Managing Orthodontic Data on a Small Computer

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A literature survey of file management, relational database management, and network/hierarchical database management systems led to selection of dBASE III to manage patient records on an IBM PC in the Department of Orthodontics at the Louisiana State University School of Dentistry. The versatility of this system's internal language enables ad hoc analysis of clinical and personal data to meet both anticipated and unanticipated management and scientific needs.

KEY WORDS: • COMPUTER • DATABASE • INFORMATION MANAGEMENT • RECORDS •

Every orthodontist in private practice maintains a large amount of data on each patient, and those in an academic environment may maintain even more. The underlying problems and possible solutions are the same in either environment, except that some university departments may have access to large computer facilities. This is not the case at Louisiana State University, where the records of all orthodontic patients were being maintained manually.

Trying to find a particular class of patients, such as Class I patients who had been treated with extractions, was so cumbersome and time-consuming that such searches were avoided whenever possible. To facilitate efficient data retrieval and make a large database available for faculty and student research, we investigated the use of a file or database management program (software) on an appropriate small computer (hardware).

Requirements

The selection criteria used in this investigation were essentially the same as those that would apply to an orthodontic practice interested in retrieving patient data. The following tabulation lists the requirements that the system selected was

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expected to fulfill. Underlying the overall performance criteria was the requirement for easy ongoing customization as new needs might arise; a system locked into certain fixed options, no matter how attractive or extensive, would not be satisfactory.

— Software —

Criteria for the software required that it be capable of the following functions:

- Operate on an entire database with a single command.
- Select subsets of data, based on criteria required for a specific application.
- Simultaneously open different databases containing different kinds of information for interactive manipulation.
- Be easy for students and faculty to learn.
- Be easy to modify without reentering data.
- Sell for less than $1,000.

Software Options

Three different kinds of file-management software are available for microcomputers.

File management systems, such as Friday!, InfoStar Plus, FMS-80.

Relational database management systems such as dBASE II and III, Condor 3, DataFlex, DataEase, Knowledge Manager, Ph.D., R:base 4000, Revelation, RL-1, and FoxBASE.

Heirarchical database management systems such as MDBSIII.

The appendix lists the companies distributing each of the above programs.

KRUGLINSKI (1983) introduces the three kinds of software to the new user, and DATE (1983) discusses the relational system. Newer books continue to appear on all aspects of computer operation, including many on specific systems, but the principles presented in these references remain unchanged. There are significant differences in the power, ease of use, and flexibility of these different types of software, and those differences can be critical in orthodontic applications.

File management systems are the simplest of the three. They permit the user to define files, enter data into those files, sort them, and create reports from them. These systems are essentially electronic filing cabinets, and although they accomplish these tasks effectively, they are not powerful enough to handle complex relationships among different items in a database.

Relational database systems, unlike file management systems, let the user operate on an entire database with a single command. In addition, they can work with several databases at the same time. By using relationships between files, a user can integrate information scattered among them.

A relational database management system can be used to sort patient records by patient ID number, then select all patients with uniarch extractions, and then obtain initial and final S-N-A angles in degrees even if that information were in another file.

Because relational database management systems permit the user to build complex data systems one step at a time in this way, they are relatively easy to learn and use. This offers flexibility that gives the user an ongoing capability of changing the kind of information required as data analysis proceeds.

Hierarchical database management systems, although even more powerful than relational database management systems in some ways, are more difficult to learn and to use. They are also less flexible.

In employing such systems, the user must view the data as a set, and then use this set as a framework for data manipulation and analysis. An example might be dividing a group of patients into two sets with and without uniarch extractions. Each of these categories could then be further subdivided into subsets with S-N-A greater or less than 82 degrees.

To access data from the hierarchical structure, a programmer would have to spend considerable time and effort writing a program to provide rapid data access, and the kinds of relationships that could be examined would be limited by the kind of data structure the user had originally established. This need to foresee future applications is a distinct disadvantage in orthodontics.

Advantages of Relational Database Management Systems

Relational database management systems have advantages for orthodontists over both file management and network/hierarchical database management systems.

Specific advantages over file management systems include satisfaction of our requirements that the system be capable of operating on an entire database of patient records with a single command, select subsets of data based on our criteria, and simultaneously open several different kinds of databases containing different types of information. They surpass network/hierarchical database management systems in satisfying our requirements that the system be relatively easy to learn and flexible enough for us to modify it to meet changing management needs while continuing to use the same data files.

An example of operating on the entire database with a single command is a calculation of changes in cephalometric measurements. We calculated the change in S-N-A (D S-N-A) between initial (I S-N-A) and final visits (F S-N-A) with the single command:

```
REPLACE DSNA
    WITH FSNA - ISNA
```

The above command calculated the change in S-N-A, called DS-N-A, by subtracting each patient's initial S-N-A (IS-N-A) from their final S-N-A (FS-N-A) as recorded in our database.

An example of selecting a subset of data is displaying the initial S-N-A, final S-N-A, and the change in S-N-A for all patients whose change in S-N-A exceeded 2 degrees, and whose initial S-N-A exceeded 84 degrees:

```
DISPLAY ISNA FSNA DSNA
  FOR DSNA > 2 AND SNA > 84
```

Because relational database management systems can simultaneously open several databases at the same time, they permit a user to subdivide a large database with various kinds of data into smaller databases, each containing a different kind of data. The management system can relate information scattered throughout the smaller databases by using a unique identifier, such as patient number, that appears in each of them. This permits the user to limit the number of items of information (fields) in each file to a small and easily manageable subset for routine tasks, while permitting operation on the fields in all three files if the need should arise.

dBASE III

Among the relational database management systems available for microcompu-

ters, dBASE III presents a number of attractive features. It can record up to 128 fields (items of information) per patient record, store up to 4,000 characters per field for a memo field, and manage up to 1,000,000,000 records on appropriate hardware.

It can handle ad hoc inquiries about these records, easily print elaborate reports that summarize them, and perform all of these functions at a reasonable speed. Because dBASE III can be run on the IBM PC, its ability to read and write from many different kinds of files can be used to integrate data among the numerous programs written to run on this popular 16-bit microcomputer and its clones. These programs include word processors such as WordStar, spreadsheets such as Lotus 1-2-3, statistical packages such as SYSTAT, and programs that support dBASE III such as Quickreport, Quickcode, dGraph III, and dUtil III.

Availability of these numerous support programs attest to the many users of dBASE III. Further evidence is Computer Systems Design's dBASE user bulletin board, which distributes information about developing applications for dBASE II and dBASE III (News: On-line services, 1985). The popularity and longevity of the older 8-bit dBASE II probably explains why most books written on microcomputer databases deal specifically with it (Jacobsen, 1984). The same kinds of books have appeared for the newer dBASE III (and dBASE III Plus) programs (Jones, 1985, 1987).

Finally, dBASE III's versatile programming language allows users to customize it for their needs. This feature alone makes this type of program invaluable in the changing orthodontic environment, where programs cast in stone become obsolete almost immediately and a growing aggravation as time goes on.

Many of the specialized professional and business programs currently in use are written in dBASE, although this is seldom noted by their authors. Many of these have been compiled for added speed and to protect them from pirating by other authors who might use them to produce a "new" product, so a word about compiling is in order here.

Disadvantages of dBASE III

Two disadvantages of dBASE III must also be considered in a complete evaluation:

- lack of password security against unauthorized access to patient records, and
- lack of multiuser capability.

The first does not affect our application, because we secure our data by storing it on floppy disks and locking them up as required. This might not be necessary in a private practice, where the data could be stored on a hard disk and backed up on floppies. There is also a utility program called dSecur that can be used to establish security for data sets.

An alternative method is to use dBASE III's internal programming language to write a program that sets up security protocols that can be made quite elaborate with different levels of security for different users. Richard D. Foerster (1985), the owner of Digital Information Systems, published such a program in the June 1985 issue of Data Based Advisor. His program requires an operator to enter an ID code to obtain access to dBASE databases on specific data disks; requires the operator to enter a job code at each access time; records the time and date of each valid access; and records the time and date of each session termination.

The second disadvantage, lack of multiuser capability, does not interfere with our plans to enter and analyze data in the Department of Orthodontics. When we selected our system in late 1984, multiuser applications and local area network-

ing were in a state of flux that continues today. Although some multiuser-oriented operating systems like UNIX and XENIX are already in the marketplace, no entry has yet set a standard for the computing community.

By 1986, a new version, dBASE III+, had appeared on the market. In the January, 1987 issue of PC Magazine, Alfred Poor selected it as the Editor's choice from among three top database management systems that he reviewed. This multiuser program could run with a networking program like NetWare (Novell). Those two programs, running on one of the powerful new 32-bit successors to the IBM PC (like the IBM AT and its clones), supplemented with an appropriate board like Microsystems ARCnet, could serve several users at the same time. Such a multiuser system could read files created using dBASE III, so upgrading to such a system in the future could be easily accomplished.

But complexities still plague even the best of multiuser systems (Derfler, 1986). Perhaps the solution lies in some successor to the IBM AT, using faster and more powerful chips like the Intel 80386, which has already appeared in the Compaq Deskpro 386. Evolution in this field is continuing at a rapid pace, and we feel comfortable with a system that can grow with future developments if we should see the need.

Compilers

High-level languages like dBASE and BASIC, even though completely different from one another, share the feature that they can be programmed in relatively simple English terms. When the program is run, the computer interprets each of these terms into a very complex set of computer commands that are executed in the background, completely transparent to the user. This goes on with lightning speed, but it does take time, and computer users become increasingly intolerant of even very short delays waiting for the computer to accomplish something.

A compiler is a program that interprets all of those commands and rewrites them into the resulting *machine language* code so that the program can be executed without going through the ponderous interpretation process every time. A compiled program can no longer be read and revised in the original language, but it can still be interspersed with commands or modules written in the original language.

Nantucket Inc. has written compiler called CLIPPER that makes programs written in dBASE run 2 to 20 times faster than interpreted code. WordTech Systems has an early compiler, dBIII Compiler, and a later one called Quicksilver, both of which can read dBASE III files. The same is true for Fox Software's compilers for FoxBASE and FoxBASE+.

We have not yet compiled any of our programs, but may later use one of these compilers to translate modules such as the dBASE III program for entering data from patient's orthodontic records into a dBASE III database.

— Hardware —

Having chosen dBASE III to manage our data, we proceeded to select a microcomputer on which it would be run.

The prerequisites for the computer system configuration to be eventually selected were low price, ease of use, and adaptability to our needs. With the current state of evolution of the microcomputer, we felt that an effective machine could be purchased within our $4,000 budget, which eliminated the minicomputers and mainframes that might be available in some university environments.

An additional prerequisite was that it be a self-contained, in-house system that could be easily controlled to enforce security of patient records. This requirement eliminated networks and timesharing, and narrowed our search to single-user microcomputers. Such a system has the added advantage of not requiring the installation and maintenance overhead involved in interconnected remote units.

We required a microcomputer that was —

- equipped with a 16-bit microprocessor that could utilize a more powerful 16-bit machine instruction set capable of running current and developing software that requires access to more than 64K of memory.
- manufactured by a stable company with reliable service.
- sufficiently popular to motivate the production of software packages and hardware expansions using current technology.
- available for less than $4,000.

These criteria gave reasonable assurance that even though the system selected might be followed in the market by newer models, it would not be rendered obsolete to such a degree that replacement would be required in the near future.

The IBM-PC satisfied our hardware requirements well within our budget. Numerous software packages have been tailored to run other applications on it, and such packages continue to appear on the market. In addition to the support of the manufacturer, many independent manufacturers continue to produce many inexpensive hardware modifications that can expand its disk, memory, and processing capabilities. Such expansions can further prolong its useful life by enabling the user to take advantage of developing technology. Finally, the broad installed base of this type of machine and software has produced a wealth of books covering their use at every level oif sophistication.

Even though the IBM-PC's 8088 central processor is not as powerful as more recent introductions, this is not a disadvantage for our single-user database management operations. The same is true for its modest 4.77 MHz clock rate, because it is the disk drive rather than the central processing unit that most severely limits the speed of this type of application.

— Data Collected —

With hardware and software installed, we proceeded to develop our data base. Based on the information already in each patient's chart, we set up a database in dBASE III to receive that information, and a program that leads the user through each item as the data is entered.

Each patient's unique chart number provides the common key to the various computer records, which contain five kinds of data:

1) personal data, such as name, address, . . .
2) diagnostic data such as openbite, crossbite, overjet, . . .
3) treatment data such as surgery, headgear, serial extraction, . . .
4) initial cephalometric data, such as S-N-A, S-N-B, . . .
5) posttreatment data for the same variables.

Each patient record contains all of the items shown in Table 1, beginning with the chart number in the first field and ending with the final lower incisor to mandibular plane angle in the last field.

The descriptive names appearing in Table 1 appear on the CRT screen whenever it is used to enter data. This is part of the program, written in dBASE, is completely flexible in the naming, size, and arrangement of the data fields. This is especially important in orthodontics,

Screen 1

Chart No.	:____:
Last Name	:_____:
First Name	:_____:
Street	:_____:
City	:_____:
State	:__:
ZIPcode	:_____:
Home Phone	:___-___-_____:
Work Phone	:___-___-_____:
Guardian	:_____:
Race	:___:
(cau=1, blk=2, spa=3, mon=4)	
Sex	:___:
Instructor	:_____:
Student	:_____:
Previous Student	:_____:
First Presentation	:__/__/__:(mo/day/yr)
Last Presentation	:__/__/__:(mo/day/yr)

Screen 2

Malocclusion Class	:__: (1 2/1 2/2 3)
Date of Birth	:__/__/__:(mo/day/yr)
Age at start of TX	:___:(yrs)
Treatment Time	:__:(mos)
Open Bite	:__:(A,P)
Crossbite	:__:(A,P)
Overjet	:___.___:(mm)
Overbite	:___.___:(mm)
Upper Crowding	:___.___:(mm)
Lower Crowding	:___.___:(mm)
Upper Spacing	:___.___:(mm)
Lower Spacing	:___.___:(mm)
Upper Bolton	:___.___:(mm)
Lower Bolton	:___.___:(mm)
Midline Discrepancy	:___.___:(mm)

Fig. 1 *above and right*
Consolidated listing of the data presently beimg entered into the six CRT (Monitor Screen) entry forms for orthodontic data.

Entry is facilitated on the actual monitor by positioning and highlighting on the screen. When data is being entered, the progression from one field (item) to the next is automatic, and new screens are presented in succession as each is completed. Fields may be skipped as desired during data entry.

This is an example only; content and format are defined by the user.

where each institution and each individual practice has unique preferences and requirements.

The operator moves the cursor from field to field on the screen by pressing the arrow keys on the keyboard. Each move brings it into exact position to begin entering data for the next item, and fields can be skipped or left blank as data entry proceeds.

When the the operator (usually a student in the school) reaches the bottom of the screen, it is possible to backtrack by pressing Q to correct any mistakes on that screen; or another key can be pressed to enter data on the next screen. Several successive screens are needed to enter all of the data for a patient.

Once a person has used the program a few times, it becomes easy to use the dBASE III editor to directly manipulate the data files. This database management system allows editing, retrieval, selection, searching, and printing reports from the files.

Examples

An example of a simple report is shown in Fig. 1. This report counts the number of patients classified in the various Angle classes of malocclusion, abbreviated in the computer as CI, CII/1, CII/2,

Screen 3

Surgery :____:
(max=1, man=2, max/man=3)
Ankylosed Teeth :__: (Y,N)
Impacted Teeth :__: (Y,N)
Supernumerary Teeth :__: (Y,N)
Cong. Missing Teeth :__: (Y,N)
Frenectomy :__: (Y,N)
Headgear (type) :__:
(cp=1 ahp=2 4h=3 php=4,
2h=5 sp=6 rp=7 cc=8)
Functional Appl. :__:
(ACT, BIO, FR1, FR2, FR3)
Expansion Appl. :__:
(w=1, rpe=2, qh=3)
Nonextraction :__: (Y,N)
Air Rotor Strip :__: (Y,N)
Serial Extraction :__: (Y,N)
Max. Extraction :__: (teeth)
Mand. Extraction :__: (teeth)
Clefts :__: (Y,N)
Spikes :__: (Y,N)

Screen 4

Peg Laterals :__: (Y,N)
Excellent Results :__: (Y,N)
Medical Problems :__: (Y,N)
Oral-Facial Anomaly :__: (Y,N)
Growth Problem :__: (Y,N)
Postpubertal :__: (Y,N)
Habits :__:
(lip=1, ton=2, digit=3, mouth=4)
TMJ Problems :__: (Y,N)
Third Molars Present
after TX :__: (Y,N)
Cuspid Expansion :__.__: (mm)
Molar Expansion :__.__: (mm)
Trans-septal Surg. :__: (Y,N)
Flared Incisors :__.__: (mm)
Root Resorption :__: (Y,N)
RETREATED CASE :__: (Y,N)
Retainer :__:
(remL=1 fixL=2 rem4=3 fixU=4 pos=5)

Screen 5

Initial S–N–A :___.__: (deg)
Initial S–N–B :___.__: (deg)
Initial A–N–B :___.__: (deg)

Init Up Incisor to N–A :___.__: (mm)
Init Up Incisor / N–A :___.__: (deg)
Init Low Incisor to N–B :___.__: (mm)
Init Low Incisor / N–B :___.__: (deg)

Init Mand Pl Angle :___.__:(deg)
Init Interincisor Angle :___.__: (deg)
Init Low Incis / Mand Pl :___.__: (deg)

Screen 6

Final S–N–A :___.__: (deg)
Final S–N–B :___.__: (deg)
Final A–N–B :___.__: (deg)

Final Up Inc to N–A :___.__: (mm)
Final Up Incis/N–A :___.__: (deg)

Final Low Incis to N–B :___.__: (mm)
Final Low Incis to N–B :___.__: (deg)

Final Mand Pl Angle :___.__: (deg)

Final Interincisor Angle :___.__: (deg)
Final Lower Incisor to
Mand Plane :__._____: (deg)

and CIII. For each classification, it also counts those treated with extractions and those treated nonextraction.

The counting statement to count the nonextraction patients classified as CI is

COUNT FOR CLASS = '1' AND NONEXT

Similarly, the statement —

COUNT FOR CLASS = '2/1' AND NOT NONEXT

counts the extraction patients classified as CII/1.

— Conclusion —

Now that our system is up and running, and our data is stored in this retrievable form in the computer, we are continuing to develop various dBASE III programs as required to select and process it as special needs arise. We expect that this capability for meeting new and unanticipated needs will prove to be the most valuable feature of the system as we continue to expand our applications.

While we have no need for some of the management and accounting functions required in private practice, this program is fully capable of meeting all such needs. It is, in fact, used in many package programs currently on the market. However, accounting is a complex subject and programming such a system from scratch can be a time-consuming process. Such modules can be acquired from other sources, and some can be integrated into a common database.

The computer novice can begin slowly with a basic system such as that described above, slimmed down to a few essentials. This can be expanded as familiarity dictates, either with in-house programming or with the addition of off-the-shelf programs.

Any computer system for information management is only as good as the data that it works with; the advantage of an adaptable database program of this type is that it can be customized to work with only the desired data. The information shown in Fig. 1 could be expanded or reduced, or changed altogether to meet specific needs.

The natural temptation to expand must be tempered by the realities of the requirement that data is of value only if it is used *and* is continually updated with new data as patients are added and treated. It is work enough to maintain that which is used; it an be a dreadful and costly chore to maintain mountains of data for a program designed to fill someone else's needs. A/O

	Classification					
	CI	CII/1	CII/2	CIII	Other	Total
Nonextraction	#45	#46	10	4	2	107
Extraction	100	#68	13	3	5	189
Total	145	114	23	7	7	296

Fig. 2. Classification of malocclusion (Class I through Class III) vs. extraction.

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Appendix

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ARCnet: Standard Microsystems Corp., 35 Marcus Blvd., Hauppauge, NY 11788

Clipper: Nantucket Corp., 12555 W. Jefferson Blvd., Los Angeles, CA 90066.

Compaq Deskpro 386: Compaq Computer Corp., 20555 FM 149, Houston, TX 77070

Condor 3: Condor Computer Corp., 2051 South State Street, Ann Arbor, MI 48104

DataEase: Software Solutions Inc., 305 Bic Drive, Milford, CT 06460

DataFlex: DataAccess, 4221 Ponce de Leon Blvd., Coral Gables, FL 33146

dBASE II, dBASE III, dBASE III Plus, FRIDAY!: Ashton-Tate, 20101 Hamilton, Torrance, CA 90502-1319

dBii Compiler, Quicksilver: Word Tech Systems, P. O. Box 1747, Orinda, CA 94563

dSecur: Micromedia Consulting Corp., Rockefeller Center Station, P. O. Box 2082, NY, NY 10185

FMS-80: DJR Associates, 2 Highland Lane, North Tarrytown, NY 10591

FoxBASE, FoxBASE+: Fox Software, 27493 Holiday Lane, Perrysburg, OH 43551

IBM PC, IBM AT: IBM Corp., Information Systems Group, 900 King Street, Rye Brook, NY 10573

InfoStar Plus, WordStar: MicroPro International, 33 San Pablo Ave., San Raphael, CA 94903

Knowledge Manager: Micro Data Base Systems, Inc., P. O. Box 248, Lafayette, IN 47902

Lotus 1-2-3: Lotus Development Corporation, 90 Annex, Atlanta, GA 30390-0370

MDBS III: ISE-USA, 85 West Algonquin Road, Arlington Heights, IL 60005

NetWare: Novell Inc., 1170 N. Industrial Park Drive, Orem UT 84057

Ph.D.: Micro Business Applications, Inc. 12281 Nicollet Ave. S., Burnsville, MN 55337

Quickreport, Quickcode, dGraph III, dUtil III: Fox and Geller, 604 Market Street, Elmwood Park, NJ 07407

R:Base 4000: Microrim, Inc., 1750 112th N.E., Bellevue, WA 98004

Revelation: Cosmos, Inc., 19530 Pacific Highway S., Seattle, WA 98188

RL-1: ABW Corporation, P. O. Box M1047, Ann Arbor, MI 48106

SYSTAT: SYSTAT Inc., 603 Main Street, Evanston, IL 60202