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Duration of the second stage of labor while wearing a dental support device: A pilot study

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Abstract

Aim: Developing a method of maximizing maternal expulsive effort should be of great value in reducing the number of cesarean sections or instrumental deliveries. Various investigations have shown that use of a dental support device (DSD) increases the isometric strength of different muscle groups. The aim of our study was to investigate the role of a DSD in second stage of pushing.

Methods: Nulliparous women with an uncomplicated singleton pregnancy course were randomly assigned either to a DSD group or to a non-device group. Duration of the second stage of labor was evaluated. Rates of cesarean section or instrumental delivery indicated for failure to descend in the second stage of labor were also evaluated. Satisfaction scores for the DSD group were evaluated (range 1–5).

Results: Sixty-four subjects were enrolled in the study. Cesarean section and instrumental delivery were performed for 12 (18.8%) and 5 (7.8%) patients, respectively. There was no difference in obstetrical and neonatal demographics between the two groups. Among 64 enrolled patients, 38 (59.3%) were evaluated for the second stage of labor ($n = 19$ for each group). Duration of the second stage of labor in the DSD group was significantly shorter than in the non-device group: (median 19 min (interquartile interval, IQI, 9) *vs* 31 min (IQI, 23)), $P < 0.001$. One patient in the non-device group required a vacuum extraction for failure to descend. The mode of satisfaction score for the DSD group was 5 (59.3%).

Conclusion: Wearing a dental support device may shorten the second stage of labor, and may decrease the number of failures to descend requiring operative intervention.

Clinical Trial Registration: NCT00629369.

Key words: dental occlusion, randomized controlled trial, second stage of labor, pushing.

Introduction

The increased use of epidural anesthesia during labor has led to an increased incidence of prolonged second stage as an indication for cesarean section or instrumental delivery.[1] The use of oxytocin has proven to be an effective method of augmenting labor in prolonged labor cases.[2] However, despite oxytocin augmentation, there has been an increase in the number of cases that require cesarean section or instrumental delivery to effect delivery.

McRobert's maneuver, which is often used to relieve shoulder dystocia, has recently been shown to approximately double the intrauterine pressure.[3] However, it is an arduous position for the pregnant woman to maintain over a long period of time. Developing alternative

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methods to maximize expulsive forces, both uterine contractions and maternal expulsive effort, may be of great value in reducing the number of cesarean sections or instrumental deliveries.

Various researchers have investigated the effect of a dental support device (DSD) on the isometric strength of different muscle groups (e.g. neck, back and extremities).[4–12] The natural condition of dental occlusion, also known as the index of physical performance, has an effect on both muscle strength and body balance.[13] When occlusal support is given to edentulous individuals they show improved physical exercise ability after the re-establishment of mandibular support.[14] Patients whose dentition is in proper occlusion demonstrate greater endurance of isometric muscle strength than those who are in malocclusion.[15] We hypothesize that optimization of dental occlusion by a DSD may improve muscle strength, leading to increased intrauterine pressure during the second stage in labor.

The aim of our study was to investigate whether the use of the DSD resulted in a shortened duration of the second stage of labor.

Methods

The present pilot study, an open label randomized controlled trial, was conducted in the Labor and Delivery Suite of the Mercy Medical Center, Baltimore, Maryland, between 1 October 2007 and 4 December 2007. Patients admitted for the onset or induction of labor were invited to participate in the study. Inclusion criteria were as follows: primipara, term, singleton, cephalic presentation, reactive fetal heart rate pattern, and functioning epidural anesthesia. Subjects with medical or obstetrical complications, including intrauterine growth restriction, large for gestational age, uterine anomaly, uterine myomata, pre-eclampsia, diabetes mellitus, fetal anomaly, and maternal heart disease were excluded.

Enrolled subjects were randomly assigned by sealed envelope to one of the following two groups: (i) subjects with DSD with active pushing in the second stage of labor; and (ii) subjects without DSD with active pushing in the second stage of labor. After obtained signed consent for the study, the subjects in the experimental group were fitted with a molded occlusal support device.[16] In our study, Extreme 3 Mouth Guards (Shield, Mfg, Inc., Tonawanda, NY, USA) PRO (Shock Doctor, Inc., Plymouth, MN, USA) were used as the dental support device.[16] Active pushing consisted of coached Valsalva maneuver during contraction in the dorsal lithotomy position as directed by a physician or certified nurse midwife in the Labor and Delivery Suite. Duration of the first stage of labor was defined as the time between the beginning of the active phase and complete cervical dilation. Duration of the second stage of labor was defined as the time between the complete cervical dilation and fetal expulsion.[17] Patients began pushing when the cervix was fully dilated.

Baseline information obtained from patients included maternal age, race, parity, height, body weight, body mass index, weight gain during pregnancy, number of missing teeth, and presence or absence of temporomandibular joint (TMJ) disease. Labor information included gestational age at delivery, estimated fetal weight, indication for induction, use of oxytocin during labor, use of epidural anesthesia, obstetrical complications, and obstetric interventions with indication. Neonatal information included birth weight, Apgar scores, head circumference, admission to the Neonatal Intensive Care Units (NICU) and its indication, as well as umbilical arterial and venous cord blood gases.

After delivery, patient compliance and satisfaction were assessed using a satisfaction scale (scale 1–5) as follows: occlusal support device was (1) disliked or refused to be used by patient; (2) not helpful; (3) fair; (4) helpful; and (5) very helpful during pushing. Comments from patients regarding the dental occlusion device during pushing stage were also collected. All subjects who used the DSD were asked to complete a satisfaction scale. The incidence and reason for discontinuation of DSD use including any perceived adverse effect was also recorded.

Power analysis was performed to determine the sample size needed to detect a 10% difference in the duration of the second stage in the dental occlusion device group. Analysis allowed an alpha error of 5% and a beta error of 80%. The mean second stage of labor with active pushing has been determined to be 75.77 ± 41.33 min ($\pm$SD).[18] In order to identify a 10% difference in the experimental group, 19 subjects are required for each arm. Assuming a cesarean section rate of 20% in nulliparous patients in 2004[19] and instrumental vaginal delivery rate with either forceps or vacuum-assisted delivery of 12.4%,[20] 27 subjects are estimated in order to evaluate the duration of the second stage of labor in vaginal birth. However, because no prior study has investigated the use of DSD during the second stage of labor, the exact sample size cannot be estimated to obtain the 19 active subjects required to analyze the second stage of labor for the

two arms. Thus, we evaluated each individual subject at the time of study entry until delivery, and made a disposition of the case, that is, whether second stage of labor was evaluable or non-evaluable. In this fashion, data were collected until the subject number met the estimated sample size determined by the power analysis (at least $n = 19$ for both arms).

The primary outcome was the duration of the second stage of labor. Apgar scores and umbilical cord gas values were evaluated as secondary outcomes. The rate of cesarean section or instrumental delivery for failure to descend in the second stage of labor was evaluated. The data from these subjects with deliveries by cesarean section, vacuum extraction or forceps, fetal malposition with occiput posterior at the time of delivery, shoulder dystocia, small for gestational age with birth weight less than 2500 grams, and precipitous delivery were not evaluated with respect to duration of second stage labor.

Continuous variables were assessed for the normal distribution by Kolmogorov-Smirnov test and expressed either by mean (±SD) or median (interquartile interval, IQI) as appropriate, analyzed by Mann–Whitney *U* test (two-way). Categorical variables were evaluated with Fisher's exact test with relative risk and 95% confidence interval. $P < 0.05$ was considered statistically significant. The statistical significance of the data was determined using the Statistical Package for Social Scientists software (SPSS, version 12, Chicago, IL, USA). The study protocol was approved by the Institutional Review Board (IRB) at the Mercy Medical Center, Baltimore.

Results

A total of 64 subjects were recruited and randomly assigned to two groups between 1 October 2007 and 4 December 2007. There were no differences between the groups with regard to demographics and obstetrical characteristics (Tables 1 and 2). The mean age of subjects was 22.6 ± 5.7 and 22.2 ± 5.8 years, respectively ($P = 0.80$). Body mass index was 31.0 ± 5.4 kg/m^2 and 32.5 ± 8.0 kg/m^2, respectively ($P = 0.59$). Weight gain during pregnancy was 16.1 ± 7.5 kg and 15.6 ± 7.6 kg, respectively ($P = 0.89$). Induction of labor was utilized in 15 (46.9%) and 13 (40.6%) patients, respectively. Oxytocin administration during labor was seen in 23 (71.9%) and 19 (59.4%) patients, respectively. All patients had epidural anesthesia.

Complications of labor are shown in Table 3. Of the 32 patients assigned to the DSD group, 19 (59.3%) completed the second stage of labor by pushing with the DSD. Of the 32 subjects assigned to the non-DSD group, 19 (59.3%) patients completed the second stage of labor. Twelve (18.8%) of 64 patients delivered by cesarean section: seven (58.3%) for non-reassuring fetal heart rate in the first stage of labor; and five (41.7%) for failure to progress in the first stage of labor. Five (7.8%) of the 64 patients underwent instrumental delivery: four (80%) for non-reassuring fetal heart rate; and one (20%) for failure to descend at +4 station secondary to inadequate pushing effort. In two subjects the presentation remained occiput posterior. One neonate was small for gestational age. One subject had shoulder

Table 1 Characteristics of patients in the study of duration of second stage labor while wearing a dental support device†

	Dental support device	No support device	*P*-value
Subjects	$n = 32$	$n = 32$	
Age	22.6 ± 5.7	22.2 ± 5.8	0.80
Race			
African American	23 (71.9%)	23 (71.9%)	1.0
Caucasian	7 (21.9%)	6 (18.7%)	
Asian	2 (6.3%)	3 (9.4%)	
Height	160.5 ± 5.0	161.3 ± 7.4	0.43
Weight	79.6 ± 13.9	85.0 ± 22.3	0.58
BMI	31.0 ± 5.4	32.5 ± 8.0	0.59
Weight gain (kg)‡	16.1 ± 7.5	15.6 ± 7.6	0.89
Gravidity	1 (1)	1 (1)	0.70
Missing teeth	0	1	1.0
TMJ disease	1	0	1.0

†Mean ± SD, median (IQI), or number (%). All Mann–Whitney *U* test or Fisher's exact test; ‡Weight gain during pregnancy. BMI, body mass index; TMJ, temporomandibular joint disease.

Table 2 Labor characteristics of patients in the study of duration of second stage labor while wearing a dental support device†

	Dental support device	No support device	Relative risk (95% CI)	*P*-value
Subject	$n = 32$	$n = 32$		
EFW	3208 ± 263	3185 ± 289		0.55
Spontaneous labor	17 (53.1%)	19 (59.4%)	0.8 (0.3–2.1)	0.8
Labor induction	15 (46.9%)	13 (40.6%)	1.3 (0.5–3.5)	0.8
Post due date	3	3		
Favorable cervix‡	8	8		
PROM	4	2		
Oxytocin in labor	23 (71.9%)	19 (59.4%)	0.6 (0.2–1.6)	0.71
Epidural anesthesia	32 (100%)	32 (100%)		1.0

†Mean (±SD) or number (%). All Mann–Whitney *U* test or Fisher's exact; ‡Term favorable cervical dilation; CI, confidence interval; EFW, estimated fetal weight (g) determined by transabdominal ultrasonography or Leopold maneuver; PROM, premature rupture of membranes.

Table 3 Labor complications in patients enrolled in the study of duration of second stage labor while wearing a dental support device

	Dental support device	No support device
Cesarean section, $n = 12$ (18.8%)	4	8
Non-reassuring fetal heart rate	3	4
Failure to progress	1	4†
Failure to descent	0	0
Instrumental delivery, $n = 5$ (7.8%)	3	2
Non-reassuring fetal heart rate	3	1
Arrest of descent	0	1‡
Occiput posterior position	1	1
Precipitous delivery	1	2
Small for gestational age	0	1
Shoulder dystocia	1§	0
Incomplete use of device	4†	NA

†One subject, occiput posterior, respectively; ‡Failure to descend at station +4 indicated for vacuum extraction; §Procto-episiotomy performed. NA, not applicable.

dystocia. Four (13.8%) patients discontinued use of the DSD prior to delivery.

Delivery characteristics are shown in Table 4. Gestational age at delivery and birth weight were similar in both groups. Duration of the first stage of labor did not differ between the two groups (453.9 ± 135.3 min *vs* 472.0 ± 186.9 min, $P = 0.92$). Duration of the second stage of labor in the DSD group was significantly shorter than in the non-device group: median 19 min (IQI, 9) versus 31 min (IQI, 23), $P < 0.001$. Apgar scores and umbilical cord blood pH were similar in the two groups. Three (9.4%) neonates in the two groups were admitted to the NICU: in the DSD group, one neonate with respiratory distress syndrome at 39 weeks had vacuum delivery indicated for non-reassuring fetal heart rate pattern, and one neonate with sepsis work-up, and one neonate for shoulder dystocia; in the non-device group, one neonate developed respiratory distress syndrome at 38 weeks spontaneous vaginal delivery one neonate for sepsis work-up, and one neonate for vacuum delivery.

Patient satisfaction with the DSD is shown in Table 5. Of 32 subjects assigned to the DSD group, three subjects did not reach the second stage of labor due to cesarean section in the first stage of labor, and two did not answer the satisfaction questionnaire. The mean satisfaction score for use of the DSD was 4.1 ± 1.4. Sixteen (59.3%) of 27 subjects who used the DSD rated the experience a '5' on the satisfaction score. Comments included: 'very helpful for pushing', 'easy to focus on pushing', and 'can hold breath when pushing'. Four (13.8%) of 29 subjects who used the DSD did not continue to use it throughout the second stage. These subjects reported the following reasons for discontinuation: 'difficulty breathing with the device', 'uncomfortable', 'feeling nauseated with the device' and 'impatience with the device'.

Discussion

Pushing during the second stage of labor is a physical activity unique to the parturient. She is able to generate over 100 mm Hg of intrauterine pressure using the Valsalva maneuver with each contraction and can continue to do so for an hour or more. In our study, duration of the second stage of labor was significantly shorter in the DSD group, compared to the non-device group. We

Table 4 Dental support device use and second stage of labor†

	Dental support device	No support device	Relative risk (95% CI)	*P*-value
Subject	*n* = 32	*n* = 32		
Gestational age§	39.5 ± 0.8	39.3 ± 0.9		0.54
Station at full dilation	2 (0)	2 (0)		0.90
Duration of 1st stage‡ (min)	453.9 ± 135.3	472.0 ± 186.9		0.20
Duration of 2nd stage‡ (min)	19 (9)	31 (23)		<0.001
Birth weight (g)	3188 ± 360	3181 ± 450		0.31
Head circumference (cm)	32.6 ± 1.9	33.2 ± 1.8		0.65
Apgar 1 min	9 (1)	9 (1)		0.50
Apgar 5 min	9 (0)	9 (0)		0.33
Umbilical arterial pH	7.26 ± 0.05	7.24 ± 0.08		0.35
Umbilical venous pH	7.32 ± 0.03	7.29 ± 0.07		0.19
NICU admission	3 (9.4%)	3 (9.4%)	0.9 (0.8–1.04)	1.0

†Mean (±SD), median (IQI) or number (%). All Mann–Whitney *U* test or Fisher's exact test; ‡*n* = 19, subjects with complete use of dental support device; §Gestational age at delivery. NICU, neonatal intensive care unit.

Table 5 Patient satisfaction for use of the dental support device

Satisfaction score (*n* = 27)†	
Mean	4.1 ± 1.4
Mode	5 (*n* = 16, 59.3%)
Incomplete use of device‡	4/29 (13.8%)
Favorable comments	
	'Very helpful with pushing'
	'Easy to focus on pushing'
	'Hold breath when pushing'
Non-favorable comments	
	'Difficulty breathing'
	'Uncomfortable'
	'Felt nauseas'
	'No patience'

†Three subjects underwent cesarean delivery in the first stage of labor, two subjects did not complete the follow-up for satisfaction; ‡Three subjects underwent cesarean delivery before use of the device.

believe that the DSD may contribute to increased maternal expulsive forces through the following three mechanisms.

Direct effect of increased muscle strength in the extremities, back and abdomen

Recent research has demonstrated a positive effect of the DSD device on the isometric strength of various muscle groups (e.g. neck, back, and extremities).[4–12] Forgino *et al*. showed increased isometric strength in the deltoid muscle with the use of a mandibular orthopedic repositioning appliance (MORA).[5,6] Increased shoulder strength was likewise demonstrated by the use of MORA.[7] Abdujabbar *et al*. observed increased muscle strength in the shoulder, elbow and knee flexion and extension muscles with the use of a bite-elevating appliance.[8] Carr *et al*. reported immediate increased postural contractile activities of human jaw muscles,[9] and several other studies have concluded that jaw repositioning by MORA enhances muscular strength and athletic performance.[10–12]

Dental occlusion status has been utilized as an index of physical performance for muscle strength and body balance.[13] Occlusal support in edentulous individuals improved their ability to undergo physical exercise.[14] Proper occlusion is associated with increased endurance of isometric muscle strength compared to malocclusion.[15] Therefore, correction of dental occlusion by a DSD may improve muscle strength in the body, leading to increased intrauterine pressure during second stage pushing.

Secondary effect of postural change enhancing the Valsalva maneuver

Correlation between dental occlusion and head-neck posture has recently been reported.[21–27] As seen in TMJ disease, lateral inclination of the occlusal plane causes cervical spine displacement and induces an imbalanced distribution of stress, which changes posture.[25,26] Furthermore, Kibata *et al*. suggested that lateral imbalance of occlusion can result in a left–right imbalance of the sternocleidomastoid muscle, leading to lateral bending of the neck.[26] They observed greater muscle strength in the jaw and sternocleidomastoid muscle with occlusal support after 2 weeks of MORA use.[27] Improved postural control and gaze stabilization were also seen with use of interocclusal splints.[28]

These data suggest that correct dental occlusion optimizes head and neck posture, thereby increasing cervical muscle strength. The Valsalva maneuver, which has been shown to increase expulsive forces during the second stage of labor by increasing intrauterine pressure,[3] is defined as a forced expiratory effort against a closed airway. Assistance by the cervical musculature has an important role in the production of this force.[3] The use of a DSD to optimize head and neck posture should result in increased intrauterine pressure during the Valsalva maneuver.

Increased isometric endurance when pushing

Proper occlusion is associated with greater endurance of isometric muscle strength.[15] By wearing the DSD, the parturient may be better able to push for a longer period of time for each contraction and thus, may contribute to a shorter second stage of labor. Many of our study subjects commented that wearing the DSD made the Valsalva maneuver easy and allowed them to focus on pushing.

Our study showed reasonable patient acceptance of the DSD. The mode of subject satisfaction score was 5 in 16 (59.3%) of 27 subjects who used the DSD. Over half of the subjects felt that the DSD was very helpful in pushing. This motivational benefit from use of the DSD may make a significant contribution to the pushing effort in labor.

Limitations of our study included reproducibility, generalizability, the non-blinded nature of randomized controlled trial, and small sample size to examine the outcomes. In this setting, it is of great interest in the use of intrauterine pressure device (CB Sciences, Dover, NH, USA) to quantify the effect of DSD use on Valsalva forces and intrauterine pressure.[3] Furthermore, it is necessary to investigate the effect of DSD use on the incidence of cesarean section or instrumental delivery indicated for failure to descend in the second stage of labor. Given the incidence of 1.7% of failure to descend during the second stage of labor,[29] 254 subjects would be needed for each arm of a study designed to identify a 50% decrease in incidence. Based on our analysis, with an additional 177 subjects required for considering the drop-out before the completion of second stage of labor, in total, 431 subjects are required for the each arm (post hoc analysis).

In summary, use of a DSD contributed to shortening of the second stage of labor. Many users felt that their ability to focus on pushing was improved. This novel approach to understand the second stage of labor requires further investigation.

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