Research Article

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A Comparative Study of Intrusive Forces Generated by Different Australian Arch Wires Giving Different Amount of Anchor Bends: An In Vitro Study

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ABSTRACT

Background: The objective of this in vitro study was to evaluate the amount of intrusive force generated by different degrees of anchor bend in incisor region with different grades of A.J. Wilcock wire and also to evaluate the effect of incorporation of toe -in and toe-out bends on intrusive force levels. Nine sets of simulating upper arch forms with teeth arrangement class I molar/canine relation in ideal way were made. These were divided into 3 groups: A, B,C and all five grades of A.J Wilcock wire were used for each group. For each groups intermaxillary circles were prepared with bands on molars, cuspids & incisors along with molar tube. For group A: 30, 40 & 50 degrees of anchor bends, for group B: 30, 40, & 50 degrees with 10 degree toe- in & for group C: 30, 40 & 50 degrees with 10 degree toe-out. Thus, these total 45 no. [9 in each group x 5 grades of wires = 45 no] arch forms which were prepared were tested for their intrusive force generation. The amount of intrusive force increases with progressive increase in anchor bend (30 to 50 degrees) in all five different grades of arch wires. There is statistical significant difference where ($p< 0.05$) in amount of force delivered by increasing the anchor bend, in each grade of wire. Difference in intrusive force level at 30 degree anchor bend was statistically significant between Special+ arch wire and Premium , Premium+, Special+ pulse straightened, Premium+ pulse straightened. The amount of intrusive force increased with higher grades of wires i.e. special+, premium, premium+, special+ pulse straightened, premium+ pulse straightened respectively with same degree of anchor bend. The magnitude increases with each degree of anchor bend, increases with anchor bend along with 10^0 toe-out bend & decreases with 10^0 toe-in bend.

Keywords: Intrusive force, arch wires, anchor bends.

INTRODUCTION

Optimal force concept is the foundation for the contemporary clinical orthodontic practice. Orthodontists are the prescribers of force values depending on the type of tooth movement required. They design the appliance to exert an optimal force to prevent tissue damage and to achieve tooth movement.[1] Begg light wire technique introduced by the biomechanical genius Dr. P.R. Begg in the middle of 20th century has undergone many changes. Although the basic concept has remained unchanged, there is a sea change in the mechanics involved due to the newer grades of Australian arch wires, which exerts different levels of force.[2]

Earlier, special and special+ wires were used. These where Austenitic, high tensile heat treated stainless

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steel wires, which were thin enough to distribute force at an optimal level for tooth movement over a considerable distance.[3] Nowadays newer grades of arch wires are having increased yield strength and resiliency. The stress relaxation properties of newer grade of arch wires are superior from the older conventional wires.[4]

In the assembly of the Begg appliance, anchor bends are routinely given in the arch wire for one or more of the following purpose.[5]

A During first stage: To intrude anterior teeth for correction of overbite, to place or to maintain anchor molars upright and to resist the forward pull of the elastics on the lower molars.

B During second stage : To maintain the anchor molars in their upright position against the forward pull of the class I and class II elastics. It also maintains the overbite which is corrected

C During third stage : To maintain the anchor molars upright and to resist the forward pull of class II elastics, Torquing and root paralleling auxiliaries used during this stage.

There is an intrusive component of the force delivered to anterior teeth due to anchor bend placed in molar tube. The force delivered may vary due to[5] :

1 Variation in the degree of anchor bends.

2 Location of anchor bends in relation to the buccal tube.

3 Variation in the size and properties of wire used.

Thus considering the foregoing account study was conducted to evaluate the intrusive forces generated by different grades of A. J. Wilcock wires using different amount of anchor bend and also to find out whether incorporation of toe–in and toe–out bends introduces any change in the intrusive force level.

MATERIALS & METHODS

A. Materials

Triple beam single pan balance Machine

B. Method:

- A typodont with arranged teeth (in good alignment) was taken.
- Teeth were banded (Anteriors and first molars)
- The bracket placement and welding was done on bands of upper anterior teeth in standardized manner. Buccal tube placement and welding was done on upper right and left first molar bands.
- All the bands were cemented on teeth.

- With each of the five grade of A.J Wilcock wire used in the study, 9(nine) standard arch forms with intermaxillary circle were prepared, in upper arch, using measurements derived from arranged teeth on typodont
- These nine arch forms in each grade were further subdivided in to 3 groups

Table 1: Arch forms with Anchor Bends, Toe-in and toe-out bend.

Group	Anchor bend	Toe- in bend	Toe – out bend
Group A	30^0 40^0 50^0	Nil Nil Nil	Nil Nil Nil
Group B	30^0 40^0 50^0	10^0 10^0 10^0	Nil Nil Nil
Group c	30^0 40^0 50^0	Nil Nil Nil	10^0 10^0 10^0

Thus, these total 45 no. [9 in each group x 5 grades of wires = 45 no] arch forms which were prepared were tested for their intrusive force generation.

- For standardized location of anchor bend, plain arch forms were inserted in the molar tubes [upper arch only]. These arch forms were marked bilaterally 3 mm mesial to molar tube.
- All the anchor bends and toe-in, toe-out bends were checked on the anchor bend grid template.
- Then the typodont was opened and upper arch will be inverted and placed on a platform. Now the occlusal plane will be parallel to floor.
- The arch wire will be inserted in buccal tube.
- Now, the anterior portion of arch wire will be hooked/clamped with triple beam single pan balance machine.
- The slider will be moved for every 5gm. This procedure will be continued till the anterior arc of the arch wire is inserted in the slot of bracket of central incisors.
- For every wire minimum 10 reading will be taken.
- This procedure will be repeated for the arch wires of different types with different degrees of anchor bends.
- The reading obtained will be tabulated and subjected to statistical analysis.

RESULTS

The amount of intrusive forces generated from different grades of arch wire were observed and recorded in tabulated form

Measurement of intrusive forces generated by different graded of A. J. Wilcock wire

1. Wire identification : Special Plus
(force values are in Grams)

Group	Wire		1	2	3	4	5	6	7	8	9	10	Total	Mean
Group A	At 30^0 Anchor bend		59	58	57	54	60	60	58	61	57	56	580	58
	At 40^0 Anchor bend		73	72	68	70	67	70	72	69	70	69	700	70
	At 50^0 Anchor bend		90	88	87	93	91	86	93	88	91	93	900	90
Group B	**Toe in bend of 10^0**	at 30^0 anchor bend	48	47	50	53	52	53	47	51	52	47	500	50
		at 40^0 anchor bend	68	67	70	71	64	68	66	67	71	68	680	68
		at 50^0 anchor bend	80	83	85	84	87	79	83	82	84	83	830	83
Group C	**Toe out bend of 10^0**	at 30^0 anchor bend	82	82	78	78	83	79	80	78	76	84	800	80
		at 40^0 anchor bend	93	95	93	96	97	95	99	92	93	97	950	95
		at 50^0 anchor bend	98	98	100	104	99	98	103	102	96	102	1000	100

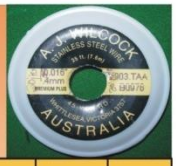
Measurement of intrusive forces generated by different graded of A. J. Wilcock wire

2. Wire identification : PREMIUM
(force values are in Grams)

Group	Wire		1	2	3	4	5	6	7	8	9	10	Total	Mean
Group A	At 30^0 Anchor bend		70	72	68	74	68	68	70	66	71	73	700	70
	At 40^0 Anchor bend		84	82	76	78	80	85	77	80	78	80	800	80
	At 50^0 Anchor bend		96	94	90	95	98	97	90	97	96	97	950	95
Group B	**Toe in bend of 10^0**	at 30^0 anchor bend	63	63	63	63	63	63	63	63	63	63	630	63
		at 40^0 anchor bend	78	78	75	75	75	75	75	75	75	75	756	75.6
		at 50^0 anchor bend	85	85	80	82	87	85	89	88	85	84	850	85
Group C	**Toe out bend of 10^0**	at 30^0 anchor bend	81	79	85	87	89	85	85	83	87	89	850	85
		at 40^0 anchor bend	105	105	105	105	105	105	105	105	105	105	1050	105
		at 50^0 anchor bend	108	104	108	106	99	101	106	99	102	107	1040	104

Measurement of intrusive forces generated by different graded of A. J. Wilcock wire

3. Wire identification : PREMIUM PLUS (force values are in Grams)



Group	Wire		1	2	3	4	5	6	7	8	9	10	Total	Mean
Group A	At 30^0 Anchor bend		72	68	68	74	70	66	72	74	67	69	700	70
	At 40^0 Anchor bend		85	88	82	86	84	85	85	81	88	86	850	85
	At 50^0 Anchor bend		100	98	104	98	97	99	95	104	102	103	1000	100
Group B	**Toe in bend of 10^0**	at 30^0 anchor bend	60	66	61	61	67	68	61	60	61	65	630	63
		at 40^0 anchor bend	84	82	75	79	80	76	84	84	78	78	800	80
		at 50^0 anchor bend	82	79	84	87	89	83	83	87	89	87	850	85
Group C	**Toe out bend of 10^0**	at 30^0 anchor bend	83	80	85	87	89	85	82	84	87	88	850	85
		at 40^0 anchor bend	100	105	108	107	105	109	104	103	105	104	1050	105
		at 50^0 anchor bend	103	106	108	110	106	107	108	104	105	103	1060	106

Measurement of intrusive forces generated by different graded of A. J. Wilcock wire

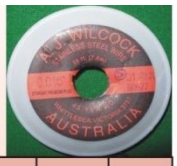
4. Wire identification : PULSE STRAIGHTENED SPECIAL PLUS (force values are in Grams)

Group	Wire		1	2	3	4	5	6	7	8	9	10	Total	Mean
Group A	At 30^0 Anchor bend		78	78	80	83	79	82	84	77	76	83	800	80
	At 40^0 Anchor bend		83	85	78	86	89	85	87	83	88	86	850	85
	At 50^0 Anchor bend		95	95	95	95	95	95	95	95	95	95	950	95
Group B	**Toe in bend of 10^0**	at 30^0 anchor bend	62	65	65	60	63	63	61	64	64	63	630	63
		at 40^0 anchor bend	80	80	82	82	86	78	81	85	84	82	820	82
		at 50^0 anchor bend	90	89	89	94	88	87	90	92	94	87	900	90
Group C	**Toe out bend of 10^0**	at 30^0 anchor bend	88	92	88	95	87	88	90	92	90	90	900	90
		at 40^0 anchor bend	105	96	97	101	105	99	97	102	98	100	1000	100
		at 50^0 anchor bend	99	102	99	102	106	103	99	100	104	106	1020	102

Measurement of intrusive forces generated by different graded of A. J. Wilcock wire

5. Wire identification : PULSE STRAIGHTENED PREMIUM PLUS

(force values are in Grams)



Group	Wire		1	2	3	4	5	6	7	8	9	10	Total	Mean
Group A	At 30^0 Anchor bend		82	82	78	78	80	84	78	81	79	78	800	80
	At 40^0 Anchor bend		92	88	87	95	89	88	90	92	90	89	900	90
	At 50^0 Anchor bend		98	98	105	98	103	98	97	104	98	101	1000	100
Group B	**Toe in bend of 10^0**	at 30^0 anchor bend	67	69	61	65	63	62	68	65	69	61	650	65
		at 40^0 anchor bend	89	86	83	85	84	82	85	81	88	87	850	85
		at 50^0 anchor bend	92	92	94	93	89	89	90	94	92	95	920	92
Group C	**Toe out bend of 10^0**	at 30^0 anchor bend	98	92	92	94	99	96	98	93	96	92	950	95
		at 40^0 anchor bend	105	108	111	105	104	110	108	108	113	108	1080	108
		at 50^0 anchor bend	110	110	119	120	115	113	118	115	113	117	1150	115

Statistical Analysis

The study design as it is based on the samples which has been unpaired on observational finding, the statistics carried out were

Descriptive statistics

ANOVA (Analysis of variance)

Unpaired t test

Tukey test for multiple variation.

Following results were obtained from this study

The amount of intrusive force increases with progressive increase in anchor bend (30 to 50 degrees) in all five different grades of arch wires. (i.e. special+, premium, premium+, special+ pulse straightened, premium+ pulse straightened). There is statistical significant difference where ($p < 0.05$) in amount of force delivered by increasing the anchor bend, in each grade of wire.

Difference in intrusive force level at 30 degree anchor bend was statistically significant between Special+ arch wire and Premium , Premium+, Special+ pulse straightened, Premium+ pulse straightened.

Difference between Premium and Special+ pulse straightened was also found to be statistically significant ($p < 0.05$).

Although, there was increase in intrusive force level between Premium and Premium+, Special+ pulse straightened and Premium+ pulse straightened, this increase was not statistically significant. ($p > 0.05$)

Difference in intrusive force level at 40 degree anchor bend was statistically significant between Special+ arch wire and Premium, Premium+, Special+ pulse straightened, Premium+ pulse straightened.

Difference between Premium and Special+ pulse straightened was also found to be statistically significant ($p < 0.05$).

However, there was increase in intrusive force level between Premium+ and Special+ pulse straightened, this was not statistically significant.

Difference in intrusive force level at 50 degree anchor bend was statistically significant between Special+ arch wire and Premium, Premium+, Special+ pulse straightened, Premium+ pulse straightened.

Difference between Premium and Premium+ pulse straightened was also found to be statistically significant ($p < 0.0.5$).

Although, there was increase in intrusive force level between Premium and Special+ pulse straightened and also between Premium+ and Premium+ pulse straightened, this increase was not statistically significant.

There is statistically significant reduction of intrusive forces generated by different grades of wire i.e. Special+, Premium , Premium+, Special+ pulse straightened , Premium+ pulse straightened at different degree of anchor bend along with 10 degree toe- in bend.

There is statistically significant increase in intrusive forces generated by different grades of wire i.e. Special+, Premium, Premium+, Special+ pulse straightened , Premium+ pulse straightened at different degrees of anchor bend along with 10 degree toe- out bend.

DISCUSSION

Sims[6] recommended the use of 0.016" diameter wire for bite opening rather than 0.014", 0.018" or 0.020" wire. According to him 0.014" arch wire was not recommended due to its inability to withstand masticatory function and adequately support the anchor molars and heavier wires (0.018" or 0.020") lacked efficient bite opening properties since they exerted force mainly on the molars rather than anterior teeth. The author suggested the use of 0.016" diameter of wire is useful in initial stages. Bite opening in the early stage of Begg mechanotherapy can be done with 0.016 or 0.018 Australian arch wire as claimed by manufacturer A. J. Wilcock.[7] Jayade[8] recommended use of 0.018" arch wire in substage I-B of the refined Begg. In the present study 0.016" diameter arch wire were used because of its efficiency in bite opening, anchorage control, alignment, correction and maintenance of arch form.

Sims[6] studied effect of increasing anchor bend at one fixed location and concluded that with increase in anchor bend the force increases. The anchor bend was increased as 30^0, 45^0, 60^0 and 80^0 which exerted force of 15gms, 30gms, 50gms and 70gms respectively

Thornton and Nikolai in (1981)[9] in similar study found that anchorage bend activated at 30^0, 45^0 and 60^0 produced the force of 28gms, 46gms and 62gms respectively. The results of above mentioned study are in accordance with the present study. In the present study the anchor bend was progressively increased 30, 40 and 50 degrees in 0.016'' arch wire. With increase in anchor bend the amount of force increased ranging from 58 to 100 grams. Tian-min X et al[10] recommended that ideal arch wire for bite opening should have the lower creep and stress relaxation factors. Jayade V. P.[8] tested and recommended the use of higher grade of A. J. Wilcock wire since, these wires were found to exhibit improved physical properties of higher resiliency and increased yield strength.

Hazel in (1984)[11] measured the force of 0.016 Australian wire of various grades with 65 degrees activation of anchorage bend . In this study the grades of arch wire used Regular , Special, Special+ , Premium+ and the amount of force delivered at 65 degree anchor bend were 69gms, 75gms, 85gms and 94gms respectively. The superior grade of arch wire generated higher intrusive forces.

Diwakar H.S. & Shetty V.S. in (1991)[1] measured the intrusive force of different grades of wire. According to their study special+ wire of 0.016" diameter at 30^0 anchor bend exert the intrusive force of 87.5gms and premium+ pulse straightened wire of same diameter and degree of anchor bend produces 105gms of intrusive force. This finding suggest that higher grades of wire exert more intrusive force. In present study higher intrusive force was measured by the superior grade of arch wire i.e. premium+ pulse straightened. These wire have high resiliency, increased yield strength, low creep and zero relaxation state. The present study also reveals the amount of intrusive force generated by anchor bend along with toe-in and toe-out bend. This study shows that there is decrease in amount of intrusive force generated by toe-in bend in conjunction with anchorage bends. The possible reason for this decrease in amount of intrusive force is, when arch wire is inserted in molar tube and engaged in bracket slots of anteriors, the anchor bend tend to roll slightly in the buccal tubes thus providing anti rotation toe-in automatically. Further incorporation of toe in bend

will make the effect of anchor bend to be expressed more horizontally rather than vertically, thus reducing the amount of intrusive force. Present study shows that there is statistical significant increase in amount of intrusive force generated with incorporation of toe-out bend in conjunction with anchor bends. This could be explained like this, Round arch wires generally have a tendency to roll in molar tubes when engaged in bracket slots of anteriors. If arch wire already has toe-out incorporated in it then this rolling will bring it to 6' O clock entry and 12' O clock exit position in molar tube i.e. the anchor bend effect will be expressed more vertically. So, it would be prudent to recommend higher grades of A.J. Wilcock wires for positive intrusion of anterior teeth. Incorporation of toe-out bend with anchor bend in stage I of Begg. technique would be helpful in further increasing the intrusive force value. Although molar should be monitored for rotational tendency. The study also suggested that incorporation of toe-in bend reduces the amount of intrusive force. This finding is beneficial in stage II of Begg's technique since toe-in bend is incorporated in this stage. Stage II do not require much intrusive force on anteriors in comparison to stage I, so reduction in intrusive force would act as an advantage.

CONCLUSION

This study was designed to find out the intrusive force exerted by different grades of A. J. Wilcock wires with different degrees of anchor bends i.e. 30^0, 40^0, 50^0. The study also investigated the effect of incorporating toe-out and toe-in bend on intrusive potential of anchor bend.

The following conclusions were drawn:

The amount of intrusive force increased with higher grades of wires i.e. special+, premium, premium+, special+ pulse straightened, premium+ pulse straightened respectively with same degree of anchor bend. The magnitude of intrusive force increased with progressive increase in degrees of anchor bend.

The amount of intrusive force increased for the anchor bend along with 10^0 toe-out bend. The amount of intrusive force reduces for the anchor bend along with 10^0 toe-in bend.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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