8.5	1.7	9.9	1.9	-1.4	NS
Maxillary molar (mm) *ms/OLp(d)*	49.6	4.5	49.9	3.9	-0.3	NS
Mandibular molar (mm) *ms/OLp (d)*	47.5	4.9	47.2	3.8	0.3	NS
Molar relation (mm) *ms/OLp minus mi/OLp (d)*	2.2	0.8	2.7	0.7	-0.5	NS

† Student's *t*-test for independent samples. *NS*, Not significant at P <0.05; OLp (occlusal line perpendicular), a line perpendicular to the occlusal line through sella

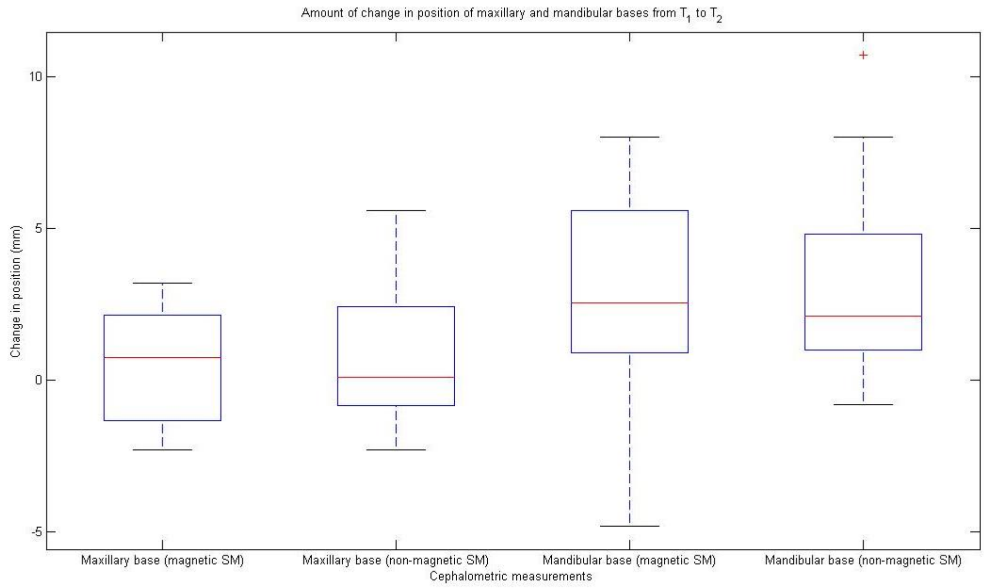
Table III:. Cephalometric changes from T1 to T2. Magnification factor of cephalograms, 8%.

T2-T1	Magnetic group (n = 12)		Non-magnetic group (n = 13)		Magnetic – non-magnetic	Significance †
	Mean	*Std dev*	*Mean*	*Std dev*	*Difference in mean*	
Cephalometric measurement						
SNA (º)	-1.0	1.7	-0.7	1.9	-0.3	NS
SNB (º)	1.4	1.0	2.4	1.7	-1.0	NS
ANB (º)	-2.4	1.5	-3.1	1.0	0.7	NS
SN-GoMe (º)	1.3	3.0	0.1	2.9	1.2	NS
Co-Gn (mm)	5.3	2.7	6.4	3.2	-1.1	NS
Ar-Gn (mm)	5.6	2.4	7.4	2.6	-1.8	NS
Y axis (º)	0.6	1.9	-0.5	1.7	1.1	NS
U1 to SN (º)	-5.8	4.0	-5.7	3.8	-0.1	NS
L1 to GoMe (º)	1.8	3.9	1.5	4.1	0.3	NS
Pancherz analysis						
Maxillary base (mm) *ss/OLp(d)*	0.5	1.9	0.9	2.2	-0.4	NS
Mandibular Base (mm) *pg/OLp(d)*	2.9	3.7	3.3	3.4	-0.4	NS
Maxillary incisor (mm) *is/OLp(d)*	-0.7	2.9	0.7	2.8	-1.4	NS
Mandibular incisor (mm) *ii/OLp(d)*	4.2	3.2	4.6	2.4	-0.4	NS
Overjet (mm) *is/OLp minus ii/OLp*	-4.9	1.6	-3.9	1.8	-1.0	NS
Maxillary molar (mm) *ms/OLp(d)*	-0.7	1.7	1.2	2.5	-1.9	*
Mandibular molar (mm) *ms/OLp(d)*	5.0	2.4	6.8	2.5	-1.8	NS
Molar relation (mm) *ms/OLp minus mi/OLp*	-5.7	1.4	-5.6	1.7	-0.1	NS
Dental changes in the skeletal base						
Maxillary incisor (mm) *is/OLp(d) minus ss/OLp(d)*	-1.2	1.5	-0.2	1.4	-1.0	NS
Mandibular incisor (mm) *ii/OLp(d) minus pg/OLp(d)*	1.3	1.0	1.3	1.4	0.0	NS
Maxillary molar (mm) *ms/OLp(d) minus ss/OLp(d)*	-1.2	1.4	0.3	1.5	-1.5	*
Mandibular molar (mm) *mi/OLp(d) minus pg/OLp(d)*	2.1	1.7	3.5	1.3	-1.4	*

(d), Changes of the measuring points were registered by calculating the difference in landmark position.

† Student's t-test for independent samples: *P <0.05; **P <0.01; ***P <0.001.

NS, not significant; OLp (occlusal line perpendicular), a line perpendicular to the occlusal line through sella.



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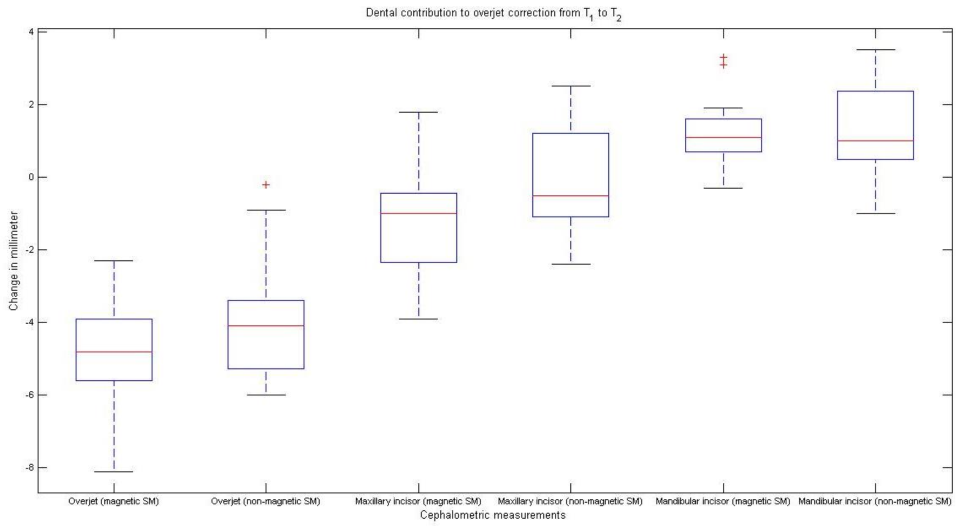
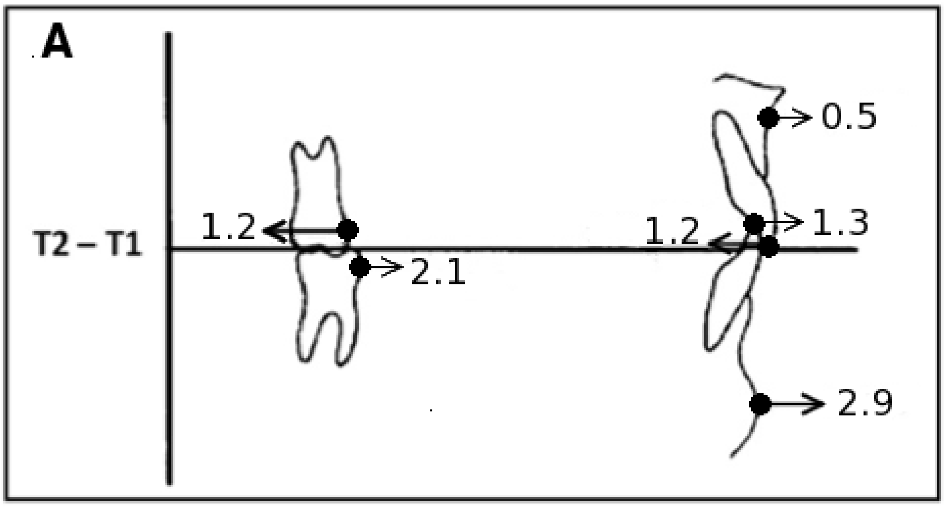


Figure 2a. Change in position of maxillary and mandibular bases from T1 to T2



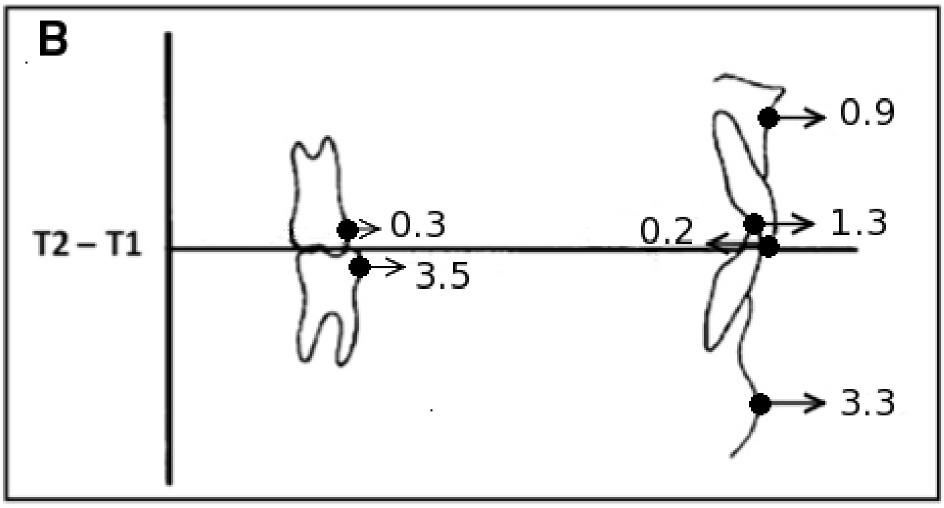


Figure 3. Diagrammatic representation of skeletal and dentoalveolar changes contributing to overjet and molar corrections: **A**, changes during treatment with the magnetic Sydney Magnoglide T2-T1; **B,** changes during treatment with the non-magnetic Sydney Magnoglide T2-T1.

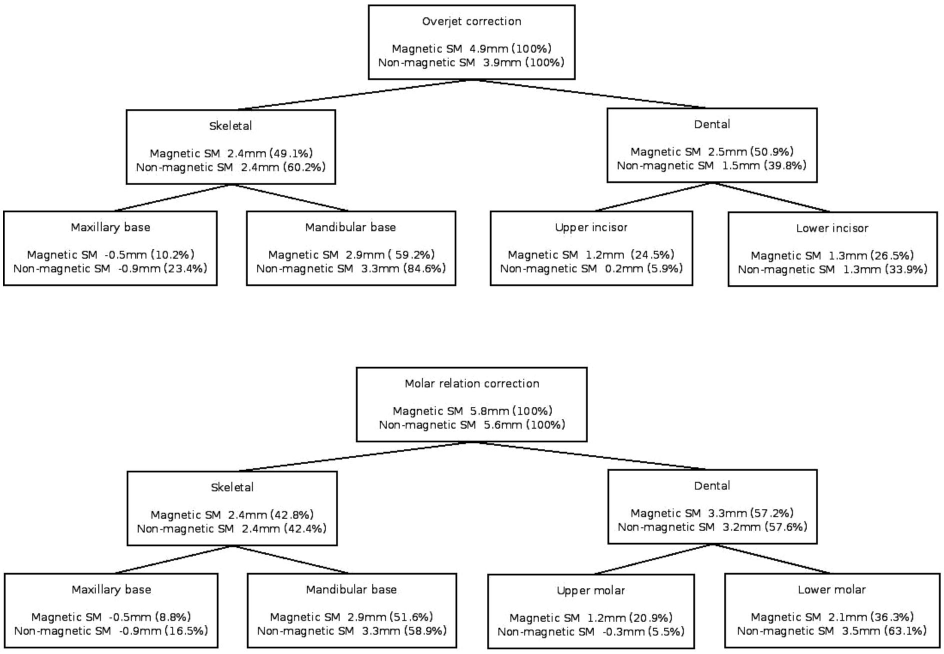


Figure 4. Pancherz analysis illustrating maxillary and mandibular skeletal and dental contributions to overjet and molar corrections, treated with the magnetic and non-magnetic Sydney Magnoglide. Minus (-) sign indicates unfavorable changes for overjet and molar corrections. SM= Sydney Magnoglide.

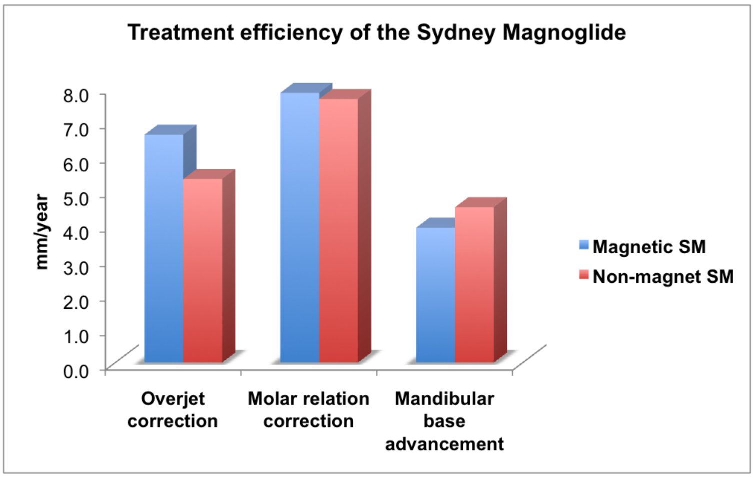


Figure 5. Comparison of the treatment efficiency of the magnetic and non-magnetic Sydney Magnoglides.

DISCUSSION

Previous study had demonstrated that the magnetic Sydney Magnoglide is an effective functional appliance for Class II correction. [9] However, the question remained if it was due to the magnetic properties or just the unique fixed configuration. The purpose of this study inter-University collaboration was to investigate whether magnets have an effect on the skeletal and dentoalveolar outcomes. Matched group of patients underwent functional therapy with either magnetic Sydney Magnoglide or the non-magnetic Sydney Magnoglide version. Our findings at the University of Queensland show that there is minimal difference between the results and certainly none of clinical significance.

The skeletal changes from both the magnetic and non-magnetic Sydney Magnoglides were primarily due to skeletal modification in the mandible while the effect of treatment on the maxillary jaw base was subtle. This is certainly a desirable feature of the bonded functional appliance with or without magnets. Studies on Twin-block therapy also did not find significant restraining effect on the sagittal position of the maxilla[10,11] hence, our findings are in sync with previous work. In contrast, the Herbst appliance and other magnetic functional appliances, such as the magnetic activator device II and the functional magnetic system have been reported to produce restraining effects on the growth of the maxilla. [12,13]

In terms of mandibular changes, the increase in SNB angle and mandibular length were greater in the non-magnetic group compared with the magnetic group, however, the differences were not statistically significant.[14] Forward position of the mandible observed after treatment with the Sydney Magnoglide was mainly due to an increase in mandibular length. The average gains of 5.3 mm in magnetic group and 6.4 mm in non-magnetic group were not statistically different but similar to that reported by Phelan *et. al.* (2012) in their study of an earlier Sydney Magnoglide.[9] Pancherz analysis showed that the mandiblular advancement in the non-magnetic group (3.3 mm) was slightly greater in comparison with the magnetic group (2.9 mm) after treatment, although not statistically significant. This translates to an efficiency rate of 4 mm/year in the non-magnetic group and 3.9 mm/year in the magnetic group (Figure 5), which is similar to the efficiency rate of 3.9-4.5 mm/year in an earlier magnetic Sydney Magnoglide .[9]

The average overjet corrections at the end of functional appliance treatment with the Sydney Magnoglide were 4.9 mm for the magnetic group and 3.9 mm the non-magnetic group and were not statistically significant (Table III, Figure 4). Pancherz analysis showed that the skeletal and dental contributions to overjet correction in the magnetic group were fairly equal. In contrast, overjet correction in the non-magnetic group was mainly due to more skeletal (60.2%) than dentoalveolar (39.8%) changes. Treatment with the Sydney Magnoglide demonstrated an efficient reduction of overjet ranging from 5 mm/year in the non-magnetic group and up to 6 mm/year in the magnetic group (Figure 5).

Most of the dentoalveolar correction is attributed to mesial movement of the mandibular molar. However, with respect to dentoalveolar changes, there is a mild mesialization (0.3 mm) of the maxillary molar in the non-magnetic group as compared with distalization (1.2 mm) of the maxillary molar in the non-magnetic group. It is hypothesized that in the magnetic group, attractive magnetic forces helped keep the mandible forward and in occlusion with the maxilla for a longer period of time as compared with the non-magnetic group. Without the aid of magnets, the patients in the non-magnetic group are prone to wearing the functional appliance in an unproductive position, especially at night when the muscles are relaxed and the chin drops back.[15] In other words, the non-magnetic group spent less time in occlusion and hence, the effect of distalization of maxillary molars were not observed as would be expected with dentals effects of functional therapy.

In this study, the majority of the subjects treated with the magnetic Sydney Magnoglide were at CS 3 (16.7%) and CS 4 (83.3%), compared with the majority of the non-magnetic group at CS 3 (30.8%) and CS 4 (69.2%). Overall, all subjects were treated at their peak mandibular growth stage, which is the strength of this study.

As reported by Phelan *et al.* (2012) for the Sydney Magnoglide group, the active treatment with an earlier version of the Sydney Magnoglide of 7 to 8 months compared well with the short treatment time of 6 to 8 months with the Herbst appliance. [9,16]

Patient feedback on the non-magnetic version of the Sydney Magnoglide was interesting with chewing and speech problems experienced only during the first couple of weeks thereafter daily oral functions were not affected. All patients accepted the appliance easily and no cooperation issues were encountered. Minor complications were experienced during treatment. In 23% of the patients in the non-magnetic group, debonding of the mandibular blocks was reported; most likely due to moisture contamination during cementation, thus more meticulous moisture control is needed to avoid such failure. Debonded mandibular blocks were managed at chairside and promptly recemented. In contrast, the magnetic group neither experience any debond nor the exposure of any of the embedded magnets. The complication rate of the non-magnetic group has been greatly improved from the 38.7% debond rate reported of an earlier Sydney Magnoglide[9], and compares very favorably with the complication rate of the banded and cast-splint Herbst appliances at 67% and 60%, respectively. [17]

The overall benefits associated with the Sydney Magnoglide include being relatively aesthetic, ease in laboratory construction, less frequent complications and emergency appointments, and patient friendly which are perhaps for the non-magnetic version too. However the main advantage being the forward nocturnal posturing of the mandible due to the configuration of magnets. The main disadvantages is the difficulty in reactivation of the appliance.

We acknowledge the major limitation in this study being the small sample size for the treatment groups. Therefore, the findings of this study may be considered as preliminary as there is insufficient evidence to reject the null hypothesis. However, this was due to the strict selection criteria and limited time for recruitment of patients for postgraduate projects. Moreover, with Obstructive sleep Apnea and breathing difficulties the Class II correction is treatment of choice and will have greater future application. [18]

CONCLUSIONS

Both the magnetic and non-magnetic Sydney Magnoglides are efficient functional appliances for Class II correction.

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