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Review Article

Suffer the little children: Fixed intraoral habit appliances for treating childhood thumbsucking habits: a critical review of the literature

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SUFFER THE LITTLE CHILDREN: FIXED INTRAORAL HABIT APPLIANCES FOR TREATING CHILDHOOD THUMBSUCKING HABITS: A CRITICAL REVIEW OF THE LITERATURE.

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ABSTRACT

A critical review of the literature is presented covering the treatment of childhood thumbsucking habits using fixed intraoral habit appliances (hayrake, palatal crib). The habit appliances are classified into type and function. Data is tabulated for key references revealing the fragmented and distorted nature of the literature and its lack of consistency. A chronological approach is presented to confirm the confused and idiosyncratic character of the literature. Information is provided on the early work of Massler and Graber and the paradox of Mack, Korner and Reider. Haryett's seminal studies at the University of Alberta regarding aspects of the treatment used are critically reviewed. Reflections are presented on why Larsson's study, casting doubt on the wisdom of using habit appliances, continues to be ignored. The emergence of the Bluegrass Appliance is discussed in terms of its being a more humane appliance and the seeming reluctance of practitioners to apply it as a kinder form of appliance therapy. Information is reported on the pain and serious injuries inflicted on children by habit appliances. A comparison of the use of appliances in the USA is made with the UK, where fixed habit appliances are not popular. Concludes that fixed intraoral habit appliances are cruel and inflict pain and suffering on children out of all proportion to their necessity. Questions why these appliances continue to be used, implying that it could be a combination of financial inducement, professional insularity and the absence of concerted opposition from behavioural therapists.

Keywords: fixed intraoral habit appliances; habit appliances; thumbsucking

INTRODUCTION

The fractured, distorted and incomplete nature of the literature of orthodontics offers a rich source of fascination for librarians and information professionals as well as for dentists and orthodontists. The process of reviewing such literature can also provide opportunities for identifying gaps in the literature and for assisting practitioners in the field by pointing to areas where future investigation might fill such gaps. The following review focuses on one aspect of the dental/orthodontic literature dealing with the controversial subject of fixed intraoral habit appliances (also known as habit appliances, habit breakers, fixed palatal cribs, rakes etc) and their use in the treatment of chronic childhood digit habits (thumbsucking and fingersucking). The subject of childhood digit habits, their influence on dentition, the complex arguments that have raged for generations regarding the need to break such habits, whether or not such habits are "meaningful habits" or "empty habits" and the possibility of psychological damage that may result are not the primary subject of this review. Neither will there be more than a passing mention of the many, non-invasive techniques devised for its treatment, other than those references where there is a direct comparison between invasive and non-invasive treatments. While the dental/orthodontic literature is inconclusive in many ways, there is nevertheless clear evidence that digit habits can have serious consequences on the occlusion of children at the age when the deciduous gives way to the permanent dentition. Depending on its nature and intensity, the habit can lead

to: reduced overbite or anterior open-bite; often asymmetrical protrusion of the upper incisors; and narrowing of the maxillary arch, leading to cross-bite and displacement (British Orthodontic Society, 2000). Van Norman (2001) also points to problems in the development of speech, articulation and socialization skills. In recent years there have been some excellent reviews of the literature on thumbsucking, including: Johnson and Larson (1993), Umberger and Van Reenen (1995), Moore MB (1996) and Van Norman (1997). The aim of this review is to trace the history of those treatments that involve the cementing of a fixed, wire appliance to the upper teeth, particularly the maxillary first or second molars, assisting or forcing children to break their digit sucking habits. This review summarizes the published literature in order to reveal the lack of any cogent and consistent philosophy, creates a coherent corpus of knowledge, and demonstrates that many thousands of children have needlessly suffered pain and discomfort. The literature is covered in its widest sense and includes reference to printed books and journals and the World Wide Web. A roughly chronological approach is adopted to establish how habit appliance therapy has evolved (or not evolved) over the years.

A PLETHORA OF APPLIANCES

Table 1 provides a useful summary of the primary references containing some of the main features of the appliances that will be referred to in the text. The first impression, other than the almost complete lack of any consistent pattern over the past 60 years, is the bewilderingly large number of different types of habit appliances used to treat this problem. Librarians tend to be obsessed by taxonomy and classification and a great deal of time has been spent trying to classify these habit appliances in terms of their function and form and the results intended. There seems to be some degree of confusion as to whether they are primarily used to treat digit habits or tongue thrust or a mixture of both. With the exception of Lingual Spurs, which are vertical spikes banded to the incisors, virtually all the habit appliances are constructed from bands on the molars to which is soldered an arch wire carrying the main element deterring or preventing the digit sucking. The definitions used in the table are the ones used to classify the appliance into form/function and comprise a mixture of terms used in the literature and terms originating with the author. Excellent images of some of these appliances can be found on the World Wide Web and specific reference of the Web Images are indicated by the appropriate appliances in the following section. The URLs for the Web Images are included in the Webliography, which precedes the main references section at the end of the article.

1). Vertical Appliances

These provide a vertical barrier or "wall" preventing the child from inserting a digit. They may be further subdivided into:

a). The Rake ("Hayrake") (Web Images R1-R4)

(i). Sharp Rake This appliance has a series of sharp points that cause the child to pierce its digit when attempting to insert it, providing painful feedback. It also pierces the tongue and is therefore popular for treating tongue thrust.

(ii). Blunt Rake This appliance is similar to the Sharp Rake but has blunt or "balled" points and does not pierce the digit. One variation can also feature wire loops. Another can comprise a Palatal Bar with short, blunt protuberances, forming a hybrid between a Blunt Rake and a Palatal Bar.

(iii) Lingual Spurs This appliance has sharp/blunt spikes and functions in the same way as the Rake (Sharp/Blunt) but is anchored to the incisors rather than the molars.

Table 1. Analysis of the Literature of Fixed Intraoral Habit Appliances.

Reference	Vertical Appliances	Horizontal Appliances	Other Types of Appliance	Fixed/ Removable	Age of Child	Duration of Treatment	Physical Injury Caused by Appliance?	Consent of Child Sought?
Locke (1936)	Sharp Rake			Fixed				
Locke (1937)			Roller, Spiked	Fixed				
Johnson (1937)	Sharp Rake	Palatal Bar		Fixed				
Swinehart (1938)	Sharp Rake/Blunt Rake			Fixed		6 months		
Johnson (1938)	Sharp Rake	Palatal Bar		Fixed				
Johnson (1939)		Palatal Bar		Fixed				
Teuscher (1940)		Palatal Bar		Fixed	4.5 years			
C. R. B. (1942)	Sharp Rake	Palatal Bar		Fixed	3 years			
Massler and Wood (1949)					3-6 years			Consent sought
Massler and Chopra (1950)	Blunt Rake/Vertical Crib	Horizontal Crib		Fixed	3-6 years		Injury reported	Consent sought
Mack (1951)	Sharp Rake	Palatal Bar/Horizontal Crib		Fixed/ Removable	3.5 years			
Graber (1952)			Graber	Fixed	3 years			
Korner and Reider (1955)	Sharp Rake			Fixed	3.75 years	8 months		Consent sought
Cimring (1955)	Blunt Rake			Removable	6-12 years			Consent sought
Graber (1958)			Graber	Fixed	2.5-18 years	3-6 months		
Traisman and Traisman (1958)		Palatal Bar		Fixed				
Graber (1959)			Graber	Fixed		3-6 months		
Jarabak (1959)	Blunt Rake			Fixed				Consent sought
Haryett (1962)		Horizontal Crib		Fixed				
Graber (1961)			Graber	Fixed		3-6 months		
Graber (1963)			Graber	Fixed	3.5-4.5 years	3-6 months		
Subtelny and Sakuda (1964)	Vertical Crib			Fixed				
Graber (1966)			Graber	Fixed		3-6 months		
Haryett et al (1967)	Sharp Rake-Vertical Crib	Palatal Bar		Fixed	4 years+	10 months		
Haryett et al (1968)	Sharp Rake-Vertical Crib	Palatal Bar		Fixed	4 years+	10 months		
Norton and Gellin (1968)	Sharp Rake/Blunt Rake/Vertical Crib	Horizontal Crib		Fixed	8 years+			Consent sought

Table 1. Analysis of the Literature of Fixed Intraoral Habit Appliances, cont...

Reference	Vertical Appliances	Horizontal Appliances	Other Types of Appliance	Fixed/ Removable	Age of Child	Duration of Treatment	Physical Injury Caused by Appliance?	Consent of Child Sought?
Haryett et al (1970)	Vertical Crib	Palatal Bar		Fixed	4 years+	6-10 months	Injury reported	
Parker (1971)	Sharp Rake/Lingual Spurs			Fixed	5.5 years+	8 months+		
Klein (1971)	Vertical Crib/Lingual Spurs	Horizontal Crib		Fixed	3.5 years+			Consent sought
Larsson (1972)	Blunt Rake-Vertical Crib			Fixed	9 years	2.5 months	Injury reported	Consent sought
Gershater (1972)	Vertical Crib			Fixed				
Curzon (1974)		Palatal Bar		Removable				
Shuff (1976)		Palatal Bar		Fixed	8 years+	2 months		Consent sought
Sim (1977)	Blunt Rake/Vertical Crib			Fixed/ Removable	5-10 years	3 months	Injury reported	Consent sought
Gellin (1978)	Vertical Crib/Blunt Rake			Fixed/ Removable	5 years+	6 months	Injury reported	Consent sought
Jacobson (1979)	Blunt Rake			Removable	6 years+		Injury reported	Consent sought
Cerny (1981)	Vertical Crib	Hawley		Removable	13 years	8 months		Consent sought
Campbell (1984)	Blunt Rake			Fixed				
Leivesley (1984)	Vertical Crib			Fixed				
Proffit and Fields (1986)		Horizontal Crib		Fixed		3 months		Consent sought
Larsson (1988)	Blunt Rake-Vertical Crib			Fixed	9 years	2.5 months		Consent sought
Hanson and Barrett (1988)	Sharp Rake			Fixed			Injury reported	
Friman and Schmitt (1989)		Palatal Bar		Fixed/ Removable	6 years+			
Haskell and Mink (1991)			Bluegrass	Fixed	7 years+	3-6 months	Injury reported	Consent sought
da Silva Filho et al (1991)	Blunt Rake			Fixed/ Removable	5 years+	10 months		Consent sought
Viazis (1991)	Vertical Crib			Fixed	10 years	3 months		
Peterson and Schneider (1991)	Blunt Rake/Lingual Spurs	Palatal Bar		Fixed/ Removable				Consent sought
Brenchley (1991)				Fixed/ Removable	10-12 years			Consent sought
Viazis (1993)	Vertical Crib			Fixed	10 years	3 months		
Proffit and Fields (1993)		Horizontal Crib		Fixed		3 months		Consent sought
McDonald and Avery (1994)	Blunt Rake		Bluegrass	Fixed/ Removable				Consent sought
Khalil (1994)	Vertical Crib			Fixed	4.5 years+			
Molinari (1995)	Vertical Crib	Horizontal Crib		Fixed		6 months		Consent sought

Table 1. Analysis of the Literature of Fixed Intraoral Habit Appliances, cont...

Reference	Vertical Appliances	Horizontal Appliances	Other Types of Appliance	Fixed/ Removable	Age of Child	Duration of Treatment	Physical Injury Caused by Appliance?	Consent of Child Sought?
Josell (1995)	Vertical Crib	Horizontal Crib		Fixed/ Removable		3-6 months	Injury reported	Consent sought
Gawlik et al (1995)	Vertical Crib			Fixed			Injury reported	Consent sought
Mathewson and Primosch (1995)	Sharp Rake	Horizontal Crib		Fixed	7 years+			Consent sought
Moore (1996)	Vertical Crib			Fixed/ Removable				Consent sought
Metaxas (1996)	Vertical Crib			Fixed/ Removable				Consent sought
Herud (1998)			Graber	Fixed				
Baker (1998)			Bluegrass	Fixed	20 months+	6 months		Consent sought
Pinkham (1999)		Horizontal Crib		Fixed		6-12 months	Injury reported	
Richardson (1999)		Palatal Bar		Removable				Consent sought
Proffit and Fields (2000)		Horizontal Crib		Fixed		6 months	Injury reported	Consent sought
Maguire (2000)		Horizontal Crib	Bluegrass	Fixed	4 years+	3-6 months		
Subtelny (2000)	Vertical Crib			Fixed				
Baker (2000)			Bluegrass	Fixed	20 months+	6 months		Consent sought
Haskell (2002)			Bluegrass	Fixed		6 months		Consent sought

Table 2. Comparative Results from Studies by Haryett et al (1967, 1970) and Larsson (1972, 1988)

Haryett et al (1967, 1970)				
Ages of Children	4-9 years	4-9 years	4-9 years	4-9 years
Treatment	Vertical Crib/Sharp Rake	Vertical Crib/Sharp Rake	Vertical Crib/Sharp Rake	Control (No Treatment)
Duration of Treatment	3 Months	6 Months	10 Months	10 Months
Habit Arrested	11	17	22	2
Habit Active	7	2	0	19
Total	18	19	22	21
Success Rate	61%	89%	100%	10%
Larsson (1972, 1988)				
Ages of Children	9 years	9 years	9 years	9 years
Treatment	Vertical Crib/Blunt Rake	Positive Reinforcement	Negative Reinforcement	Control (No Treatment)
Duration of Treatment	2.5 months	2.5 months	2.5 months	2.5 months
Habit Arrested	11	11	14	2
Habit Active	7	8	5	17
Total	18	19	19	19
Success Rate	61%	58%	74%	11%

b). The Vertical Crib (Web Images V1-V6) This appliance takes the form of a semicircular wire "gate" which does not pierce or prod the digit but simply forms a barrier to its entry. One variation can incorporate small spurs ("crib with spurs") along the bottom edge of the crib body.

2). Horizontal Appliances
These do not form a barrier to the digit's entry but lie horizontally in such a way as to partially cover the palate. This prevents the digit from making pleasurable contact with the palatal tissue and prevents the formation of a seal to enable suction to take place. It is also claimed that they act as "reminders" to the child rather than physical preventive measures.

a). The Palatal Bar This is the simplest appliance and takes the form of a single, double or looped wire fitted across the arch wire. Its barrier properties are minimal and acts more as a reminder to the child.

b). The Horizontal Crib (Web Images H1-H5) This appliance takes a physical form similar to the vertical crib, with a semicircular "gate", but turned through 90 degrees so that it partially covers the palate.

3). Combination and Special Appliances
There are two special habit appliances: the Graber Appliance; and the Bluegrass Appliance.

a). The Graber Appliance (Web Images G1-G2) This combines the Blunt Rake, the Palatal Bar and the Horizontal Crib into a single appliance, allowing adjustment of the treatment by the practitioner. It was invented by Graber and will be described *in the section covering* his contribution to the literature.

b). The Bluegrass Appliance (Web Images B1-B6) This is a totally unique type of habit appliance in that it uses a Teflon roller or several beads that are free to rotate on a Palatal Bar. The child is encouraged to treat it as a "toy" and so the underlying philosophy of the appliance is totally different from the other fixed intraoral habit appliances. The Bluegrass Appliance will be described in a separate section.

THE EARLY USES OF HABIT APPLIANCES: 1936-1960

The earliest reference in the literature to fixed intraoral habit appliances was traced to a patent by Locke (1936) which clearly shows the characteristic form of the Rake, albeit with short spikes and having some of the characteristics of the Horizontal Crib. The digit is allowed to enter the mouth and touch the palate but the spikes in a Palatal Bar make the activity painful. Locke (1937) followed this with another patent in which the spiked Palatal Bar is replaced by a spiked roller designed to ensure that the child's digit always encounters spikes however it tries to circumvent the appliance. Confirmation that this approach to habit aversion originates in the 1930s is given by the thorough review by Lewis (1930), in which a wide range of mechanical methods for breaking digit habits are described but no intraoral appliances are mentioned. Johnson (1937, 1938, 1939) refers to the treatment of "older" children using a Palatal Bar which may or may not carry sharp spurs (Sharp Rake) designed to convert a pleasure-giving situation into an unpleasant one. Swinehart (1938) talks about "the familiar fixed bar" (Swinehart (1938) p.742), which suggests that the technique must have been fairly well-established within a few years, even if not documented in the literature. The illustrations in Swinehart show the two forms of Locke's Rake (Sharp and Blunt), with the Blunt Rake having balled ends. Swinehart is the first practitioner to express concern about the morality of treating children in this way, considering that, at first glance, such an appliance

seems "too cruel to be placed in the mouth of a child" (Swinehart ,1938, p.742). The statement that, "when put on, the projections had balled ends to protect the tongue from injury" (Swinehart, 1938, p.743) begs the question of when and why the Sharp Rake is to be used. Johnson (1939) and Teuscher (1940) both mention habit appliances very briefly and recommend the Palatal Bar, with no mention of the Rake. Teuscher suggested the use of crowns on the molars to hold the bar, stressed the importance of the age and individuality of the child in connection with the decision to use habit appliances and referred to the frequency of failure. A disturbing letter was submitted to a journal by a partially anonymous practitioner (CRB, 1942) in answer to a question about effective methods for preventing a child of 3-years from sucking its thumb. One method suggested the use of a Palatal Bar or a Sharp Rake attached to crowns. Another recommended treatment was a good sound spanking, with the comment that "nothing has so lasting an effect on a young child as pain" (CRB, 1942 p.2278)! CRB's letter brought forth a robust rebuttal from Lemkin (1943). Traisman and Traisman (1958) reported the first really major survey of thumbsucking children in which 2,650 children in a general paediatric practice were studied for their thumbsucking habits. 1,208 (46%) were found to have the habit. This study is of interest to this review in that it reported only 4 children being treated with a habit appliance and indicated that this treatment failed in 3 out of the 4. Increased psychological stress was observed in these 3 children after insertion of the appliance. This low incidence of appliance use (0.33%) suggests little enthusiasm among practitioners at this early stage.

Jarabak (1959) reports work undertaken at Loyola University Dental School in the 1950s to treat thumbsucking children using a Blunt Rake of unusual design (incorporating a form of Palatal Bar). This work is of particular interest as it focuses attention on the need to condition the patient to appliances. Jarabak takes note of the danger of a poorly conditioned child forcibly removing its appliance or continuing with the habit despite the presence of the appliance. Jarabak stresses the need for the appliance to be simply a reminder.

Massler's Seminal Articles

In 1949 and 1950, two articles were published by Massler (Massler and Wood, 1949, Massler and Chopra, 1950) which were truly seminal and could have made a more lasting impression had they been taken more seriously by practitioners. While all the references up to this time mention fixed habit appliances more or less in passing, Massler's papers bring together all the main strands of thought and raises all the important issues involved with habit appliances. Massler and Wood (1949) do not specify any particular type of appliance but deal for the first time in considerable detail with factors such as the most appropriate age to apply treatment (infant, pre-school, grade school, and teenage), with the main focus being on the 6-12 year group. Some of the important points stressed by Massler include:

1). No appliance should be used unless the child actually requests it.
2). There is no appliance which will stop the child thumbsucking if the child resents it and does not want it.
3). Appliances presented to the child as a form of punishment are to be condemned and seldom succeed.
4). If an appliance is used on an unwilling child and appears to stop the thumbsucking, the habit will not be broken but simply transferred.

These four guidelines of Massler and Wood (1949) are deemed to be essential in determining the appropriateness of habit appliance therapy. Unfortunately,

future research tended to ignore the first three and focus on the fourth, seeking to show that appliances do not cause habit transference.

Massler and Chopra (1950) built on the earlier paper by focusing on the physical types of appliances that might be used to treat oral habits. Their article shows for the first time in great detail three types of appliance: the Horizontal Crib; the Blunt Rake; and the Vertical Crib. The article also includes the first really detailed, step-by-step description of how the appliances are constructed (using gold as the wire material rather than stainless steel). A peculiar feature is that Massler and Chopra (1950) specify only the Horizontal Crib for treating thumbsucking and recommend the Blunt Rake and the Vertical Crib for lip sucking and tongue thrusting, respectively. Once again, Massler stresses that the most important aspect of appliance therapy is that the full cooperation of the child be won and a non-cooperative, resentful child can easily overcome the most painful appliances. Two other issues appear for the first time:
a). The danger of serious injury caused by a palatal crib becoming deeply embedded in the soft tissue of the palate through vigorous thumbsucking.
b). The addition of a plastic base to the palatal surface of the crib to prevent such embedding.

The Strange Case of Mack, Korner and Reider

1). Mack's evaluation of the management of thumbsucking

Two studies, by Mack (1951) and by Korner and Reider (1955), tend to be considered separately and in isolation but, on close inspection, may be seen to be closely linked. Mack worked at the Mount Zion Hospital Dental Clinic, San Francisco and his article is the first to discuss in any depth both the dental treatment of thumbsucking and the psychological aspects of the treatment. Korner and Reider were both psychiatrists at the Department of Psychiatry at the Mount Zion Hospital and all three practitioners actually worked together. Mack's article is the first to discuss the use of removable appliances and the first to dismiss them on the obvious grounds that they can be removed - which is why they are called removable!. Mack concludes that habit appliances can be benign and three types of fixed appliances are considered, the Palatal Bar, the Horizontal Crib and the Sharp Rake which Mack refers to as "looking vicious" (Mack, 1951. p.42). The fact that Mack claims that the first two appliances will not be successful (as reminders) with the persistent child suggests that Mack does not understand the importance of the child's cooperation, as stressed by Massler and Wood (1949), and Massler and Chopra (1950). This fear is confirmed by Mack's report of the results of a questionnaire completed by a sample of 15 children and parents. One of the questions was "Are you mad at Mother and Father for bringing you here" (Mack, 1951 p.42) and suggests that the consent of the child was not sought. The small size of the sample makes the validity of the results questionable but this is the first time that any such information appears in the literature and is valuable for that alone. Mack concluded that the technique was successful but it is worrying that 2 out of the 15 said that they were "mad at" Mack for "putting this thing on your teeth" (Mack, 1951 p.42).

2). Korner and Reider's assessment of Mack's approach

Having expressed satisfaction with fixed appliance treatment for thumbsucking and recommending that a palatal crib or Hayrake should be used on a child over 3.5 years, Mack then consulted Korner and Reider to perform a psychological study of three children referred to them personally by Mack. Their case study results were published in full in an article

by Korner and Reider (1955) but the latter's disquiet was so great that they took the trouble to publish a letter summarizing the results and their concerns (Reider and Korner, 1952). Mack placed the Sharp Rake in each of the children - two aged 3.75 years and one aged 5.58 years - and the children and parents were studied by Korner and Reider before using the appliance, during use and after removal. In all three children, the appliance failed to correct the habit and had to be removed. In one case the child injured herself and in all three cases there were serious psychological changes. The study concluded that the use of the Sharp Rake could be hazardous without thorough psychological investigation prior to its use.

3). The paradox of Mack, Korner and Reider.

The report of the study by Korner and Reider (1955) makes melancholy reading but close study causes some paradoxical and quite disturbing questions to emerge:

a). If Mack hoped to find endorsement for the treatment which he was recommending in his 1951 paper and with which he claimed to have total success in the 15 cases in his survey, was it pure chance that the 3 children he referred to Korner and Reider were about as unsuitable as they could possibly have been and where the result was total failure?
b). If Mack was free to select the children to be referred to his colleague, why did he select these particular children?
c). Why has the link between Mack and Korner and Reider hardly ever been made in the literature and why did these results not deter other practitioners from using this treatment? One practitioner who picked up the link and the main concerns was Cimring (1955) who cites the Reider and Korner (1952) letter and reports on a technique which used a Blunt Rake (with loops) which was fitted to a removable appliance. This is one of the earliest references to removable habit appliances. The children in Cimring's study were 6-12 years and a 100% success rate was reported for the 53 out of 55 children who agreed to wear the appliance. Others who have picked up on the issues raised by Korner and Reider (1955) include Kaplan (1958) and McDonald and Avery (1994).

Graber and the Graber Appliance

Graber is well-known for his development and application of the Graber Appliance. This appliance is attached to full crowns. It is fairly unique in that it combines the Blunt Rake, the Palatal Bar and the Horizontal Crib into a single appliance. This allows a wide range of adjustments which enable the dentist to tailor the treatment to the needs of the individual child. The posterior loop attached to the Palatal Bar acts like a normal Horizontal Crib and the anterior spurs can either be horizontal, extending the Horizontal Crib, or can be bent downwards to form a Blunt Rake. The first article to report the appliance showed all the main features but provided no details regarding its function and use (Graber, 1952). The first full description of its use was in Graber (1958) where more details are supplied including the duration of treatment – 3 to 4.5 months initial treatment followed by the gradual removal of parts of the appliance. An analysis of the efficacy of the appliance treatment as used by Graber at Northwestern University Dental School reported a success rate of 207 successfully treated children out of a total of 225 children (92%). What is worrisome is the advice to be given to the parent:

a). At no time should the parent ever mention the habit and the stock response to all questions should be "This is a brace to straighten the teeth". In the case of the Graber Appliance, this advice, while not being in the spirit of gaining the consent of the child, is not an untruth since this appliance is unusual among habit

appliances in having a possible functional action on the teeth.

b). Place the appliance in late spring or summer so that the child's energies are channelled into outdoor play activity at a time when the child is at its health peak and less likely to get sick and relapse into infantile mannerisms. No appliances should be placed in the winter for fear that a childhood disease plus the boredom of inactivity might stimulate regression. This raises the issue of how a child can cope with an uncomfortable appliance during childhood illness (chicken pox, measles) or stomach upset (vomiting).

In Graber (1959), the bending down of the anterior spurs to form a Blunt Rake is explained as being necessary to counteract tongue thrust in cases of extreme open bite. This raises the question of whether the child might perceive this as being punitive as the appliance becomes more uncomfortable and restrictive. Graber (1963) stated the optimal age for appliance placement as being 3.5-4.5 years, even though Korner and Reider (1955) demonstrated that such treatment should be delayed until the child is older.

The actual construction and application of the Graber Appliance is given in considerable detail in the two editions of Graber's textbook (Graber 1961, 1966). These references are more explicit about the removal of the parts of the appliance as the treatment progresses. It is recommended that the Blunt Crib (anterior spurs) should be removed when the child has not sucked the digit for 12 weeks, followed 3 weeks later by the Horizontal Crib and 3 weeks later still by the Palatal Bar and crowns (making the total duration of treatment 3-6 months). This process of gradual removal of parts of the appliance might seem to the child as if the reduction of the severity of the appliance was conditional on good behaviour and hence punitive in form if not in intent.

Graber is very informative in giving some idea of the scale of the "business" of applying fixed appliances to thumbsucking children. Graber (1963) reports that 600 cases were treated with the Graber Appliance during a 17 year period (35 children per year). In a later communication, Graber (1970) claimed to have treated over 1,300 children "with the spurs turned towards the palate" since 1947 (23 years at about 57 children per year). If other practitioners treat children at this rate (over 1 per week) then it raises the question of how much time needs to be spent working with each child. Finally, the enduring nature of the Graber Appliance may be judged by the fact that Herud and Warnack (1998) describe its use in Poland in the late 1990s.

HABIT APPLIANCES IN THE 1960s

While the 1950s saw fixed intraoral habit appliances becoming widely used, despite the shaky theoretical foundations and lack of agreement within the literature, very few references could be found from the 1960s. Graber's (1961, 1963, 1966) work has been covered for simplicity sake in the section on the Graber Appliance. Subtelny and Sakuda (1964) briefly mention the use of a Vertical Crib but emphasize that no sharp areas should be introduced as punitive measures at any time.

Norton and Gellin (1968) review the whole subject of the management of thumbsucking and tongue thrusting. This article is of interest in that it recommends that treatment be left until the child is 8 years of age and that the child's consent be sought to the degree that the child should be enthusiastic and cooperative. The fixed appliances shown include the Blunt Rake (with loops), the Vertical Crib, the Horizontal Crib and the Sharp Rake (felt by the authors to be "rather medieval") (Norton and Gellin, 1968 p.374). They also shed light on the confused nature of the duration of the

treatment by stating that most appliance therapy is geared toward over-treatment and if the habit reoccurs, the patient may lose faith in the appliance and the dentist's ability to treat the problem.

However, the few references which did appear in the 1960s were arguably among the most important, influential and, in the author's opinion, most controversial of all. A series of papers emerged that described a program of research undertaken at the Department of Orthodontics, University of Alberta, Edmonton, assisted by the Department of Psychology, University of Calgary, and headed by Haryett.

Haryett : The "Keystone of the Arch"

The series of papers published by Haryett and his colleagues (Haryett (1962); Davidson et al (1967); Haryett et al (1967); Haryett et al (1968); Haryett et al, 1970) sought to investigate the effectiveness of several types of fixed habit appliances: the Palatal Bar (a Palatal Arch consisting of two arched bars) and the Vertical Crib in the form of a Vertical Crib/Sharp Rake ("crib with spurs") (Haryett et al (1967); Haryett et al, 1968) and a Vertical Crib without a Sharp Rake ("crib without spurs") (Haryett et al, 1970). Haryett's first article (Haryett, 1962), published prior to the study, mentions appliance therapy only briefly, referring to Graber's study and its success both in breaking the children's habits and its reference to the lack of habit transference or psychiatric trauma. The appliance shown is a Horizontal Crib. Why Haryett should choose something as extreme as a Vertical Crib/Sharp Rake appliance for the main study is not revealed.

A summary of the University of Alberta study was published separately (Haryett et al, 1968), along with an article by the psychologists (Davidson et al, 1967) on the psychological aspects of the study. The full reports are to be found in Haryett et al (1967) and Haryett et al (1970).

Ostensibly, the study also undertook to determine the influence of what it termed "psychologic treatment" on the outcome of the appliance/non-appliance treatments.

Haryett's Main Study (Haryett et al, 1967)

In the first study, which was reported in full in Haryett et al (1967) and summarized in Haryett et al (1968), 66 children, 4 years and older from Edmonton City were referred by dentists because of chronic thumbsucking and malocclusion. Six groups of 11 children each were subjected to 6 different treatment protocols over a period of 10 months:
1). Control group. No treatment.
2). Psychologic treatment, involving using a mirror to show the child the damage caused by the habit, showing the child plaster models and colour photographs of malocclusion, tongue thrust and lip abnormalities caused by thumbsucking, and motivating the child, through some unspecified process.
3). Palatal Bar
4). Palatal Bar plus psychologic treatment.
5). Vertical Crib/Sharp Rake.
6). Vertical Crib/Sharp Rake plus psychologic treatment.

The results indicated that all the treatments failed except the Vertical Crib/Sharp Rake, which was 100% effective. The psychologic treatment appeared to make no difference to the outcome. The conclusion was that treatment using a Vertical Crib/Sharp Rake for 10 months is the best for breaking a child's thumbsucking habit.

Haryett's Follow-up Study (Haryett et al, 1970)

Haryett's second study (Haryett et al, 1970) was a 3-year follow-up with children from the first study but it also aimed to determine the optimum duration of treatment with the Vertical Crib/Sharp Rake and to study the effectiveness of a

Vertical Crib without the spurs of the Sharp Rake. 65 of the original 66 children in the first study were examined annually. After 3 years, it was found that 2 out of the 22 children treated with the Vertical Crib/Sharp Rake had relapsed. This meant a success rate of 91% at 3 years compared with 100% at 1 year. The 37 children from the treatment groups in the first study, who did not initially use the Vertical Crib/Sharp Rake (Control group - no treatment; psychologic treatment; Palatal Bar; Palatal Bar plus psychologic treatment) and who were still sucking their thumbs, were then treated with the Vertical Crib/Sharp Rake. This group of 37 children was split into two groups, with 18 children and 19 children using the appliance for 3 months and 6 months, respectively. Once again the Vertical Crib/Sharp Rake was shown to be effective and the results indicated that treatment from 6 to10 months would be the optimum duration. Finally, the effectiveness of the spurs on the Vertical Crib/Sharp Rake in deterring thumbsucking was determined by taking a completely fresh sample of 29 children and fitting them with a Vertical Crib (no Sharp Rake) (2 later dropped out of the study). This was followed up by a trial involving another completely fresh sample of 44 children, divided into four groups of 11 children each and subjected to four treatment protocols (5 subjects later dropped out of the study):

1). Control group (no treatment). (8 children)
2). Vertical Crib/Sharp Rake. (11 children)
3). Vertical Crib/Sharp Rake plus psychologic treatment. (10 children)
4). Vertical Crib (no Sharp Rake) plus psychologic treatment. (10 children)
plus the group separately tested:
5). Vertical Crib (no Sharp Rake) with no psychologic treatment (27 children)

The results indicated that the Vertical Crib (no Sharp Rake) is as effective as the Vertical Crib/Sharp Rake. However, the issue of tongue thrusting and the possible deterrent effect of the spurs is raised as being of possible importance in the eventual choice.

Serious Concerns Raised by Haryett's Studies

While Haryett and his colleagues' work provides the basis for the justification by most practitioners to use any type of appliance for treating thumbsucking, with the "6-10 month treatment leading to a 91% success rate after 3 years" being the popular mantra cited regularly in the literature, it is necessary to examine the many serious concerns that arise from a closer inspection of this study:

1). The so-called "psychologic treatment" seems very cursory and hardly seems likely to win over the cooperation of the child, particularly when compared to the personal attention and in-depth counselling involved in most behavioural treatments.
2). There is absolutely no suggestion that any of the children were willing to give up their habit prior to treatment as flagged by Massler and Wood (1949) and Massler and Chopra (1950). The lack of enthusiasm for the treatment expressed by the children as a group is freely admitted (Haryett et al, 1970).
3). In the first study (Haryett et al, 1967), 11 children were fitted with a Vertical Crib/Sharp Rake without psychologic treatment and in the second study (Haryett, 1970), 27 children were fitted with a Vertical Crib (no Sharp Rake) without psychologic treatment. This implies that each child was fitted with the appliance without any explanation as to its function or purpose. It is difficult to imagine how terrifying this must have been to the children involved, some of whom were of pre-school age. It is also difficult to believe that any parent would consent to their child being subjected to this treatment.

4). The almost total failure of the Palatal Bar strongly suggests that all the children were being forced rather than reminded.
5). The second study (Haryett et al, 1970) focused on the determination of the optimum treatment time involved fitting the Vertical Crib/Sharp Rake to the 37 children who had not received this appliance but who were still thumbsucking. Half this group of 37 children were forced to use the appliance for 3 months (18 children) and the other half for 6 months (19 children). This group of 37 children included the 18 children who had been fitted previously with the Palatal Bar. This means that some of the children in the study had been forced to suffer a fixed appliance of some kind for between 13 and 16 months.
6). When judging the long-term effect of the treatment on the personality of the child, specific questions were asked of the parents regarding fears, sleep disturbances, night terrors, aggressiveness, school progress and relationships with parents/siblings. These effects were found to be absent. However, more worrying was the fact that most children were irritable and cried easily, and the observation that such emotional disturbances passed in time could simply mean that the child became resigned to its fate. Unhappily, children are known to suffer an inordinate amount of ill treatment, including sexual abuse, without showing symptoms of distress.
7). The length of time reported for the child to overcome its initial distress ranged from 1 day to 2 months, with some being upset for 1 week or less, some being upset for 2-3 weeks and one being upset for 2 months. In the latter case, the child was about to start kindergarten at the time of the crib treatment. This raises serious questions as to the mentality of either the parent or the practitioner in agreeing to fit a spiked appliance to a child so young and about to start kindergarten.
8). One theme that showed up in this study, which occurs throughout the literature of treatment for digit habits, is the physical injuries sustained by these children. It is reported by Haryett et al (1970) that as many as 20 out of the 55 children (36%), who were treated with the Vertical Crib/Sharp Rake, experienced some difficulty with the appliance itself. Of these, 17 complained of a soreness or an irritation of the palate and 3 others either broke the appliance or had the appliance come loose. The incidence of such injuries will be treated separately in this review.

It is the opinion of the author that these studies were exceptionally cruel to some of the children, particularly with regard to the non life-threatening nature of the condition (thumbsucking) being studied.

HABIT APPLIANCES IN THE 1970s

It is regrettable that the literature from the 1970s onwards tends to be based to a great extent on the University of Alberta studies, undertaken by Haryett et al, which the author believes to be morally-questionable. Ayer and Gale (1970) cite the studies as providing experimental evidence that dentists can use punitive appliances based on aversive conditioning methods for the treatment of thumbsucking. The fact that there was some unease among practitioners is shown by the letters which appeared criticizing Ayer and Gale (Berman, 1970; Penzer, 1971). The sensitive reaction of the dental/orthodontic profession to such criticism of Haryett et al is represented by an extremely long letter by Graber (1970) defending both Ayer and Gale (1970) and Haryett et al (1967, 1970). Very little of the controversy surrounding habit appliances has spilled into the correspondence of dental/orthodontic journals (the author checked the letter columns of all the major journals to make sure). In this case the dichotomy that exists among practitioners may be seen as being those who argue that the technique works and does not seem to harm the child and those who think there should be some more humane alternative or approach to the treatment.

Individuals who are interested in the patterns formed by the literature will be interested to note that the first item published by Haryett (1962) on habit appliances cited the results of the study by Graber (1958) and the last item published by Graber (1970) on habit appliances cited the results of the studies by Haryett et al (1967, 1970) so the circle is complete!

The acclaimed freedom from the danger of warping the child's personality was cited by Parker (1971) as justification for using a Sharp Rake with prongs that are sharpened to the point of drawing blood on the soft tissue of the thumb. The search for an appliance capable of controlling both the thumb and the tongue led to the development of Lingual Spurs in which sharp prongs were attached to bands on the incisors. Klein (1971) continues the long-standing debate about whether thumbsucking is a meaningful or empty habit. The fixed mind-set among dental/orthodontic practitioners still shows through in Klein's conclusion that the "meaningful" thumbsucking habit should be treated with a psychological approach, while the "empty" thumbsucking habit should be treated with habit appliances. Klein does stress, however, that successful appliance therapy can only be achieved if the child has a genuine wish to cooperate, a sincere desire to stop thumbsucking and welcomes the assistance of the habit reminder. The appliances shown in Klein's article include the Horizontal Crib, confusingly called a "Palatal Bar"; the Vertical Crib, confusingly called the Hayrake (Blunt/Sharp Rake) even though there are no spurs; and Lingual Spurs. One interesting feature of Klein's article is the illustration of the use of occlusal rests for both the Vertical Crib and Horizontal Crib to give support and prevent embedment in the palatal tissue.

Gershater (1972) does approve of the use of habit appliances but warns against indiscriminate use. He lists categories of patients where the appliance would be contraindicated. A warning is given against the use of the Sharp Rake. Gershater insists that the child have a strong desire to stop the habit, and the practitioner should be sensitive to the child's physical and psychological factors involved. Curzon (1974) approaches habit appliances from the paediatrician's viewpoint and demonstrates the dangers of taking the literature at its face value. Curzon concludes that counselling the child will have dubious effect and cites Haryett et al (1970) as authority, even though a reading of this article, or even better, the earlier one (Haryett et al, 1967) would reveal the relatively cursory and unsatisfactory nature of the counselling given compared to the personal attention and in-depth counselling involved in most behavioural treatments. The article by Stambach and Gellin (1977) is a general account written by dental practitioners for paediatricians. While only mentioning habit appliances in passing, they cite Haryett et al (1970) as the authority for the emotional/psychological aspects of thumbsucking. Gellin (1978) recommends the use of the Vertical Crib and the Vertical Crib/Blunt Spurs when all the incisors have erupted but stresses that this should only take place if there is a good relationship between the child and the practitioner, if the child cannot stop and if the child gives consent. A removable appliance is suggested if the child's emotional status demands it. The suggestion of occlusal rests to prevent the lingual arch wire from pushing into the palatal tissue suggests once again the potential danger of injury with these appliances.

Jacobson (1979) is one of the first to suggest that the removable appliance is the best. He counsels that the removable appliance should be directed to the 6-12 year age category and that it be used to serve as a reminder to the patient. Jacobson recommends the Hawley appliance with a "grid" incorporated into

the palatal surface (effectively a Vertical Crib with loops). It is concluded that this appliance is unlikely to produce any psychological traumas in the patient. Success in treatment depends on the desire of the child to break the habit. Jacobson states that "The child who is inadequately motivated to break the habit will destroy even the most rigid of fixed appliances" (Jacobson, 1979 p.520). This echoes concern for the injuries suffered by children in the Canadian studies (Haryett et al, 1967, 1970). If the child needs to suck its thumb, the appliance may be removed without fear of causing psychological traumas.

The articles published in the 1970s were mainly rehashing old techniques and ideas, albeit in contradictory and confusing ways. However, the decade did see the publication of the results of a remarkable study undertaken by Larsson, an extremely influential orthodontist, which will be discussed at length in the next section.

Larsson's Forgotten Study

The study of thumbsucking children undertaken by Larsson (Larsson ,1972, 1988) and Andersson and Tode (1971), in Skovde District Dental Centre, Sweden, during the early 1970s, is extraordinary for three reasons:

1). It is the only body of research to compare the effectiveness of a fixed intraoral habit appliance with other, behavioural techniques. Haryett et al (1967, 1970) tended to pay lip service to the behavioural approach to therapy.
2). It indicated for the first time that appliance therapy, though effective, was no more effective than other, behavioural techniques.
3). Despite the results being published as part of an historic series of articles covering different aspects of the effect of dummy (pacifier) sucking and thumbsucking on facial growth and occlusion the Larsson/Andersson and Tode study has been almost totally ignored.

The Larsson study was conducted in association with two psychologists (Andersson and Tode, 1971). The reports of the Larsson/Andersson and Tode study are much less detailed than those of Haryett et al (1967, 1970) and differ from the latter in that the children were generally older (9 years) and the study only ran for only 2.5 months. The 76 children were split into four groups each of which underwent one of four treatments:

1). Fixed appliance. A fixed Vertical Crib/Blunt Rake (palatal crib with spurs), similar to Haryett et al.
2). Positive reinforcement. The object was to reinforce the child's non-sucking behaviour through different forms of encouragement provided for the child by the mother after special instruction by both the clinician and the psychologist.
3). Negative reinforcement. The children and their parents were informed about the consequences of prolonged thumbsucking emphasizing the risk of permanent damage to occlusion.
4) Control. No treatment given.

The 75 children (1 dropped out) were examined 1 year after the cessation of the treatment. It was reported that the percentage of children having ceased their habit were as follows: Vertical Crib/Blunt Spurs (61%); Negative reinforcement (74%); Positive reinforcement (58%); and Control (11%). Table 2 compares the results from the two studies. Two points are worth noticing:

1). The results for the control groups in both studies are similar (10% for Haryett et al and 11% for Larsson).
2). Larsson's success rate for 2.5 month's crib treatment (61%) was the same as Haryett et al's success rate (61%).
These points suggests that the two studies may be reasonably comparable

and counters criticisms made to the author by some senior orthodontists that the studies are not comparable, particularly on the grounds that the age range of the children was different. The question is, if Larsson's non-appliance treatments had continued beyond 2.5 months, in which they were comparable to Haryett et al's (1967,1970) results, to the 6 months and 10 months of Haryett et al's studies, might the success rates of Larsson's non-appliance treatments have been similar to Haryett et al's appliance treatments? At the very least, Larsson's findings cast grave doubts on the accepted wisdom that the palatal crib is superior to other, non-dental treatments in treating thumbsucking children, particularly in view of the fact that these appliances do cause considerable distress and have also been known to cause physical injury.

It is surprising that no-one has set these results, published by Larsson (1972, 1988) alongside those of Haryett et all (1967, 1970) (Table 2) and spotted the significance over these past 12 years. Only three references have come close to recognizing the value of the Larsson/Andersson and Tode study. Foster (1990) cites Larsson (1988) and reports that significantly more 9-year old children stopped the thumb sucking or fingersucking habit within 1 year when treated either with verbal encouragement or with an intraoral appliance than did similar children who received no such treatment. Moore MB (1993) cited Larsson (1988) in his thesis and even quoted the actual results with comments on them. However, he then omitted this information in his otherwise excellent review (Moore MB, 1996) and cited Haryett et al (1967, 1970) as authority for fixed appliance therapy. Incidentally, out of the 44 references cited by Moore MB (1996), no fewer than 8 were published by Larsson, yet the weaning study by Larsson (1972, 1988) was overlooked. Johnson and Larson (1993) cites Larsson's study but make no special comment about it. This provides further evidence of the fractured and distorted nature of the orthodontic literature. In order to understand this published literature better, the author contacted Larsson (2001) with questions about the study. Larsson confirmed that:

1). The appliance used was a Blunt Rake (unlike Haryett et al, 1967, 1970).
2). All 76 children were willing to undergo the treatment (unlike Haryett et al, 1967, 1970).
3). In one or two cases the appliance became embedded in the palatal tissue or caused irritation (a much lower incidence than Haryett et al (1967, 1970) but still worrying).
4). Some of the children removed their appliance and needed it to be reinserted (like Haryett et al, 1967, 1970).
5). The restricted duration of the treatment (2.5 months compared to 10 months in Haryett et al (1967, 1970) was due to the psychologists' recommendations. Psychologist's were looking for substitution behaviors in children whom the researchers believed should be unable to suck because of the appliance in their mouths. However, some children were found to thumbsuck despite the appliance.

As a result of the study, Larsson turned away from using fixed intraoral habit appliances and would countenance using one only if the child is anxious to get a non-removable reminder. A removable appliance with a Vertical Crib is currently preferred by Larsson, if used at all.

HABIT APPLIANCES IN THE 1980s

The 1980s saw the emergence of ever-more sophisticated behavioural treatments for thumbsucking. This review is not the place to examine such techniques in detail but it is worth indicating that the technique of Habit Reversal, developed by Arzin (Azrin et al, 1980), recorded a mean success rate of 89%. Arzin noted in the discussion that this was almost as

favourable as the 91% obtained by Haryett et al (1967, 1970) with the Vertical Crib/Sharp Rake appliance. Similarly, Van Norman (1985, 1997) reports a success rate of 87% to over 90% using the type of positive behaviour modification described in various sources (Van Norman 1997, 1999, 2001, 2001a).

Cerny (1981) mentions in passing that a positive psychological approach, cooperation from the digit sucker and a habit breaker of a mechanical, chemical or dental nature is the most successful in habit-breaking. Since Cerny cites Haryett et al (1967, 1970) as the basis for this, some concern should be felt about how this positive, cooperative approach is to be achieved.

Schneider and Peterson (1982) review the whole range of oral habits and only mention habit appliances in passing. They state that, if non-appliance methods fail, the dentist can construct a variety of fixed or removable intraoral appliances to treat the habit and such appliances are not punitive. What is worrying is the literature cited by this article. Out of the four references cited, one is for Cimring (1955), which is fine as it is the earliest reference to removable appliances but the others are Haryett et al (1967, 1970) and Korner and Reider (1955), all three of which describe the Sharp Rake which is certainly punitive.

Campbell (1984) states that some clinicians are violently opposed to fixed appliances for deterring thumbsucking and in favour of counselling. Campbell confesses to have once considered them to be "barbaric" (Campbell, 1984 p.254) but was won over by the phenomenal success rate achieved. This is another case of the end justifying the means being the basis for appliance therapy. The article is useful in illustrating not only the Blunt Rake used alone but also as an element built into other orthodontic appliances, such as the palatal expansion appliance.

Leivesley (1984) illustrates a Vertical Crib fitted with a plastic (Nance) button to prevent palatal embedment. This is the first reference in the literature to a support of this sort since its initial recommendation by Massler and Chopra (1950). Friman and Schmitt (1989) cover a wide range of treatments. They mention habit appliances very briefly, noting that they should be used if all other methods fail and if the child is over 6 years. The ability to select from fixed and removable appliances is noted.

HABIT APPLIANCES IN THE 1990s

The 1990s saw a resurgence in innovative activity with two newly patented habit appliances emerging - Viazis's Triple-Loop Corrector (TLC) and Haskell's Bluegrass Appliance - each of which will be described separately. A Brazilian study, by da Silva Filho et al (1991), describes case studies involving the treatment of thumbsucking children with the Blunt Rake (with loops). A large measure of freedom was given to the children to consent to or refuse treatment. The use of removable appliances was countenanced in selected children.

The title of an article by Peterson and Schneider (1991) suggests that only the behavioural approach to oral habits is covered but, in fact, mention is made of habit appliances including the Palatal Bar, the Blunt Rake (with loops) and Lingual Spurs. At least the authors refer to it being necessary for the child to want to cease its habit. Khalil (1994) reports results of an Egyptian study, conducted to evaluate the short-term and long-term effects of thumbsucking treatment using a Blunt Rake. The study concluded that short-term speech problems were caused by the appliance - a result that was already known from Haryett et al (1967, 1970). The study recommended that the appliance should only be used with

children over 4.5 years, where speech is fully developed.

Molinari (1994) suggests that fixed appliances be used if all other methods of deterring thumbsucking fail. Oddly, the only reference Molinari cites is Traisman and Traisman (1958) in which only 4 children out of 1,208 surveyed were being treated with a habit appliance and this failed in 3 out of the 4 children treated! Rosenberg (1995) gives a brief review of thumbsucking that mentions the Rake. This review is of particular interest as it is written for paediatricians and includes a note by the Editor of the In Brief section of the journal, Pediatrics in Review, expressing concern about the wisdom of using "aversive therapies" (Rosenberg, 1995 p.74).

Josell (1995) suggests that habit appliances be used if all behavioural methods have failed and indicates that habit appliances work best with children who express a true desire to eliminate their habit. Appliances included palatal cribs which may be fixed or removable. It was difficult to determine the type of appliance described by Metaxas (1996), so the author contacted him for further information. Metaxas (2001) confirmed that the appliance was a Vertical Crib and indicated that he tends to use a Vertical Crib particularly when tongue thrusting is also present. A removable appliance was used in the case described because compliance was present, as he finds that it tends to be in 80-90% of cases. Removable appliances are the first choice because they give the child the opportunity to be responsible, independent and "in control". What was worrying was his statement that if compliance is not present, it was always possible to move to the fixed solution, thus raising the spectre of the appliance being forced upon an unwilling child.

Van Norman (1997) raises an important point regarding the provision of therapies for treating thumbsucking, at least in the USA. Insurance benefits are only available for treatments supervised or provided by licensed dentists. Any other behavioural treatment, such as that provided by the International Association of Orofacial Myologists, is not covered. Since it is "estimated that 50%-90% of the [US] population will not seek and undergo procedures that are not covered by insurance" (Van Norman, 1997 p.31) and since appliance therapy tends to be the main treatment taught at dental schools, most families turn either to habit appliances or to no treatment at all.

Viazis' TCA Appliance

The Thumb-Sucking Control Appliance (TCA) is notable in that it is one of the few habit appliances to be covered by patent (Viazis, 1993). It takes the form of an unusually-shaped Vertical Crib shaped from a single palatal wire which is bent into two or three large loops to form a barrier to the thumb. The TCA is also unusual in that the loop-barrier passes through the open-bite area and carries over the lower incisors. The earliest account of the appliance (Viazis, 1991) shows it with three loops and calls it the Triple-Loop Corrector (TLC) but the later account (Viazis, 1993a) shows it with two loops (as in the patent) and calls it the Thumb-Sucking Control Appliance (TCA), trade-marked and manufactured by GAC International Inc. A special feature of the appliance is that it can be attached to the molar bands in such a way as to be easily detached and re-attached at a later date. Viazis (1993) suggests that if the appliance is placed on Friday afternoon and, if the habit stops over the weekend, the TCA can be removed before school on Monday, leaving the bands in place for three months in case the habit is resumed.

Haskell's Bluegrass Appliance

The Bluegrass Appliance, invented and patented by Haskell (2000) is one of the most remarkable developments in the history of fixed intraoral habit appliances and breaks the mould completely by approaching the design of such appliances totally afresh. Haskell and Mink (1991) note the injuries sustained by children fitted with the Rake and similar punitive appliances and the need for a habit appliance that does not have these punitive characteristics. In place of a Vertical Crib, Sharp/Blunt Rake or Horizontal Crib, the Bluegrass Appliance uses either a circular/hexagonal-section Teflon or urethane roller or a series of coloured plastic beads that are free to rotate and move laterally on a cross palatal wire soldered to steel bands cemented to the child's molars in a similar manner to conventional habit appliances.

A description of the construction of the appliance is illustrated in Haskell (2001). The rollers/beads can be in two halves to enable them to be fabricated over existing wire appliances. The obvious potential danger of the two halves coming apart during treatment is addressed by the use of "pegs" and "holes" to give a more secure attachment. It specifically addresses the perceived hazards of traditional habit appliances. The child is encouraged to treat the appliance as a toy and to use its tongue to spin the rollers/beads and move them from side to side along the wire whenever the thumbsucking urge occurs leading to a "fascination response which is quickly imprinted due to the intense sensitivity and neuromuscular nature of the tongue and a new, non-destructive habit of playing with the roller" (Haskell, 2002, p. 22). Haskell and Mink (1991) report results of a study, undertaken at the paediatric dentistry clinics of University of Kentucky and University of Louisville. Baker (1998, 2000) reports further work but uses the Modified Bluegrass Appliance which has several beads rather than a single roller to increase the tactile possibilities. Baker (1998) reports the treatment of 63 children with thumbsucking habits and 3 children with pacifier habits in which all but 2 children were successfully treated. Baker (2000) reports the continuation of this work using 209 children with thumbsucking habits, 32 children with pacifier habits and 1 child with a nail biting habit in which, again, all but 2 children were successfully treated. Where Haskell and Mink (1991) differ from Baker (1998, 2000) is that, whereas the former did not use the appliance for pre-school age children, the latter used the appliance mostly with children of pre-school age and as young as 20 months. Moore NL (2001) criticizes the Baker studies on the grounds that children at the younger end of this spectrum would not have the cognitive ability to understand what was being done to them. He also indicates the study by Warren et al (2000) which reports that the incidence of digit sucking falls from 22% at 2 years to 12% at 4 years, suggesting that a very large percentage of the children treated by Baker would have ceased their habit in the natural course of time without any treatment.

The appliance is of particular interest to the Librarian in that it brings together ideas from different disciplines. Haskell and Mink (1991) state that the idea for the appliance came from the equine industry, where a bit with copper rollers is used to distract irritable horses and Haskell (2000) cites a patent for such a bit (Simington, 1977). The concept is also derived from such appliances as the Lingual Pearl (Ritto and Leitao, 1998), used for tongue retraining which employs a plastic bead on a palatal arch wire. Moore NL (2001) suggests that the mechanism of habit breaking is more akin to the habit reversal behavioural technique reported in Azrin et al (1980) and this observation is confirmed by Haskell (2002). Haskell (2002) also

reports that the Bluegrass Appliance, which seems to be increasingly called the "Habit Correction Roller", has been found to reduce tongue irritation in patients undergoing traditional quad helix or similar expansion therapy and has found use in the treatment of cerebral palsy patients to improve tongue placement and assist in the control of drooling. With all this activity invested in such an innovative habit appliance the remarkable thing is that it is so little known among dental/orthodontic professionals. For example, a very well-known orthodontist and enthusiast of fixed habit appliances confessed to the author that he had never heard of it, illustrating once again the terribly confused state of the literature and literature searching habits of dentists/orthodontists. When it is mentioned in the literature, along with other habit appliances (Maguire, 2000), the non-punitive, non-threatening aspects are ignored.

PHYSICAL INJURY CAUSED BY HABIT APPLIANCES

The fact that children do suffer serious injuries as a result of fixed intraoral habit appliance therapy is not in doubt. Examples of such injuries are clearly reported in the literature. The most remarkable thing about this is not that these injuries occur but that dentists/orthodontists continue to use habit appliances and subject the children to these risks regardless of the published dangers.

As mentioned earlier, Haryett et al (1967, 1970) reported that 20 out of the 55 children (36%) in the study who were treated with the Vertical Crib/Sharp Rake, experienced some difficulty with the crib itself and of these, 17 children complained of a soreness or an irritation of the palate and 3 others either broke the appliance or had the appliance come loose. Children were injured in the study by Larsson (1972, 1988, 2001)/Andersson and Tode (1971), to a lesser extent but sufficient to cause Larsson to turn away from their use (Larsson, 2001).

Gawlik et al (1995) reports that digital or resting tongue pressure can cause the appliance to become embedded in the palatal tissues - a fact that was originally reported by Massler and Chopra (1950) almost 50 years earlier! This palatal embedment is reported to cause infection, discomfort, increased anxiety and bilateral mesial tipping of the banded molars. Gawlik (1995, p.409) states that "Removal of the embedded appliance often requires an operation under local anesthesia and possible incision of the overlying mucosa". The article includes a disturbing photograph taken of a child with a Blunt Rake (with loops) that has become so embedded in the palate that only the tips of the loops are showing. Sim (1977) also describes a patient with a Vertical Crib that has been driven into the palatal tissue and become embedded after 8 weeks of treatment. The solution proposed by Gawlik et al (1995), in addition to making the wires thicker and more rigid, is to use a Nance button support of the type suggested by Massler and Chopra (1950). However, Gawlik et al (1995) also hints that such a measure would make the appliance more difficult for the child to remove, thus suggesting that the modification may also be a means of forcing the child into compliance.

Haskell and Mink (1991) refer to these injuries as "iatrogenically self-inflicted" wounds (Haskell and Mink, 1991, p.83). Josell (1995) warns of the risk of personal injury associated with uncooperative children who damage or destroy their appliances. Moyers (1988) indicates that children with intractable thumbsucking often remove the appliance several times and recommends that it should always be recemented.

Proffit and Fields (2000) and Pinkham (1999) state that an imprint of the appliance usually appears on the tongue

as an indentation. Their further observation, that the imprint disappears soon after the appliance is removed suggests that the tongue is in firm contact with the appliance throughout the entire course of the treatment.

Hanson and Barrett (1988) describe a particularly cruel version of the Sharp Rake in which the prongs are sharpened and positioned in such a way as to lacerate the tongue should it be protruded and a series of prongs may be placed in light contact with the gum tissue above the maxillary incisors with a loop of wire so placed behind the teeth that protrusion of the tongue causes the needle points to be driven into the gums. These are primarily tongue thrust appliances but the principles are similar to the treatment of thumbsucking with this appliance

Possibly the worst of all, Van Norman (1997) states that "the thumb/finger, as well as the tongue, can be lacerated or impaled on such devices. Some youngsters yank the appliance from their mouths damaging teeth and pulling gingiva out with it" (Van Norman (1997) p.31). Moore NL (2001a) argues that children also face a definite (if remote) chance of serious injury if they develop epilepsy or other infantile seizures when fitted with a fixed intraoral habit appliance. The ages of the children when they are usually fitted (4.5-8 years) corresponds roughly to the ages for the onset of epilepsy. The lengthy treatment (3-12 months) also increases the risk on a probabilistic basis.

When the three editions of the standard orthodontic textbook (Proffit and Fields, 1986, 1993, 2000) are compared it may be seen that the latest edition (Proffit and Fields (2000) differs from the other two editions in stressing that the appliances can be deformed and removed by children who are not compliant and do not truly wish to stop the habit, so cooperation is still important. Since no mention of this problem is present in the earlier editions, it must be concluded that the risk of injuries is increasingly becoming recognized and acknowledged with the passing of time.

REMOVABLE APPLIANCES AND THE SITUATION IN THE UNITED KINGDOM (Web Images RM1-RM2)

When the literature of fixed intraoral habit appliances is considered from a geographical viewpoint some significant features emerge:

1). There are very few references to habit appliances of any kind being used to treat thumbsucking children in Britain.
2). Such references as there are tend to show a reluctance to use appliances and a distinct leaning towards the use of removable appliances rather than fixed appliances.

The author checked books in the sections on paediatric dentistry and orthodontics of some of the UK's largest dental libraries and found that it was possible to identify the country where the book was published by the presence or absence of any mention of habit appliance therapy for thumbsucking. All the books published in North America tended to contain references to habit appliances but all the books published in the UK tended to have no mention of appliance therapy.

Parkin et al (1970) is the earliest reference to habit appliances in the UK and insists that the final aim is to instil into the child a positive wish to stop the habit. After a month's trial period, an offer can be made to help by providing a "reminder" in the form of an oral screen. The additional explanation that it will start pressing on the front teeth and begin the to put them tight is useful also, but the child must be the one to decide if help is wanted.

While not being the earliest reference to habit appliances in the UK, Shuff (1976) is the most detailed. The appliance

described is a variation on the Palatal Bar, with a simple wire across the palate looped twice horizontally. The total absence of sharp spurs, spikes or similar deterrents is stressed. Shuff states that, "If the patient enjoys his thumbsucking and does not wish to stop the habit or if the patient has no malocclusion of the anterior teeth, there is no indication for an appliance (Shuff, 1976, p.175). Shuff also points out that before the palatal guard is inserted it should be carefully explained that the purpose of the appliance is to help overcome the habit. It should be made clear that the appliance is only an aid to assist the patient to stop thumbsucking and will not be inserted if the patient does not wish to stop the habit. The appliance is recommended for children aged 8-15 years who wish to give up the sucking habit but are having difficulty doing so. Attempts to suck the thumb usually cease after less than 2 months after insertion of the appliance.

The reticence to treat with fixed appliances shows up in Brenchley (1991), who describes two case studies of thumbsucking children. The first was treated with a fixed appliance while the second used a removable appliance (both of unspecified type). The first patient was seen to have a thumbsucking habit at 8.4 years but only became sufficiently interested to request treatment 18 months later. The second child was seen to have a problem at 7.3 years but owing to a lack of maturity and cooperation, treatment was not started but deferred until requested by the child at 12.2 years.

Moore MB (1996) comes closest to being enthusiastic about fixed intraoral habit appliances, presenting images of the Vertical Crib (with and without Nance button support) and citing/summarizing the Haryett et al (1967, 1970) studies. The use of removable appliances is also included. Moore was contacted by the author (Moore MB, 2000) and further information about Moore's own strategy emerged. Initially, an attempt is made to educate the child about the link between their habit and their malocclusion and often this is all that is needed. When this is not successful and the child expresses a real desire to stop their habit, then the next line of therapy is to consider a removable appliance. An important consideration is seen to be that it must be the child who requests help in stopping the habit, not the parent. Finally, and as a last resort, a fixed appliance would very occasionally be considered and only if the child claimed to find the removable appliance helpful but could not resist the temptation to take it out when they want to suck. It is revealing that Moore could not remember the last time when he felt it necessary to resort to a fixed habit appliance and did not want the author to think that such appliances were in regular use in the UK.

Moore's study (Moore MB, 1993) is a thesis undertaken for Edinburgh University that reports on the craniofacial and occlusal characteristics of children with persistent digit sucking habits (Moore MB, 1993; Moore and McDonald, 1997). The study was not directly interested in determining the efficacy of habit appliances but includes information which can illuminate the UK scene. Moore MB (1993) reports that the study was conducted at the Victoria Hospital, Kirkaldy, Scotland and involved 885 new patient consultations, over an 8 month period, out of whom 54 children were selected for appliance therapy (6%) and 4 children subsequently dropped out. Normal practice in the Orthodontic Department for treating patients with prolonged digit sucking habits involves an initial period of orthodontic aversion appliance therapy to help break the habit if it is considered to be causing orthodontic problems and if the patient expresses a desire for treatment. This is carried out in conjunction with an explanation of the problem to the patient. Following cessation of the habit the occlusion is then

reassessed and any necessary corrective orthodontic treatment provided. With the exception of one child of 5 years and one of 7 years, the remaining patients were aged 9-16 years, with the largest group in the 10-11 year range. In order to determine the type of appliances used, the author contacted McDonald at Victoria Hospital (McDonald, 2001) who confirmed that, while having used fixed intraoral habit appliances in the past and preferring the Horizontal Crib with no sharp impediments, removable appliances are the only type used at the Victoria Hospital. The stated philosophy is that a child needs to be reminded rather than dissuaded from a thumbsucking habit. Richardson (1999) believes in counselling the child to cease the habit and if this fails after 6 months have elapsed provides a removable appliance with a simple Palatal Bar. Levine (1999) is a briefing paper for the British Dental Association which does state that "It is generally agreed that a persistent digit sucking habit should be treated and various mechanical devices, usually a modified orthodontic appliance, with a palatal bar or "roller" (Bluegrass Appliance?) have been advocated" (Levine (1999) p.108). However, it also states that "There is no consensus as to which method is more effective, but clearly the various non-physical methods should be tried first" (Levine, 1999, p.108).

In 2000, the British Orthodontic Society published its guidelines on dummy (pacifier) and digit sucking habits (British Orthodontic Society, 2000), after deliberation by the Development and Standards Committee. The publication is available from the BOS Web site <http://www.bos.org.uk> and, strictly speaking, is available only to members. However, it is worth contacting the BOS for a password since the author was successful. While the guidelines do specify intraoral habit appliances, they do not specify fixed appliances. They also stress that appliances must be fitted with the full understanding and cooperation of the child. The beginning of the guidelines includes a note that there are no controlled clinical trials at present.

The author contacted two senior members of the Committee David Tidy (Chairman) and Simon Littlewood since there was some concern that the references cited in conjunction with appliance therapy were Haryett et al (1967, 1970) and da Silva Filho (1991), all covering fixed appliances and the first two being the subject of some concern by the author on moral grounds. Littlewood (2000), of the University Dental Hospital, Manchester, states that fixed appliances for breaking habits are very rare in the UK, claims not to know personally any orthodontist who have used them and finds the other, simpler, less invasive techniques successful. Tidy (2000), of the Princess Royal Hospital, Telford, confirms that in the past the UK has had more of a removable appliance tradition, with fixed habit appliances not being widely popular and are regarded by many as a distinctly undesirable approach to the problem. Most orthodontists prefer like himself to work by persuasion, giving the child the responsibility for ending the habit. For the few resistant cases a simple removable reminder appliance seems to be all that is needed. One slightly worrying feature of the UK scene is the appearance of a UK orthodontist Web site which advertises fixed intraoral habit appliances (McCance, No date). The author contacted McCance (McCance, 2002), who confirmed that the appliance used was a Vertical Crib/Hayrake and that removable appliances have not been very successful. Happily, this UK orthodontic practice seems to be the exception but it could signal a sea change in UK opinion among practitioners.

The current pattern in the UK is fairly clear. All habit appliances are viewed with some distaste, removable appliances seem to be the furthest UK orthodontists are prepared to go along this road and the children who are treated tend to be older

than those treated in the USA. The attitude in the UK seems to be based more on the child being free to choose while in the USA, the child may be forced into compliance and punished by the types of fixed appliances used. Finally, another sign of the incomplete nature of the literature is the fact that no detailed study has been published about the effectiveness of removable appliances. Consequently, the producers of the BOS guidelines were forced to cite the references they did on the grounds that no other studies, based on removable appliances, had been published.

CONCLUSIONS

This review clearly reveals the chaotic state of the literature of fixed intraoral habit appliances over the past 60 years. There are many different designs of fixed appliances but no consensus as to which is the best type of appliance to use, or even how long to use them in treatment. There also exist indications that the therapy is potentially extremely dangerous yet this appears to be completely ignored by many practitioners. This lack of coherent thought, coupled with the potentially injurious nature of the therapy begs the question as to why so many children have been made to suffer so much for so long without any effort being made to put a stop to the practice. It is not as if there have been no voices counselling caution and disapproval over the years. Ilg and Ames (1955) advised against using a "really horrid-looking device known as a 'hay-rake', a metal device with vicious looking (and probably feeling) prongs. Merely looking at a picture of such a device would prevent most tender-minded parents from dreaming of using such a thing" (Ilg and Ames, 1955, p.150). Pierce (1978) expresses regrets that her section on mechanical restraints could not be written in the past tense, with many dentists and orthodontists still using these appliances and with this situation likely to continue to be the case until myotherapy gains wider acceptance and availability. Hanson and Barrett (1988) state that "these devices are basically merely ornamented forms of punishment; beneath the paint and bandages they remain as crude as a hit in the head" (Hanson and Barrett, 1988 p.334). Gober (1996) remarks that such appliances are "beyond the realm of what most parents would like to see their children endure, especially in relation to a disorder that at first glance seems harmless" Gober (1996, p.8). Even some of the early protagonists, such as Massler and Wood (1949) and Massler and Chopra (1950), give the impression of being lukewarm in their advocacy. It is not even the case that alternative measures causing less pain and suffering are not available to dentists/orthodontists. Three possible explanations may be suggested to explain this situation:

1). Financial Inducement.
2). Professional Insularity.
3). Absence of Concerted Opposition.

1). Financial Inducement

It has already been seen that Graber (1963) and Graber (1970) report that it was possible to treat between 35 and 57 children per year. Masella (1997) quotes the cost of crib treatment (probably a Horizontal Crib) as $250-$350. Two parents of children treated with a habit appliances (Panunto, no date; and R. G., no date) both quote $500 as the cost of treatment. Another reference (Anon, No date) quotes the cost as being $400 to $800. If $500 is taken to be the most likely cost, then a dentist/orthodontist could potentially earn $28,500 per year through fitting these appliances (assuming that the productivity figure quoted by Graber could not be exceeded by an enthusiastic dentist/orthodontist). A very crude estimate of the market for habit appliances can be made. The US Census for 2000 reports the total number of boys and girls in the USA aged 5 years to be 3,844,678

(this age is taken to be the ideal age for habit breaking to be recommended). Warren (2000) estimates the incidence of thumbsucking among children of 4 years to be 12% so the incidence at 5 years could be about 10%. It is impossible to arrive at an accurate estimate of what fraction of these children at risk will be subjected to appliance therapy but Moore MB (1993) reported that 6% of a series of thumbsucking children were selected for appliance therapy (the appliances were removable but this was because fixed appliances are not favoured in the UK). If this incidence of habit appliance therapy is taken, then the total market for this therapy may be estimated to be 3,844,678 x 10% x 6% x $500 = $11.534 million per year. If dental/orthodontic practitioners were to refer thumbsucking patients to behavioural therapists, they would forfeit a great deal of money.

A vital consideration that has already been mentioned (Van Norman, 1997) is that, in the USA at least, insurance benefits are only available for treatments supervised or treated by licensed dentists. Although behavioural treatments for thumbsucking do exist and are proven to be extremely effective, such treatments are not covered by dental insurance. This probably acts as an incentive for many parents to opt for appliance therapy.

2). Professional Insularity

There is considerable reluctance to look outside the dental/orthodontic profession for solutions to this problem. Moore MB (1996) stated that the various behavioural therapies available are "in the area of clinical psychology and are not within the remit of the dentist or orthodontist" (Moore, 1996 p. 420) and he further sums up this attitude with the statement: " I would not wish to offer advice on the use of psychological methods which I have no personal experience of. This is not to say that I doubt they may have a role to play, but not I feel in the dental surgery" (Moore MB, 2000). Kochman (2001) provides a particularly good example of the dental/orthodontic mindset by stating that ".. dentists treat this common oral problem with appliances. I believe that parents should consult a dentist first to manage this oral habit" Kochman (2001 p.129). Such comments provide a cynical counterpoint to all the articles in the literature which piously insist that all other approaches to solving the thumbsucking problem should be tried before turning to dental treatments. Even the unwillingness to switch to less punitive and less dangerous appliances, such as the Bluegrass, which have been in use for over a decade now and the lack of awareness of the existence of superior, behavioural treatments is an indictment of the casual attitude generally towards the best interests and well-being of the children.

3). Absence of Concerted Opposition

While there has been some criticism of fixed intraoral habit appliances in the literature, it has been sporadic and lacking in cohesion. Although the USA is fortunate to have organizations such as the International Association of Orofacial Myology (IAOM), which organizes behavioural therapy practitioners throughout the nation, it is regrettable that no concerted effort has been made by bodies such as this to try to influence public and professional opinion away from fixed appliance therapy. A few brave souls, such as Pierce (1978), Green (1999), Van Norman (1985, 1997, 1999, 2001, 2001a), Hanson and Barrett (1988) and Mason (2001) have spoken up publicly but the rest seem content to allow this appliance treatment to continue unchecked. Van Norman (1997) reports on the treatment of 723 children, based on detailed data compiled for every child treated. If data could be collected in a project involving all the members of the IAOM and other organizations using

behavioural techniques to treat thumbsucking children, then there could be a massive amount of information available to counter the protagonists of habit appliances. Better still, if the behavioural therapists could work with a major dental school, the issues of whether the appliances offer the best route to breaking this habit in children could be tested and the general public informed of the outcome.

It is the view of the author that thumbsucking is a behavioural problem. The use of dental/orthodontic solutions to behavioural problems is both inappropriate and cruel. Bearing in mind that evidence-based dentistry is becoming increasingly the focus of attention, it is time that a concerted effort be made to get to grips with this complex habit without resorting to appliances.

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The Literature Search

An exhaustive search was undertaken of the MEDLINE (PubMED) database <http://www.ncbi.nlm.nih.gov/entrez/query.fcgi > and the US Government Patent and Trademark Office <http://www.uspto.gov/patft/index.html >, both of which are freely available online on the World Wide Web. The articles retrieved were checked at the Dental Library, Edinburgh University, The Warner Dental Library, Guy's Hospital, London and the Eastman Dental Hospital Library, London. The references cited by each article were noted and checked. The author welcomes any feedback to this article and would be most happy to supply anyone interested with details of the search strategy used and an attachment with all the references retrieved as part of this project, upon receipt of an email message. The author can also provide a Boolean search strategy ready to be copied and pasted into the MEDLINE search engine for ease of searching.

WEBLIOGRAPHY : Appliance Images on the World Wide Web.

Rakes (Hayrake)

Web Image R1. Drs. Osborne, Bernard & Elmer.
<http://www.drsosbern.com/resources/appliances/tongue_crib.shtml>

Web Image R2. Johns Dental Laboratories. <http://www.johnsdental.com/articles/ortho/habit.htm>

Web Image R3. Excellence in Orthodontics. <http://www.drrichardlitt.com/treatop_f.html>

Web Image R4. Dynaflex. <http://www.dynaflex.com/lab/fixedhabit.shtml>

Vertical Cribs

Web Image V1. Columbia University in the City of New York. School of Dental and Oral Surgery.
<http://cpmcnet.columbia.edu/dept/dental/Dental_Educational_Software/D7656/case13.htm>

Web Image V2. AlbanyBraces.com. <http://www.albanybraces.com/appliances.htm#FIXED TONGUE/HABIT GUARD>

Web Image V3. Southern Illinois University. Dental Technology Lab. <http://www.siu.edu/~hcp/DT/Examples.html>

Web Image V4. Dr. Alex J. Johnson. <http://dralexjohnson.com/Orthodontics_Page_Habits.htm>

Web Image V5. David E. Harmon. <http://www.harmonorthodontics.com/habit2.htm>

Web Image V6. Dynaflex. <http://www.dynaflex.com/lab/fixedhabit.shtml>

Horizontal Cribs

Web Image H1. MED et al. <http://www.medetal.w1.com/treatment.htm>

Web Image H2. Creighton University, School of Dentistry.
<http://cudental.creighton.edu/images/thumb%20suck%20appl.jpg>

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Web Image H4. Drs. Osborne, Bernard & Elmer.
<http://www.drsosbern.com/resources/appliances/habit_appliance.shtml>

Web Image H5. David E. Harmon. <http://www.harmonorthodontics.com/habit2.htm>

Graber Appliance

Web Image G1. Mouth Jewelry. <http://www.smoe.org/braces/misc/thmbcrib.jpg>

Web Image G2. Specialty Appliances. Orthodontic Laboratory Services.
<http://www.specialtyappliances.com/appliances/metal-other.htm>

Bluegrass Appliance

Web Image B1. Johns Dental Laboratories. <http://www.johnsdental.com/articles/ortho/bluegras.htm>

Web Image B2. Qualitydentistry.com. <http://www.qualitydentistry.com/dental/orthodontics/thumb.html>

Web Image B3. Customsmiles.com.
<http://www.customsmiles.com/html/clear_braces___appliances.htm#bluegrassappliance>

Web Image B4. Accutech Orthodontic Lab Inc. <http://www.accutechortho.com/fixedapp.shtml>

Web Image B5. David E. Harmon. <http://www.harmonorthodontics.com/habit2.htm>

Web Image B6. Kiddsteeth.com <http://kiddsteeth.com/tties.html>

Removable Appliances

Web Image RM1. Mouth Jewelry. <http://www.smoe.org/braces/misc/hbtret.jpg>

Web Image RM2. Customsmiles.com.
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