

**Critical Review:** What are the effects of palatal plate therapy on orofacial features and speech in children with Down syndrome?

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This critical review examines the orofacial and speech effects of palatal plate therapy on children with Down syndrome. Multiple studies, varying in style design, have investigated this topic. Features analyzed in these studies include tongue protrusion, mouth occlusion, tooth eruption, sucking habits, articulation and facial expression. Overall, there is suggestive evidence that palatal plate therapy can improve tongue protrusion and mouth occlusion, and facial expression and equivocal evidence that palatal plate therapy will improve articulation in children with Down syndrome.

### ***Introduction***

Children with Down syndrome have common orofacial features consisting of orofacial hypotonicity, a protruding tongue, and an open mouth posture. Complications associated with these orofacial characteristics include difficulty sucking, swallowing, drooling, dentition, (Limbrock, Castillo-Morales, Hoyer H Stover, & Onufer 1993) esthetics, and speech (Korbmacher et al. 2002). In order to improve several of the primary and secondary pathologies common to children with Down syndrome, a treatment approach called palatal plate therapy was initiated. Palatal plate therapy was developed and introduced by Castillo-Morales (Backman, Grevér-Sjölander, Holm, & Johansson, 2003), in Munich, Germany in 1978 (Korbmacher, Limbrock, Khal-Neike, 2002). Palatal plate therapy as described by Castillo-Morales consists of two components, the insertion of a palatal plate device and orofacial therapy provided typically by a physiotherapist or speech language pathologist (Limbrock et al. 1993).

The palatal plate is designed to improve orofacial function and appearance in children with Down syndrome (Limbrock et al. 1993). Each palatal plate is individually designed to fit the maxilla and is formed with thin acrylic plates, knobs, a bowl like depression and a stimulating button. Additional springs are added if the child has teeth (Carlstedt, Henningsson, McAllister, Dahllof, 2001). The palatal plate is designed to “alter the resting position of the tongue, stimulate specific tongue movements, to increase mobility of the upper lip, and to increase tonus of the facial musculature” (Carlstedt, Henningsson, Dahllof 2003). Castillo-Morales suggests using palatal plate therapy for children with interdental or interlabial tongue posture and hypotonic lips and tongue (Korbmacher et al. 2002). Additionally, Castillo-Morales advises the palatal plate to be used in

association with orofacial therapy. Orofacial therapy consists of basic muscle activation and stimulation of areas on the face (Limbrock et al., 1993). Various studies have investigated the effects of a modified version of Castillo-Morales palatal plate therapy technique on children with Down syndrome.

The studies obtained have been conducted in Europe; as a result, it is an area that may not be studied in North America. This paper offers new insight into the field of orofacial and communication therapy for children with Down syndrome.

### ***Objectives***

The objective of this paper is to critically evaluate the current literature pertaining to palatal plate therapy and determine the effects of palatal plate therapy on children with Down syndrome.

### ***Methods***

#### Search Strategy

Computerized databases, including CINAHL, PubMed, Embase, Cochrane Library, PsychINFO and Scopus were searched using the following search strategy: ((Down syndrome) OR (trisomy 21)) AND ((palatal plate)) AND/OR ((language) OR (speech)) AND/OR (child\*). Additionally, studies referenced in obtained articles that met the inclusion criteria were included.

#### Selection Criteria

The search was limited to articles written or translated into English. The studies included in this review investigated the oral motor and/or speech and language effects of a palatal plate on children with Down syndrome.

### Data Collection

Multiple design studies have been used to explore this topic; Randomized clinical trials, mixed groups, nonrandomized clinical trials, single group pre-posttest and within groups repeated measures.

### **Results**

#### **Studies that evaluate short-term results after an average of 1-1.5 years of treatment**

Limbrock, Fischer-Brandies and Avasle (1991), Carlstedt, Dahllof, Nilsson, Modeer (1996) and Backman et al (2003) evaluated the effects of palatal plate therapy after one year of treatment. Limbrock, Castillo-Morales, Hoyer H Stover, & Onufer (1993) assessed the outcomes of palatal plate therapy after an average of 17.9 months of treatment.

Limbrock et al. (1991) reported a single group pre and posttest study, designed to evaluate the effects of Castillo-Morales' therapy with 67 Down syndrome children recruited from a local clinic. The average age at the start of therapy was 13.9 months with a range from 1-73 months. The children wore the palatal plate a few hours a day for an average of 12 months and most received orofacial physiotherapy in accordance with Castillo-Morales. A paediatric orthodontist analyzed the structural features of the child and constructed a palatal plate. A neuropaediatrician completed the clinical evaluations for initial and outcome measures. Significant positive results were documented for: tongue position, tongue protrusion (analyzed using a six-grade scale) upper and lower lip tonicity, and position, mouth closure, drooling and sucking. Four children increased in drooling and one child changed from a normal sucking pattern to an abnormal sucking pattern. Furthermore, it was noted that children who were initially rated to have more severe features at baseline demonstrated enhanced improvements from treatment.

Strengths: This study demonstrates a 2b level of evidence with a large sample size. The article included exclusion criteria for the treatment group. Additionally, the evaluation after treatment was completed by a blinded neuropaediatrician. Statistical analysis used was appropriate.

Limitations: One limitation of this study was a high attrition rate was observed; 89 participants started the therapy and 67 participants remained at follow up is a limitation of the study. Additionally, there was a large age range (1 month – 73 months) and no control group assessed in this study. Moreover, the study lacked details regarding how many times a day the treatment group participated in treatment and not all children in the treatment group received physiotherapy.

Based on the strengths and limitations, the study provides suggestive evidence for the improvement of tongue position and posture, mouth and lip closure, as well as drooling and sucking.

Additionally, Limbrock et al. (1993) conducted a retrospective study, single group pre-posttest study, to determine if Castillo-Morales palatal plate therapy can improve tongue protrusion and mouth closure in children with Down syndrome. Participants consisted of 39 infants who had been treated with Castillo-Morales therapy for an average of 18 months (range 3-40 months) and used the palatal plate for about 1-hour, three times a day. The average age at commencement of therapy was 12 months. Final evaluations were completed by orthodontic and neuropaediatric assessments after treatment, and compared with initial reports. Results indicated significant improvements in mouth posture and tongue protrusion.

Strengths: A large sample size and an explanation of exclusion criteria for the participants are strengths of this study. Additionally, the study provided a description of orofacial therapy and the palatal plate device. Moreover, the authors applied specific criteria for discontinuing treatment.

Limitations: A limitation of this study was the range of treatment time (3-40 months) and lack of control group. Also, the study failed to mention the age range of the children at treatment time, and details regarding the evaluation of facial features. There was no description of statistical analysis used.

Overall, this level 3 design provides suggestive clinical evidence for the use of palatal plate therapy to improve tongue protrusion and mouth posture.

Carlstedt et al. (1996) reported a mixed randomized clinical trials study with the purpose of analyzing the effects of palatal plate therapy on children with Down syndrome. The participants were children with Down syndrome, randomly divided into a test group (n=14) and an aged matched control group (n=15), the average age of both groups was 24 months (range of 3 months-5 years). Both groups were provided with physiotherapy for oral musculature by a speech therapist. The treatment group differed from the control group by the insertion a palatal plate for ½-1 hour twice a day. The groups were videotaped at baseline, and every three months for 12 months. The parameters observed were closed mouth, tip of tongue visible, open mouth, inactive protrusion of tongue, and active protrusion of tongue and measured based on duration. Significant results were reported after 12 months of therapy for closed mouth (increased duration) and inactive protrusion of the tongue (decreased duration)

( $p < 0.001$ ). Additionally, parents reported progress in eating and drinking behaviors and a reduction of drooling.

**Strengths:** The participants were randomized into treatment and control groups and only differed by use of a palatal plate. Moreover, the paper clearly described how each parameter was defined, and the protocol the evaluators would complete in the case of contradictory findings. Parametric statistical analyses were appropriate.

**Limitations:** The control and treatment groups were relatively small and there was a large age range for the start of treatment. The video recordings were 10-minutes in length, which may not have been adequate to fully assess the child's features.

Thus, Carlstedt et al's (1996) level 1 study provides compelling evidence for the improvement of inactive tongue protrusion and closed mouth, after being treated with palatal plate therapy.

Similarly, Backman et al. (2003) conducted a one-year non-randomized mixed clinical trial study to describe oral motor effects of children treated with a palatal plate and communication therapy. Participants were divided into one treatment group ( $n=42$ ) of infants with Down syndrome and control group of typically developing age-matched infants ( $n=31$ ), and one control group of infants with Down syndrome not receiving the treatment ( $n=33$ ). Both the treatment group and control group of infants with Down syndrome received communication, oral motor and sensory therapy, however the treatment group was also treated with a palatal plate from  $\leq 6$  months of age to  $18 \pm 3$  months of age. The plates were inserted 2-3 times a day for 5-30 minutes at a time. A dentist using a video recorder evaluated the facial features, and a speech language pathologist evaluated speech features. Results suggested that palatal plate therapy did not generate a significant improvement on oral parameters (number of teeth erupted, type of sucking habits, morphology of tongue, occlusion). However, non-statistic results revealed that a palatal plate in association with oral motor and sensory stimulation has a positive effect for development the fundamentals for speech articulation. No negative effects were documented.

**Strengths:** Strengths of this level 2a study include a relatively large sample size, as well as two age matched control groups. Statistical analysis (ANOVA) was appropriate.

**Limitations:** The study does not explain exclusion criteria, and the method in which children with Down syndrome were divided into control or treatment group. Additionally, the study does not describe how long the videotape segments were and who evaluated the

parameters.

Based on the strengths and limitations, this study provides equivocal evidence of the improvement of speech articulation in children with Down syndrome, following palatal plate therapy.

#### **Studies evaluating immediate results after an average of 4 years of treatment**

Carlstedt et al. (2001), Carlstedt, Henningsson, Dahllof, (2003) and Backman, Grevér-Sjölander, Bengtsson, Persson, & Johansson, (2006), evaluated the effects of palatal plate therapy after 4 years of treatment.

Carlstedt et al. (2001) conducted a randomized mixed group. The study assessed oral motor function of children with Down syndrome after four years of palatal plate therapy. The treatment group ( $n=9$ ) consisted of children with Down syndrome and the control group ( $n=11$ ) was comprised of age-matched children with Down syndrome. Both groups participated in orofacial physiotherapy provided by a speech language pathologist while the treatment group also inserted a palatal plate for one hour twice a day for four years. The age range of the children at the start of therapy was 3-33 months. To evaluate the results, two blinded speech language pathologists analyzed video segments of the participants and reviewed parent questionnaires. Significant results were reported for the treatment group in three parameters; lip rounding during speech ( $p < 0.05$ ), inactive open mouth and inactive tongue protrusion ( $p < 0.01$ ). As well, a general trend towards increased active variables was noted in the treatment group.

**Strengths:** The treatment and control group were aged matched, randomized and only differed in the parameter of palatal plate insertion. Additionally, the study presented a description of how each of the nine variables was measured. The observers were blinded and a correlation value of  $r=0.94$  was reported between evaluators. Moreover, appropriate nonparametric statistical analysis was used to evaluate the results.

**Limitations:** The small sample size and short length of the video segment (10 minutes) are limitations of this study.

Thus, compelling evidence can be obtained from this level 1 study for the use of palatal plate therapy on the improvement of lip rounding, inactive open mouth, and inactive tongue protrusion.

Moreover, Carlstedt et al. (2003) further explored the data from the previous study to include additional oral facial parameters as well as articulation and communication function. Parameters were analyzed using a clinical examination, which included a speech

assessment as well as a parent questionnaire. The results indicated significant differences for visible tongue during speech ( $p < 0.01$ ) and non-speech periods ( $p < 0.05$ ), lip rounding during spontaneous speech ( $p < 0.01$ ), and reduction in open mouth ( $p < 0.05$ ). Facial expression was significantly better for treatment group ( $p < 0.05$ ). Nocturnal snoring was documented to be significantly less ( $p < 0.05$ ) in the treatment group according to the parental questionnaire. Lip rounding and visible tongue were correlated for the treatment group ( $r_s = 0.58$   $p < 0.01$ ). No statistically significant values for communicative preference and articulation were found.

**Strengths:** Similar strengths observed in Carlstedt et al. (2001) in terms of methods and participants were observed as in Carlstedt et al. (2003). Additionally, parent questionnaires were used to assess improvement in the parameters. Moreover, appropriate non-parametric statistical analysis was used.

**Limitations:** Similar limitations were observed in this study, as in Carlstedt (2001).

Based on the strengths and limitations, this study provides compelling evidence for the improvement of reduction visible tongue, lip rounding during spontaneous speech, reduction in open mouth, facial expressive and nocturnal snoring

Similarly, Backman et al (2006) followed children with Down syndrome over four years of therapy. Backman et al. (2006) continued evaluating the children from the Backman et al (2003) study until the children reached 48 months of age. This longitudinal non-randomized mixed clinical trials study was designed to examine the effects of palatal plate therapy in association with speech and language intervention on orofacial parameters as well as speech. The treatment group ( $n = 36$ ) was composed of children with Down syndrome, and two aged matched control groups were included in the study. One control group consisted of children with Down syndrome ( $n = 31$ ), and the second of children with typical development ( $n = 36$ ). A dentist observed oral parameters, two speech language pathologists and a phonetician evaluated speech and language. Statistically significant positive values were calculated for mouth occlusion in the treatment group. Speech, language and communication were measured qualitatively. Positive effects were observed in the treatment group for oral facial expression and speech; the study group answered more test questions and had more correct pronunciation (% consonants correct) than the Down syndrome control group. Additionally, facial expression was qualitatively improved in the study group compared to the control group with Down syndrome.

**Strengths:** Strengths of this study include two age matched control groups, one with children with Down syndrome and the other a healthy control and appropriate non-parametric statistical analysis.

**Limitations:** There were six treatment participants who dropped out of the study after Backman (2003), which may have altered the data. The study did not provide a description of how each feature was measured, or exclusion criteria.

Overall, this 2a study design provides suggestive evidence for improvement in mouth occlusion, oral facial expression and speech.

### **Studies that evaluate short-term and long-term effects**

Glatz-Noll and Berg (1991) Hohoff and Ehmer (1999), Korbmacher, Limbrock, Khal-Neike, (2002) and Korbmacher, Limbrock, Khal-Neike (2006) conducted studies that evaluated short-term and long-term effects of palatal plate therapy.

Glatz-Noll and Berg (1991) presented a longitudinal mixed groups repeated measures study aimed at investigating lip and tongue function as well as the effects of stimulation plates on children with Down syndrome. The study included a treatment group ( $n = 24$ ) comprised of children with Down syndrome between the ages of 2-12 years old, and a control group ( $n = 19$ ) of healthy children less than 3:9 years of age served as a comparison. The treatment group was monitored between 4-11 months and a follow up was done 5-20 months after treatment for 7/24 children in the treatment group. The treatment group was instructed to wear the plate for 1-2 hours two or more times a day and 5/24 children also received orofacial physiotherapy. Parameters were rated through observation of 300-second video clips of the children. The study reported decreased duration of lip protrusion in the treatment group by 95.5 seconds/300 second video recordings. Additionally, an improvement in optimal tongue rest position in 10/24 patients was recorded while no difference in lip posture was calculated. After a period of 20 months from the end of treatment, the results appeared stable in 5/7 children who participated in the follow up. Additionally, two of the participants in the treatment group left the study due to an increase in tongue protrusion duration.

**Strengths:** Both long-term and short-term results were investigated. Additionally, video recordings were evaluated a third time in the case of a discrepancy. Moreover, non-parametric analysis was used to evaluate the results of tongue rest position.

**Limitations:** Limitations include non-aged-matched treatment and control groups and the small number of children who received follow-up analysis, only 7 of 24

(7/24). Furthermore, evaluations were based on short video recording (300 seconds), which may not be representative of the child's features. Additionally, children in the treatment group received inconsistent care; 5/24 children also received physiotherapy, and treatment times from 4-11 months. Moreover, the study was lacking a control group of children with Down syndrome.

Based on the strengths and limitations, this level 2b design study provides equivocal evidence for the improvement of tongue position.

Hohoff and Ehmer 1999 investigated the short and long-term effects of palatal plate therapy, insertion of palatal plate in combination with orofacial physiotherapy. The study was designed as a within groups repeated measures design. The treatment group consisted of 47 children with Down syndrome aged approximately 6.5 months. The children were evaluated at three different stages: Pre treatment examination (Rec 1), first follow up examination (Rec 2) occurred 4 months after the completion of treatment (n=38), the second follow up exam (Rec 3) took place 53 months after treatment was completed (n=18). The average duration of treatment for those who stayed in the study until Rec 3 was 9.9 months of treatment. The palatal plate was worn for four, one-hour periods a day. Parameters were evaluated based on a parent interview and clinical examination. Conformity between the two measures was evaluated.

Results revealed an improvement in habitual mouth posture. Significant improvements were noted for all time periods for "mouth slightly open," and "mouth closed." The authors describe non-significant trend results for "tongue protruding slightly over lips" and "Tongue mostly in oral cavity." Parent interviews were consistent with these results.

Strengths: Strengths of this study include a description of selection criteria, an investigation of short term and long-term effects, appropriate non-parametric analysis as well as consistent treatment provided to all participants. Moreover, this study reviewed consistencies between parent report and clinical findings.

Limitations: Limitations of this study involve the number of participants who dropped out between each follow up examination.

Overall, this level 2b study provides suggestive clinical evidence for improvement of mouth slightly open and mouth closed.

Similar to Hohoff and Ehmer (1999), Korbmacher et al (2002) conducted a longitudinal study in which they

measured participants at three stages. It was designed as a within groups repeated measures. The participants included 20 children with Down syndrome who had received palatal plate therapy approximately 12 years prior. Treatment involved insertion of the palatal plate one hour three times a day, and participation in a physiotherapy program. At beginning of therapy mean age of the participants was  $16 \pm 23$  months and mean duration of therapy was  $11.5 \pm 4$  months. At the time of follow up, mean age was  $14.1 \text{ years} \pm 38$  months. Three time periods were analyzed: diagnosis before treatment (T), immediately after completion of therapy (R1), 12.9 years after beginning treatment with palatal plate (R2). Outcomes were documented by a neuropaediatrician using standardized forms. The features were further assessed during parent interviews. Results for "habitual mouth posture" and "habitual tongue posture revealed an improvement at R1 and R2. Members who displayed more severe symptoms at baseline exhibited better outcomes.

Strengths: Strengths include uniform treatment amongst the participants, consistent methods and criteria used to obtain follow up results as were used for original evaluations, and use of standardized forms in assessment. Additionally, the study described the protocol used if contradictory observations were recorded. Moreover, short and long-term effects of the therapy were analyzed and compared.

Limitations: The value of the study's evidence is reduced based on the sample size; out of 102 patients who had been treated 12 years ago and were recalled for follow up, only 20 chose to participate in the study. These 20 participants may not be representative of the entire population treated by the therapy 12 years prior. Moreover, the age range at the start of therapy (1 month- 60 months) and lack of control provide limitations. Additionally, only descriptive statistics were reported.

Based on the strengths and weaknesses of the study, this 2b design provides suggestive evidence for the improvement of habitual mouth posture and habitual tongue posture.

Korbmacher et al. (2006) conducted a similar longitudinal study, a within groups repeated measures as the one stated above, to address the long-term effects of palatal plate therapy. The treatment group consisted of 27 adolescents with Down syndrome who had been treated with palatal plate therapy according to Castillo-Morales. Treatment with the palatal plate was provided for three, one-hour periods a day, in combination with orofacial physiotherapy. The average age for the start of treatment was  $13 \pm 4$  months, and the mean duration of treatment was  $19 \pm 4$  months.

Korbmacher et al. (2006) assessed three time periods: T; pre treatment, R1: end of therapy, R2; follow up exam 13 years post treatment. To evaluate the effects of treatment a standardized questionnaire was filled out by parents in addition to a clinical exam judged by a neuropaediatrician, using the same grading system in all three evaluations. Results revealed an improvement in habitual mouth posture (T-R1, T-R2) and habitual tongue posture (T-R1, R1-R2, T-R2). The Mann Whitney U test revealed a significant value between the severity of habitual mouth and tongue protrusion at baseline and the magnitude of improvement.

Strengths: This study compared short-term and long-term effects of palatal plate therapy and used appropriate non-parametric statistical analysis. Additionally, consistent therapy was provided to the participants. Furthermore, the methods were clearly described and followed the same protocol as the original evaluations.

Limitations: The value of the study's evidence is reduced based on the sample size. Out of 102 patients who had been treated 13 years ago and were recalled for follow up, only 20 chose to participate in the study. These 20 participants may not be representative of the entire population treated by the therapy 13 years prior. Additionally, no control group was examined.

Overall, this 2b study design provides suggestive evidence for the improvement of habitual mouth posture and habitual tongue posture.

#### **Studies that evaluate long-term effects**

Hohoff and Ehmer (1997) and Schuster and Giese (2001) documented long-term effects of palatal plate therapy on children with Down syndrome.

Hohoff and Ehmer (1997) document a retrospective, non-randomized clinical trial-mixed groups. The study is composed of a treatment group (n=20) of children with Down syndrome, average age 4.8 months at the beginning of therapy, as well as a control group (n=18), of children with Down syndrome, average age 47.5 months at examination. Treatment took place for an average of 10.8 months and consisted of palatal plate insertion, two hours in the morning, two hours in the afternoon. Additionally, physiotherapy and speech therapy was recommended to everyone, but not all members participated. Follow up occurred 39.5 months after treatment. Evaluation involved parent questionnaires, parent records and a clinical exam completed by an orthodontist and speech language pathologist.

Based on the evaluations, Hohoff and Ehmer (1997) concluded that speech in the treatment group was

developed 2-3 months faster than in the control group. Additionally, the treatment group was objectively observed to display better oral motor control. Moreover, according to data collected in interviews with parents, improvement in mouth and tongue position during treatment occurred in 16/20 treatment participants. After treatment, mouth and tongue worsened in one participant.

Strengths: Strengths of the study include an aged matched control group of children with Down syndrome, consistent treatment (without the palatal plate) for the control group and the description of exclusion criteria. Additionally, standardized forms (for parent questionnaire and medical data) were analyzed, and a copy of a parent questionnaire was provided in the report. Appropriate non-parametric statistical analyses were used. Moreover, this was the only study examined to assess rate of speech development.

Limitations: The control group and treatment group did not differ solely based on treatment. The control group was found to have better hearing and visit an SLP more often. As well, the study did not abide by Castillo-Morales's palatal plate therapy components, of using a palatal plate and providing orofacial physiotherapy, as not all the participants were provided with orofacial physiotherapy. Moreover, the results may be subjective because half of results were based on parent questionnaires.

In all, this 2a study provides suggestive evidence for earlier development of speech in children with Down syndrome after palatal plate therapy.

Schuster and Giese (2001) present a retrospective, non-randomized mixed study. The study aimed at analyzing the effects of palatal plate therapy according to Castillo-Morales, when implemented at an early age. The treatment group involved 20 children with Down syndrome who had undergone early treatment with a palatal plate. These children presented with severe orofacial features at the age of 8 months. The control group consisted of 13 children with Down syndrome who did not have early intervention and presented with mild orofacial signs at seven months of age. The treatment group received palatal plate therapy four times a day for half an hour over a two-year period. Additionally, 95% of those in the study group saw a speech language pathologist and 40% worked with a physiotherapist.

Results were obtained from a clinical examination and parent questionnaire approximately 6 years after the completion of treatment. Outcomes revealed minimal differences between the two groups at follow up. Lip posture and mouth closure improved in both groups, but

a larger improvement was observed in the study group. As well, the palatal width of the jaw was evaluated to be the same in each group and tongue position improved as well (in 55% of treatment group it was sitting either in the mouth or on the dentition). Moreover, according to the parent questionnaire, 65% of parents reported an improvement in facial profile, associated with mouth closure. Parents also noticed an improvement in speech.

**Strengths:** The study was strengthened by the presence of a control group, description of inclusion criteria as well as an analysis of long-term results.

**Limitations:** The study did not investigate early intervention for mild cases of orofacial dysfunction. Additionally, initial findings for the control group were from photographs only. Moreover, inconsistent attendance in speech and physiotherapy for control and treatment group is a limitation in this study. No statistical results were used.

The study is 2a level of evidence and provides suggestive evidence that early intervention using palatal plate therapy can improve lip, mouth and tongue posture of children with Down syndrome.

### ***Discussion***

#### ***Impact of Palatal Plate on oral motor function***

##### ***Tongue***

The information collected from the reviewed studies suggests that palatal plate therapy can improve tongue position. Reduction in tongue protrusion time and an improvement in tongue position were noted in several studies ranging in length of treatment and time of evaluation in relation to treatment. Carlstedt et al. (1996, 2001, 2003) noted significant reduction in tongue protrusion values, and reduction of visible tongue during speech and non-speech activities.

Additionally, Glatz-Noll and Berg (year), Hohoff and Ehmer (1999), Korbmacher et al (2002) and (2006) recorded qualitative short term and long-term improvements in the reduction of tongue protrusion, or improvement in tongue rest position for children with Down syndrome. Each study varied in length of treatment, from 4 to 12 months. Only Korbmacher et al. (2006) reported significant values in improvement of tongue position and additional improvement after therapy had been completed.

Moreover, it was observed that immediate insertion of a palatal plate reduced tongue protrusion time by an average of 60%, which is statistically significant (Limbrock et al 1993).

In contrast, Carlstedt (1996) found no significant difference in the parameter “tip of tongue visible” between control and treatment groups.

##### ***Occlusion/ Lips Improvement***

There is suggestive evidence to indicate that palatal plate therapy improves mouth posture/occlusion. Many studies noted improvement in occlusion, irrespective of length of treatment or time of evaluation.

Short-term improvements of occlusion were noted in several studies varying in length of treatment. Backman et al. (2006) found statistically significant results, after four years of treatment, in occlusion for those who began with more severe occlusion deficits. Similarly, Carlstedt et al. (2001) and (2003) evaluated significant results for the parameter of “inactive open mouth” after four years of treatment with palatal plate therapy. Carlstedt et al. (1996) documented significantly longer duration of closed mouth for the treatment group after one year of treatment. Moreover, Limbrock et al. (1991) and (1993) obtained significant positive results reducing open mouth posture.

Additionally, studies that measured further long-term effects confirmed an improvement in occlusion. Hohoff and Ehmer, (1999) reported significant reduction of open mouth posture, and a significant improvement in mouth closed for short term and long-term effects. Also, Korbmacher et al. (2006) noted improvement in occlusion in the treatment group over long term and short-term evaluations.

However, Glatz-Noll and Berg (1991) documented individual variability with open mouth habit, however, no differences in mouth posture were evident after 4-11 months of treatment with palatal plate therapy.

##### ***Sucking/Drooling***

Palatal plate therapy may have an effect on sucking and drooling. Limbrock et al. (1991) reported positive results for decreasing drooling and sucking after implementing palatal plate therapy for one year. However, Backman et al. (2003) documented no improvement in sucking habits after one year of treatment.

##### ***Teeth eruption***

Palatal plate therapy does not seem to improve tooth eruption in children with Down syndrome who participate in the treatment. Both long-term and short-term effects of palatal plate therapy revealed no improvement in tooth eruption (Schuster and Giese 2001 and Backman et al. 2003, 2006).

### **Impact of palatal plate on speech and language**

Few studies reported significant findings for improvements in speech and language. Most authors reported descriptive results, with a positive trend in improvements of articulation, speech and facial expression in children with Down syndrome who participate in palatal plate therapy. This evidence is mostly equivocal or suggestive and must be interpreted with considerable caution.

### **Articulation**

Several studies that analyzed short-term effects revealed improvements in speech as a result of palatal plate therapy. Backman et al. (2003) documented a positive trend for those who participated in palatal plate therapy and improvements in pre requisites for speech. Backman et al. (2006) obtained qualitative results for articulation, and reported an improvement in percent consonants correct for the treatment group. Additionally, Carlstedt (2001) and (2003) recorded a significant increase in rounding of lips during speech compared to control group. It was qualitatively noted in Carlstedt (2003) that there were fewer difficulties with articulation due to velopharyngeal insufficiency and hypotonicity in the treatment group when compared to the control group.

Furthermore, Hohoff and Ehmer (1997) documented a retrospective study in which they calculated a qualitative improvement in early speech development in children who wore a stimulating palatal plate.

### **Facial expression**

Backman et al. (2006) and Carlstedt et al. (2003) reported on facial expression. Backman et al. (2006) qualitatively evaluated a positive trend in improvement in facial expression, and Carlstedt et al. (2003) found statistically significant improvements in facial expression, compared to the control group.

It must be noted that a limitation of all studies reviewed is the lack of objective measures used to evaluate orofacial parameters.

### ***Conclusion And Clinical Implications***

Results suggest that palatal plate therapy has a positive effect on a variety of features of children with Down syndrome. Suggestive evidence has been analyzed for palatal plate therapy to improve tongue protrusion and mouth occlusion and equivocal evidence evaluated for improvement on speech in children with Down syndrome. Based on the studies surveyed above, length

of treatment does not appear to have an effect on the outcome.

In all, the evidence is suggestive that a child with Down syndrome may benefit from participation in palatal plate therapy. However, it is also important to be aware that children with Down syndrome are a heterogeneous group and as such, each child with Down syndrome should be evaluated as an individual. Prior to recommending palatal plate therapy, one should consider the various co morbidities exhibited by the child, and the stressors experienced by the family (Backman et al 2006).

Although it is difficult to predict which child with Down syndrome will benefit from palatal plate therapy there are some observed trends. A consistent trend across studies was a child who presented with more severe orofacial features at baseline had optimum improvements at the end of treatment (Korbmacher et al 2002, 2006; Limbrock et al 1991, 1993). Nevertheless, positive findings have been associated with clients with mild to moderate oral facial dysfunctions who are willing to participate in treatment (Korbmacher et al 2002). Secondly, compliance of the child and family is important and should be taken into consideration when applying this treatment. (Schuster, Giese 2001 and Korbmacher et al. 2006)

Additionally, it is unclear if speech language therapy/physiotherapy in combination with palatal plate therapy improve the outcomes of the palatal plate, or if similar results may be acquired with the palatal plate alone. However, it is unlikely that such a study would be conducted.

Recommendations for future research:

1. Specify a standardized orofacial therapy program provided by the SLP/physiotherapist
2. The use of objective measures to evaluate orofacial disorders by further exploring the Hugh McMillan approach (Limbrock et al. 2003)
3. Implement studies to examine the effect of palatal plate therapy on other populations with orofacial and speech anomalies
4. Implement studies examining the speech outcomes after palatal plate therapy

Palatal plate therapy should be considered for future clinical practice. There is evidence to suggest that palatal plate therapy can improve tongue and mouth posture and have a positive impact on speech and communication.

### ***References***

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